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Population Structure of the Juvenile Penaeid Shrimps Occurring in the Sandspit Backwaters of Karachi Coast, Pakistan

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Abstract. Ten species of juvenile penaeid shrimps were collected from Sandspit backwaters, Karachi coast, Pakistan. The genus *Penaeus* was represented by *P. penicillatus*, *P. merguiensis*, *P. indicus*, *P. monodon*, *P. semisulcatus* and *P. japonicus*, the genus *Metapenaeus* was represented by *M. monoceros*, *M. stebbingi* and *M. affinis*, whereas the genus *Parapenaeopsis* was represented by a single species, *P. stylifera*. Population structure, such as the species composition, seasonal abundance, size distribution, sex ratios, and the length frequency distribution were studied for seven species. The remaining three species (*Penaeus semisulcatus*, *P. japonicus* and *Parapenaeopsis stylifera*) were found only once and thus excluded from the above noted studies. The juvenile population in the Sandspit backwaters was dominated by *M. monoceros* (40.97%) and *P. penicillatus* (32.64%), which altogether constituted 73.6% of the population. These were followed in the order of abundance by *M. stebbingi* (10.73%) and *P. merguiensis* (9.29 %). The three less abundant species were *P. indicus* (3.27 %), *M. affinis* (2.14%) and *P. monodon* (0.87 %). *P. penicillatus* dominated during July to October, *M. monoceros* dominated during March to June, and *M. stebbingi* dominated during December and January. The average total length of *P. penicillatus* (juveniles) was found to be 57.1 mm with a range from 11 mm to 119 mm. In *P. merguiensis*, the total length varied from 11 mm to 123 mm with the average length of 54.3 mm. The total length of *P. indicus* varied from 12 to117 mm, with the average length of 60 mm. The total length of *P. monodon* (juveniles) ranged from 49 to 163 mm, and the average length was 105 mm. The total length of *M. monoceros* ranged from 11 to 93 mm, with the average size of 46 mm. The size of *M. stebbingi* (juveniles) varied from 10 to 90 mm in its total length and the average size was found to be 31 mm. In *M. affinis*, the total length varied from 18 to 95 mm, with the average length of 55 mm. The overall sex ratios in juveniles of all the species were not found to be significantly different. However, in certain size classes, the sex ratios deviated significantly.

Keywords: shrimp population, penaeid juveniles, Karachi coast, *Panaeus* species, *Metapenaeus* species, *Parapenaeopsis stylifera*

Introduction

Studies on the population structure of juvenile shrimps are limited, as compared with those of the post-larval shrimps. This is inspite of the fact that abundance of the former shrimp stage may be a more accurate predictor of the subsequent shrimp harvest than the latter. The predictive capability increases with each successive life stage because of the decreased time span between the estimated and subsequent commercial harvest (Sullivan, 1985). A number of research studies have been published on the population structure of juvenile shrimps from other parts of the world (Liu and Loneragan, 1997; Vance *et al.*, 1996; Mohan *et al.*, 1995; Loneragan *et al.*, 1994; Obrian, 1994; Haywood and Staples, 1993; Sasekumar *et al.*, 1992; Staples and Vance, 1987, 1986, 1985; Dutt and Ramaseshaiah, 1986; Coles and Lee, 1985; Staples, 1980a, 1980b, 1979; Kuttyamma and Antony, 1975; Beardsley, 1970; Pullen and Trent, 1969; Menon and Raman, 1961).

Extensive sampling was done from Sandspit backwaters, Karachi coast of Pakistan for a period of two years and the population structure related with species composition, size distribution, seasonal abundance, sex ratios, and length frequency distribution of seven species of penaeid shrimps was studied. These seven species were: *Penaeus penicillatus*, *P. merguiensis*, *P. indicus*, *P. monodon*, *Metapenaeus monoceros*, *M. stebbingi* and *M. affinis*. The other three species (*P. japonicus*, *P. semisulcatus* and *Parapenaeopsis stylifera*) collected during the present investigations were found only once, and hence their population structure could not be studied.

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Materials and Methods

In all, 18242 shrimp specimens were collected from Sandspit backwaters of Karachi coast (Table 1). Sampling was done fortnightly for a period of 24 months (June 1987 to May 1989). Shrimps were collected mostly during low tide, when they concentrate in deep channels and in tidal ponds. Three different types of nets were used for collecting juvenile shrimps, which were: (a) beam trawl having a mouth opening of 100 cm long and 30 cm wide, fitted with a net bag of 4 mm mesh size; (b) cast net of eight feet dia and 6 mm mesh size, and (c) hand

net of 25 cm dia and 2 mm mesh size to collect small shrimps adhering to shallow banks where the other two types of nets could not be operated. The beam trawl was dragged manually on the substrate for about ten min. Usually, two such hauls were made on each collection. The substratum was so uneven and muddy at most places that beam trawl lost its efficiency, and particularly the large sized shrimps escaped back. In such situations, the cast net was also used to capture the shrimps. Shrimps were identified, sexed and measured. The total length (TL) was taken from tip of the rostrum to the tip of the telson, and the carapace length (CL) was taken from the orbital notch to the dorso-posterior margin of carapace. All the measurements were taken to the nearest mm with the help of a divider and an mm scale. The smaller shrimps (less than 5 mm CL) were measured under a stereomicroscope.

Sexes were differentiated by the presence of petasmal endopodites in males and by the developing lateral plates of thelycum in females. The petasma and thelycum were found

Table 1. The number of juvenile shrimps of ten species* collected during June 1987 to May 1989 from the Sandspit backwaters, Karachi coast, Pakitsan

Collection period (year/month)	Genus *Penaeus*				Genus *Metapenaeus*			Total
	P. penicillatus	*P. merguiensis*	*P. indicus*	*P. monodon*	*M. monoceros*	*M. stebbingii*	*M. affinis*	
1987								
June	5	6	112	0	1053	170	69	1425**
July	109	10	3	12	33	41	5	213
August	523	74	19	30	16	11	0	673
September	76	55	4	24	16	3	0	178
October	498	135	35	38	128	64	0	898
November	228	205	1	6	15	34	0	489
December	101	183	0	2	83	324	0	693
1988								
January	89	48	14	0	42	156	50	399
February	83	44	10	1	203	220	100	661
March	145	50	2	2	837	45	49	1135**
April	105	41	2	0	636	13	12	809
May	7	12	55	9	835	0	1	922**
June	298	60	103	0	408	116	3	988
July	836	36	34	5	127	5	0	1043
August	1103	51	3	3	83	1	11	1255
September	605	71	0	6	152	0	0	834
October	315	99	0	15	577	8	1	1015
November	203	197	0	1	127	13	0	541
December	285	202	4	1	10	216	0	718
1989								
January	12	0	15	0	7	135	18	187
February	83	32	10	0	155	381	47	708
March	206	46	9	1	219	0	15	496
April	34	16	3	2	717	1	10	783
May	5	21	158	0	995	0	0	1179
Total	5954	1694	596	158	7474	1957	391	18242

* = three species were collected only once during the study: *Penaeus semisulcatus* (June 1987, 10 specimens), *P. japonicus* (May 1988, 3 specimens), *Parapenaeopsis stylifera* (March 1988, 5 specimens); the number of these species have been reflected in the total** for the respective collection period (month/year)

mostly at different stages of development, and such shrimps were considered as 'juvenile'. Few adult specimens were also found with fully developed genitalia. A large number of juveniles, particularly in the *Penaeus* species were found without any growth of petasmal endopodite or thelycal plates. These specimens were termed as indeterminate, i.e., not determinable sexually.

Sex ratios among the juvenile shrimps were tested for the distribution of equality by chi-square. Size classes were made by the Sturge's rule (Zuwaylif, 1979), which provides a convenient approximation to the number of classes. According to this rule:

number of classes = 1 + 3.3 log N

where:

N = number of observations

Class width was determined by the following formula:

$$\text{class width} = \frac{\text{highest variate - lowest variate}}{\text{number of classes}}$$

Results and Discussion

Species composition. The juvenile penaeid shrimps population in the Sandspit backwaters was predominated by *M. monoceros* (40.97%) and *P. penicillatus* (32.64%), which together constituted 73.61% of the total population (Fig. 1). Following these two species, in the order of abundance were *M. stebbingi* and *P. merguiensis*, which respectively constituted 10.73% and 9.29% of the total population. The three less abundant species were *P. indicus*, *M. affinis* and *P. monodon*, and respectively constituted 3.27%, 2.14% and 0.87%. Although juveniles of *P. monodon* were found during most of the months, yet their number was relatively less, and hence constituted only 0.87 % of the total population. The remaining three species (*P. japonicus*, *P. semisulcatus*, and *Parapenaeopsis stylifera*) were found only once, and respectively constituted 0.02, 0.05 and 0.03% of the total juveniles during the period.

The month-wise species composition of the juvenile shrimps is shown in Fig. 2. *Metapenaeus monoceros* was the most abundant species in June 1987, followed by *M. stebbingi*.

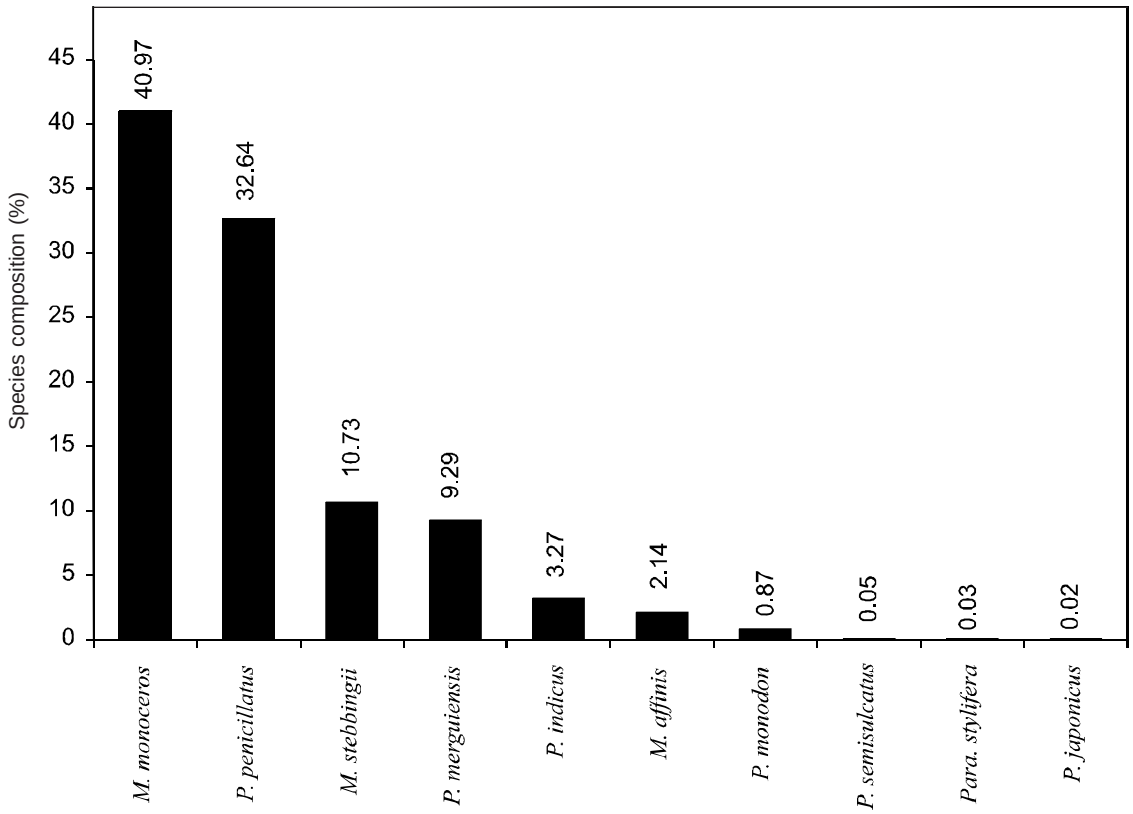

Fig. 1. Overall species composition (%) of the juvenile shripms of the genera *Metapenaeus (M.)*, *Penaeus (P.)*, and *Parapenaeopsis (Para.)* collected from the Sandspit backwaters, Karachi coast, Pakistan.

These two species constituted 85.8% of the total population during this month. However, in July 1987, *P. penicillatus* juveniles dominated and constituted 51.17% of the total population. *M. stebbingi* constituted the second most abundant species in the population during this month. The number of *P. penicillatus* increased in August 1987 and constituted 77.71% of the population. The dominance of *P. penicillatus* was sustained until November 1987, when it constituted 46.63% of the population. In December 1987, *M. stebbingi* juveniles dominated the population and constituted 46.75% occurrence. *P. merguiensis* was the second most abundant species. *M. stebbingi* remained the dominant species during January-February 1988. In February 1988, *M. stebbingi* constituted 33.28%, while *M. monoceros* constituted 30.71% of the population. *M. monoceros* was the most abundant species during March-June 1988, with the maximum abundance of 90.56% in May. The other six species together constituted only 9.44 % of the population. *P. penicillatus* was the most abundant species during July-September 1988 and constituted 87.89% of the population in August 1988. In October 1988, the population was composed of 56.85%, 31.03% and 9.75% for *M. monoceros, P. penicillatus* and *P. merguiensis,* respectively. The other three species together constituted only 2.37 % of the population. In November 1988, *P. penicillatus* and *P. merguiensis* respectively constituted 37.52% and 36.41% of the population. *P. penicillatus* remained dominant during December 1988 and constituted 39.69%. In January-February1989, *M. stebbingi* constituted 72.19% of the population. During March-May 1989, the population was mostly composed of *M. monoceros* juveniles and constituted 91.57% of the population. However, the other six species constituted 8.43% of the population.

Seasonal abundance. Seven species were found regularly or intermittently round the year, and the changes in their seasonal abundance are given in Fig. 3.

Penaeus penicillatus. A total of 5954 juvenile specimens were collected during the study period, and their seasonal abundance is shown in Fig. 3A. In 1987, juvenile specimens were abundant during August and October and thereafter the number gradually decreased to a minimum during May 1988. However, from June 1988 onwards, their number increased rapidly and their maximum abundance was recorded during August 1988. Their number, however, consecutively decreased in the subsequent months until January 1989. There was a slight increase in the number of juveniles during February and March 1988, but their number again rapidly decreased.

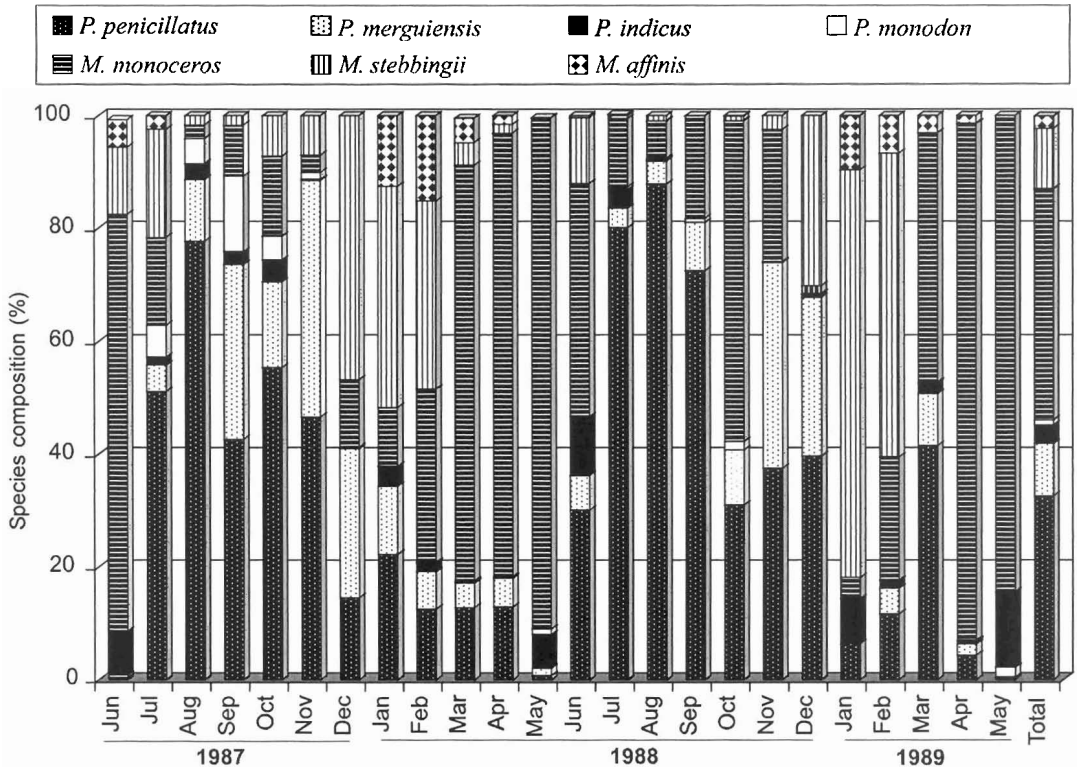

Fig. 2. Month-wise species compostion of the juvenile shrimps of the genera *Penaeus* and *Metapenaeus* collected from the Sandspit backwaters, Karachi coast, Pakistan.

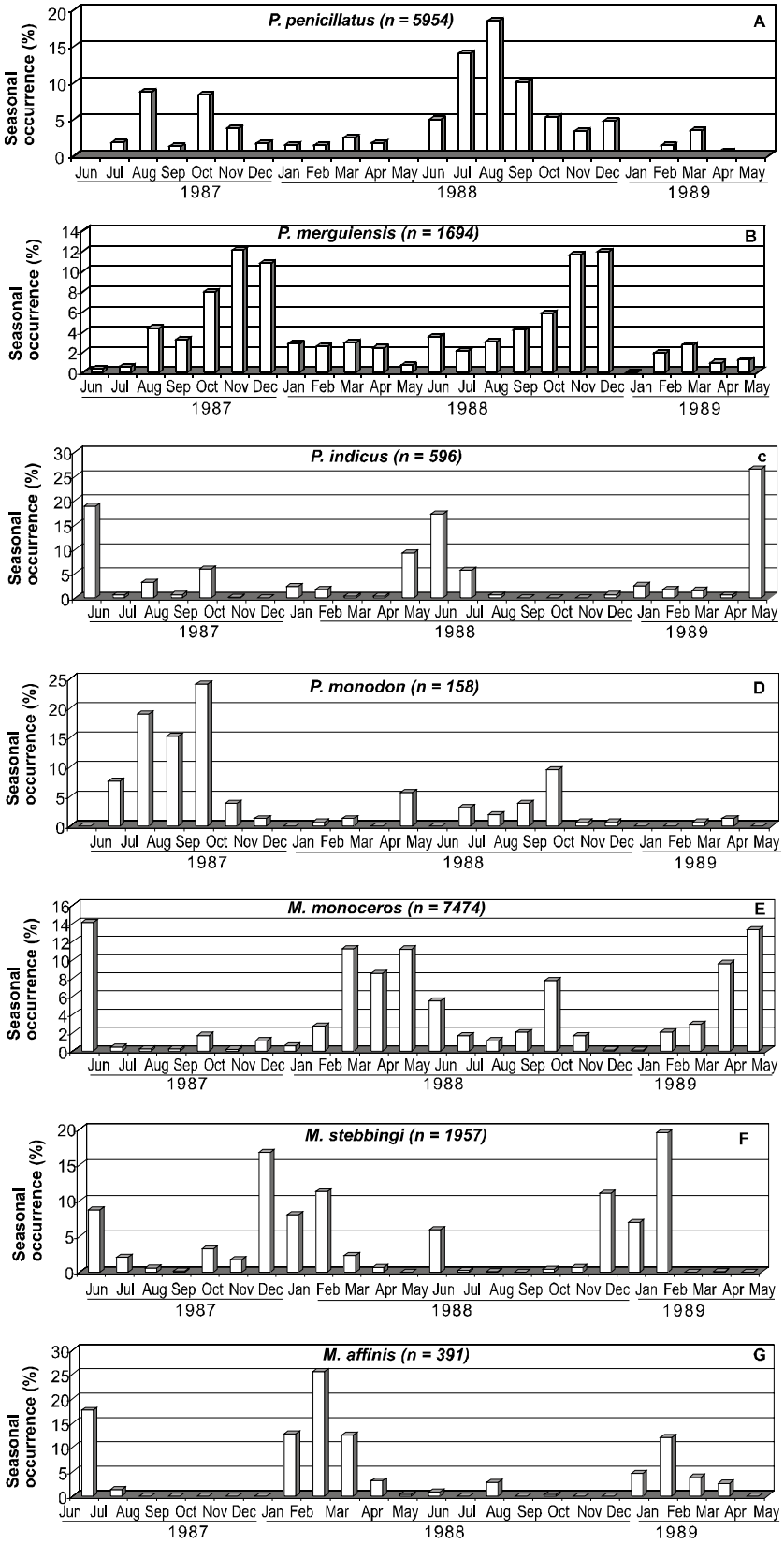

Fig. 3. The seasonal abundance of seven dominant-peaneid juvenile species of the shrimp genera *Metapenaeus* and *Penaeus* in the sandspit backwaters, Karachi coast, Pakistan.

Penaeus merguiensis. A total of 1694 juvenile specimens of this species were collected during the present investigations. The maximum number of juveniles was found during November-December in both the years (1987, 1988), whereas the minimum number was found during January 1989 (Fig. 3B). The juveniles increased gradually in their number from June-November 1987, which then disappeared from the population. Very few juvenile specimens were found during May 1988. From July 1988 onwards, the number of juveniles increased gradually and their higher abundance was observed during December 1988. The number dropped suddenly during January 1989, when juveniles were completely absent in the backwaters. However, in the subsequent months, they started reappearing.

Penaeus indicus. A total of 596 juvenile specimens of this species were collected during the present study. Large numbers of juveniles were found in May and June 1987, whereas they were totally absent during December 1987, and during September-November 1988. During other months, they were found in small numbers with no regular pattern of abundance (Fig. 3C).

***Penaeus monodon*.** The seasonal abundance of *P. monodon* juveniles is shown in Fig. 3D. A total of 158 juvenile specimens were found during the study period. The juveniles were most abundant during October 1987 and 1988, although the number of juveniles was considerably less in 1988. Availability of juveniles increased from June 1987 and reached their maximum abundance in October 1987. Thereafter, the number of juveniles decreased rapidly, which completely disappeared in January and April 1988, indicating a migratory pattern of *P. monodon* from nursery ground to breeding ground. However, few did occur during February and March 1988. Similarly, juveniles of this species were not found in June 1988, and January and May 1989.

Metapenaeus monoceros. Juveniles of this species were found during all the 24 months of the study period and their number was also the highest (7474). However, they were quite abundant during March-June 1988 (Fig. 3E). Their peak abundance was noted during May to June.

Metapenaeus stebbingi. A total of 1957 juvenile specimens were collected during the study period. The juveniles were abundant in winter months, the maximum numbers of the juveniles were observed in February 1989 (Fig. 3F). The juveniles were also abundant during December 1987. A minor peak of abundance was found in June 1987 and 1988. They were not collected during May and September 1988, and March and May 1989.

Metapenaeus affinis. A total of 391 juvenile specimens of this species were found during the study period. They were mostly abundant during the winter months of January, February and March 1988 and 1989, with the exception of June 1987. Juveniles of this species almost disappeared during August-December 1987; July, September, November-December 1988; and May 1989 (Fig. 3G).

Length frequency distribution. The length frequency distribution of juvenile shrimps of different species is given in Fig. 4.

Penaeus penicillatus. Total length of the juvenile *P. penicillatus* ranged from 11 mm to 119 mm with mean total length of 57.1 ± 8.4 mm (SE). The mean total length calculated for each monthly sample ranged between 44 to 87 mm. In the month of June 1987, the mean length was 87 mm and then there was a gradual decrease in the mean length of the juveniles until September 1987, when the mean length was 49 mm. Thereafter, the mean length of the juvenile population gradually increased until November 1987, when it was found to be 67 mm. From December 1987 to March 1988, the mean length fluctuated between 56 mm and 59 mm. However, from April to September 1988, there was a gradual decrease in the mean length of the juvenile shrimps from 65 mm to 49 mm. Again, there was an irregular fluctuation in the average size from September 1988 to May 1989, and was found to be between 44 mm and 63 mm.

Penaeus merguiensis. In *P. merguiensis* the total length varied from 11 to 123 mm, with the mean length of 54.3 ± 9.9 mm (SE). However, the monthly mean length varied from 42 mm to 87 mm. The average total length of the juveniles decreased gradually from 87 mm to 42 mm, and then there was a gradual increase in the mean length until November 1987, when it was found to be 60 mm. There was an irregular fluctuation in the mean length from December 1987 to March 1988 when it was found to be between 45 mm and 61 mm. From April - September 1988, there was a gradual decrease in the mean length from 64 mm to 46 mm. Again, the mean length of the juvenile shrimps fluctuated irregularly but juveniles of larger sizes occurred during January 1989, as compared to December 1988 and February 1989.

Penaeus indicus. The total length varied from 12 to 117 mm, with an average length of 60 ± 14 mm (SE). The monthly average size varied from 27 mm to 86 mm. The average size decreased rapidly from 86 mm to 27 mm in 1987. There was a rapid increase in the mean length after August 1987 till October 1987, when the mean length was 80 mm. An irregular fluctuation was observed in the mean length that varied from 49 mm to 72 mm during January-August 1988. In the months of September-November 1988, the juveniles of *P. indicus* were absent. However, during December 1988, the mean length of 79 mm was found, which decreased gradually up to March 1989, when the mean length was noted to be 48 mm.

Penaeus monodon. The total length in juveniles of this species ranged between 49 mm and 163 mm. The mean length was found to be 105 ± 20 mm (SE). The mean length decreased from July-September 1987 and June-September 1988. Irregular length frequency distribution was found during other, perhaps on account of the entry of smaller size groups of the species.

Metapenaeus monoceros. The juveniles of this spcies ranged from 11 mm to 93 mm in total length with the mean length of 46 ± 9 mm (SE). The smallest size juveniles were found in July 1987, when the mean length was 18 ± 6 mm (SD). The length frequency of juveniles gradually increased to 50 ± 12 mm (SD) during September 1987. During October 1987 to May 1988, the mean length fluctuated between 36 mm and 54 mm. However, during May to September 1988, the mean length declined to 40 mm. Thereafter, an increase in the length was observed and the maximum mean length of 65 mm was recorded during January 1989. The mean length then again gradually decreased and it was found to be 45 mm during March 1989.

Metapenaeus stebbingi. The size of the juveniles of *M. stebbingi* varied from 10 mm to 90 mm in their total length. The mean length of juveniles was found to be 31 ± 5 mm (SE). However, month-wise length distribution showed that the mean length in June 1987 was 40 mm, which gradually decreased to 21 mm in August 1987. Thereafter, the mean length started to increase (53 mm) untill February 1988. From February-July 1988, the mean monthly length decreased (except during June). The mean length in July was found to be 34 mm. A gradual increase in length was again observed from July 1988 onward and in January 1989 the mean length was found to be 58 mm.

Metapenaeus affinis. The range of total length was found to be 18 mm to 95 mm with the mean length of 55 ± 8 mm (SE). In January 1988, the mean length was 63 mm, which gradually decreased to 36 mm in August 1988. Again, in January 1989, higher mean length was observed (67 mm). However, from January onwards, the mean length declined.

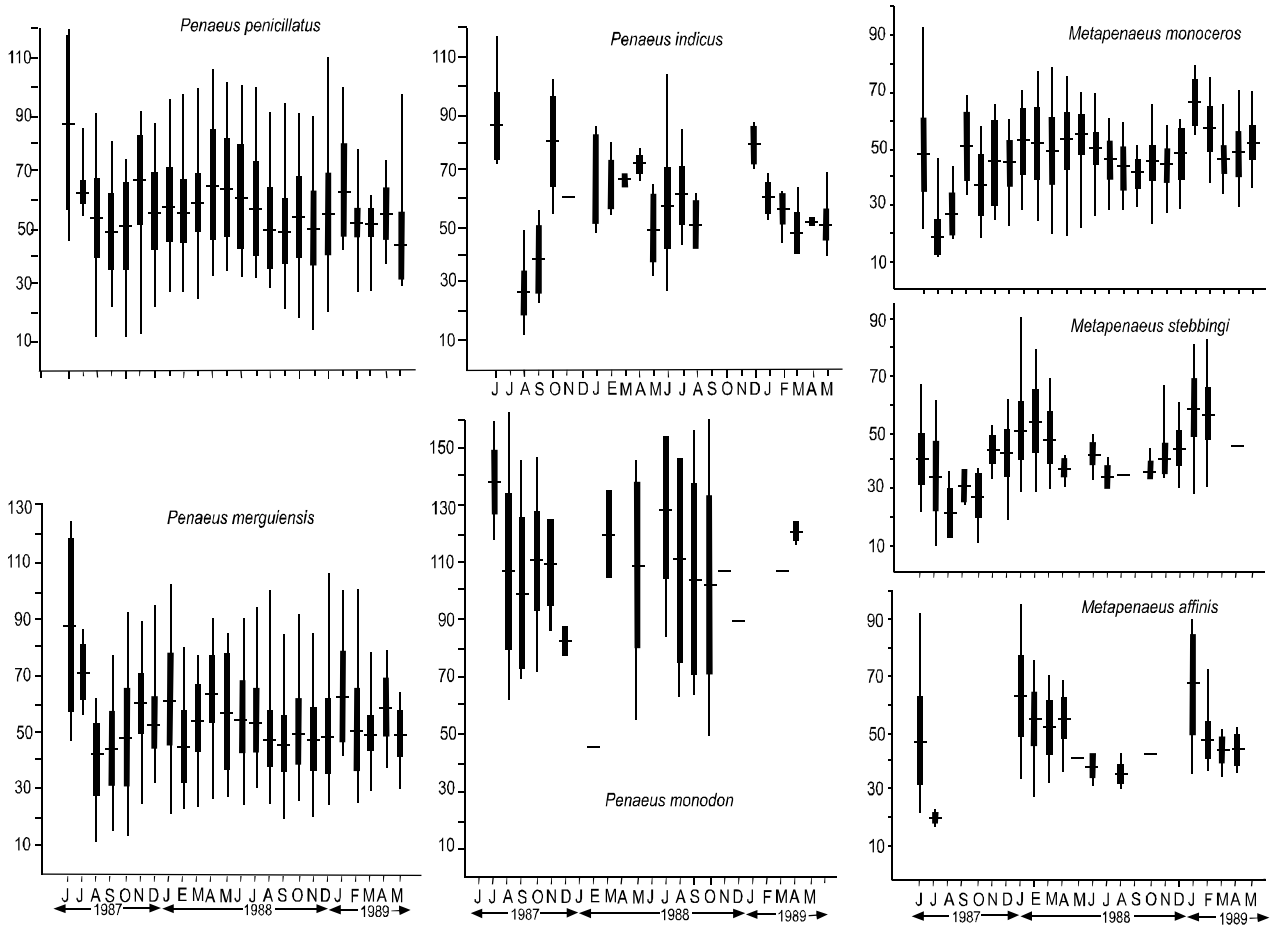

Fig. 4. The length size (mm) distribution of the juvenile penaeid shrimps collected from the Sandspit backwaters, Karachi coast, Pakistan during June 1987 to May 1989.

Sex ratio. The sex ratios of the seven species of juvenile shrimps collected during the present investigation are given in Table 2. In *P. penicillatus, P. merguiensis* and *P. indicus,* females were more abundant than males and the ratios between males and females in the three species were found to be 1 : 1.05, 1 : 1.09 and 1 : 1.03, respectively. Chi-square test revealed that these differences were not statistically significant. In the case of *Penaeus monodon, Metapenaeus monoceros, M. stebbingi* and *M. affinis,* the males were more abundant than the females and the ratios between males and females in the four species were found to be 1 : 0.90, 1 : 0.97, 1 : 0.96 and 1 : 0.95, respectively. However, these differences were also not found to be statistically significant, when chi-square test was performed.

Sex ratios in different size groups. In *P. penicillatus,*the male to female ratio was 1 : 0.33 for size group range from 42 - 49 mm. This deviation from the expected ratio of 1:1 was found to be statistically significant. In all other size groups, the sex ratio did not deviate significantly. In the case of *P. merguiensis,* however, the sex ratios in different size groups were found to be normal, except in the size groups 70-77 and 84-91 mm. *P. indicus* had four size groups, in which sex ratios deviated significantly in the size group 77-84 mm, and the sex ratio between males and females was found to be 1 : 1.42. Similarly, in the size group 91-98 mm, the sex ratio of males and females was found to be 1 : 7.25. In the next size group, 98-105 mm, the male and female ratio was 1 : 0.08, while in the size group 126-133 mm, only males were present. In *P. monodon* all the size groups had normal male to female ratio, without any significant deviation, except the 70-77 mm size group. In *M. monoceros* different size groups showed normal distribution of male and female sex. At different size groups, *M. stebbingi* and *M. affinis* displayed significant deviation from the expected 1 : 1 ratio. In *M. stebbingi* females dominated the males in the size groups 30-36 mm, 48-54 mm and 54-60 mm. In the other two larger size groups, 66-72 and 72-78, there were more males than females, and again the difference was found to be statistically significant. In *M. affinis,* only the two size groups, 36- 42 and 54-60 mm, had a ratio of 1 : 2.07 and 1 : 0.43 (male : female) and the sex ratio deviated significantly. Other size groups had almost normal distribution of male and female.

Species composition of the juvenile shrimps showed that *Metapenaeus monoceros* and *Penaeus penicillatus* were the most dominant species in the Sandspit backwaters. These two species were found throughout the year and all together constituted 73.6% of the penaeid population. *Metapenaeus stebbingi* and *P. merguiensis* were next in abundance, and their juveniles were collected from the Indus delta on two occasions; in February 1980 and then in May 1980. Ahmed (1985) reported that juveniles of *Metapenaeus affinis* were most abundant in January and February 1980, while juveniles of *P. indicus* were second most in abundance. Hassan (1992) studied the immigration of *Metapenaeus monoceros, M. stebbingi* and *M. affinis* juveniles and observed that *M. affinis* juveniles were the most abundant at Korangi creek, while *M. monoceros* was the most abundant at the Sandspit backwaters.

Dumetriades and Forbes (1993) investigated species composition of different size categories of penaeid prawns at Tugela Bank off the east coast of South Africa. In the smaller size categories of juveniles, they observed two seasonal abundance in CPUE during January- May and July-September, which were dominated by *P. indicus* and *M. monoceros*.

The present study has shown that juveniles of *Metapenaeus monoceros* dominated during March to June, while juveniles of *P. penicillatus* dominated during July to November. However, *M. stebbingi* predominated only during December to January (winter). Ahmed (1985) reported that juveniles of *M. affinis,* with the size range of 11-107 mm, occurred in the Indus delta. During the present study, size range of 18-95 mm of juveniles of *M. affinis* was observed in the Sandspit backwaters.

Table 2. Sex ratios at $p < 0.05$ in seven juvenile shrimps species of the genera *Penaeus* and *Metapenaeus*, collected from the Sandspit backwaters, Karachi coast, Pakistan during June 1987 to May 1989

Species	Number	Indeterminate sex	Males (M)	Females (F)	M : F	Chi-square
P. penicillatus	5954	2902	1489	1563	1:1.05	1.794
P. merguiensis	1694	724	465	505	1:1.09	1.650
P. indicus	596	87	242	267	1:1.03	1.228
P. monodon	158	4	81	73	1:0.90	0.416
M. monoceros	7474	89	3741	3644	1:0.97	1.274
M. stebbingi	1957	21	988	948	1:0.96	0.826
M. affinis	391	2	199	190	1:0.95	0.208

Ahmed (1985) found the size range of 9-76 mm of *P. indicus* juveniles in the Indus delta, whereas size range of 12-104 mm was observed during the present study at Sandspit backwaters.

Mohan *et al.* (1995) studied population structure of juvenile shrimps in the mangrove habitat of Muthupet, India. Among the eight commercially important species, *Penaeus indicus*, *P. merguiensis*, *P. monodon* and *M. dobsoni* were found as the dominant species. *P. indicus* and *P. merguiensis* were found in the size of 9-11 mm total length, while *P. monodon* was found in 12-14 mm total length. The minimum size of *P. monodon* was found to be 46 mm at the Sandspit backwaters.

The presence of *P. monodon* juveniles in the Sandspit backwaters is unique, where the average salinity was 36.91±0.97 (Sultana and Mustaquim, 2003). This species is known to prefer low salinity and grows best at salinities between 10-20 ppt (Primavera and Apud, 1978). It is, therefore, an abundant species in countries like Bangladesh, the Philippines and Thailand, where the estuaries have low salinity due to high rainfall as well as freshwater discharge from the rivers. In the Philippines, peak occurrence of *P. monodon* was reported in August and September (Mohammed, 1965). *P. monodon* juveniles have never been earlier reported from the backwaters or creeks along the Pakistan coast. During present investigation, *P. monodon* juveniles were found in most months and were abundant during August–October.

It has been reported that *Parapenaeopsis stylifera* completes its life cycle in the deep sea and the post-larvae and juveniles avoid backwaters and shallow creeks (Mohammed and Rao, 1971). However, few juveniles of *P. stylifera* were caught in February 1980 from the Indus delta by Ahmed (1985). During the present investigations, incidental presence of *P. stylifera* was observed at the Sandspit backwaters.

Sex ratios have been often reported to deviate from the natural ratio of 1 : 1 for penaeid shrimps in adult stocks. The deviation may be caused by a number of intrinsic and extrinsic factors, such as environmental, migratory, breeding, selective mortality and fishing intensity. Menon (1957) studied the sex ratio of penaeid shrimps, from southwest coast of India, and reported striking differences in *Metapenaeus dobsoni*, but in the case of *Penaeus indicus* and *Metapenaeus affinis* no such striking difference in sex ratio was observed. In their study of sex ratio of penaeid shrimps, Kuttyamma and Antony (1975) observed male dominance in *Penaeus indicus*, whereas female dominance was noted in *M. dobsoni* and *M. monoceros* at Cochin backwaters, India. However, they did not give the magnitude of dominance, neither they performed any statistical test to observe whether the differences were significant or not. Hussain (1974), who studied the sex ratio of *Penaeus merguiensis* from Karachi Fish Harbour, for a period of one year (May 1970 to April 1971), found a ratio of 1 : 1.4 (male : female). In month-wise analysis, this author observed that males dominated the females during December–January.

Though no statistical test was performed during this sutdy, yet it is evident from the given table that the reported data were statistically significant ($\chi^2 = 36.815$; df = 1; $p > 0.05$). In a more recent study, Ayub and Ahmed (1992) reported 1 : 1 sex ratio in the adult population of *P. penicillatus*, *P. merguiensis*, and *M. affinis* from Pakistani waters. While considering the monthly percentage of sexes, they found that in *P. penicillatus* and *P. merguiensis*, 1 : 1 ratio deviated significantly in certain months. During the present investigation, the overall sex ratios in juveniles of each species were not found significantly different from the natural 1 : 1 ratio. However, in certain size classes, the sex ratios deviated significantly from 1:1. This significant difference in the sex ratio in small size classes may be due to the fact that the males develop secondary sexual characters earlier than the females. Hence, the males in small size classes were sexually determined, while the females remained as indeterminate juveniles.

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