CONTRIBUTION TO THE SPECIES COMPOSITION AND BIOLOGY OF PENAEID PRAWNS IN THE JAFFNA LAGOON

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Vingnanam – Journal of Science 6: 20 — 35 (1991)

ABSTRACT: *Metapenaeus monoceros, Penaeus semisulcatus, Penaeus indicus, Penaeus latisulcatus* and *Penaeus monodon* are the five species of penaeid prawns found in the Jaffna lagoon. *M. monoceros* with an average species composition of 62.7% was the dominant species in the Jaffna lagoon, followed by *P. semisulcatus*, with 28.5%. The average contributions of *P. indicus, P. latisulcatus* and *P. monodon* to species composition were 4.8%, 2.4% and 1.5% respectively. Growth studies using modal progression analysis have indicated that *M. monoceros* and *P. semisulcatus* have an average growth of 9.17 mm month $^{-1}$ and 12.5 mm month^{-1} respectively and that the fishery of these species in the Jaffna lagoon is supported by the O-year class. The calculated total length-weight relationship gives b values varying from 2.6827 to 3.0242 for the different species. Generally all the species showed a predominance of females during 1986 and 1987. The females of all the five species recorded are larger than males. Food analysis of the stomach contents reveals that animal material comprising annelids, molluscs, insects, crustaceans, miscellaneous chitin and detritus varying from 59.5% to 69.3% form the main dietary component of all the five species.

Introduction

The need for a substantial increase in supply of animal protein and the significant earnings in foreign exchange have stimulated interest in the prawn industry in Sri Lanka and abroad. Most of the current production of prawns in Sri Lanka comes from lagoons (ADCB Report 1980). The Jaffna lagoon is the largest water body situated in the northern part of Sri Lanka.

Satchithananthan and Thevathasan (1970) have reported the topography and substratum of the Jaffna lagoon. Investigations carried out by Chitravadivelu and Arudpragasm (1983) indicated that there are five species of penaeid prawns in the Jaffna lagoon and that they are collected mainly by four types of gear. The efficiency of the fishing gear used in prawn fishery in the Jaffna lagoon has been reported by Chitravadivelu (1990).

The Jaffna lagoon has an area of approximately 421 km². The lagoon is shallow and its depths do not exceed 4.0 m. It lies between approximately 70° 50' E to 80° 38' E long and 9° 26' N to 9° 46' N lat. The lagoon is connected to the sea at Ponnalai between Karaitivu and Kayts and between Kalmunai and Mandaitivu. Five distinct bays – Ponnalai Bay, Velichavedu Bay, Kalundai Bay, Ariyalai Bay and Kachchai Bay are marked out in the lagoon (Satchithananthan and Perera 1970).

The present investigation, undertaken from January 1986 to December 1987, aimed to study the species composition and some aspects of biology of the penaeid prawns in the Jaffna lagoon. This will contribute to the understanding of the prawn fishery, help the growing interest in shrimp culture in Sri Lanka and aid in the adoption of suitable management measures.

Materials and Methods

Bimonthly random samples of prawns were taken from the total catch of similar gear of identical dimensions, operated for a day, from 10 landing centres in the Jaffna lagoon. To maintain uniformity, the gear were either supplied or partly financed and cost of maintenance met by the investigator, throughout the period of study.

Prawns are caught in the Jaffna lagoon mainly by (i) Sirahuvalai or stake net (ii) Drag net (raal valai) (iii) Hoop net (raal hoodu) and (iv) Kandi (trap or tidal weirs or cone cage or aproned cone cage). The structure and mode of operation of these gear are described in detail by Pearson (1923), Satchithananthan and Thevathasan (1970), Kurian and Sebastian (1976) and Chitravadivelu and Paranthaman (1987). The drag net is an active gear while the other three are passive gear (Laevastu 1965).

The date of collection and the name of the landing centres were recorded for each sample collected. Samples were brought to the laboratory for detailed analysis.

The temperature of the air and surface water, pH and salinity were recorded at each station. Rainfall data were obtained from the Meterological Office at Kankesanthurai.

Initially, each sample was separated into different species, sexed and the number of specimens of each species was counted. The carapace length and total length of each specimen were measured to the nearest mm, the former using a Vernier Caliper and the latter using a measuring board. The carapace length is the distance from the orbital notch to the posterior dorsal margin of the carapace and the total length is the distance from the tip of telson (Garcia and Reste 1981). An Ohaus Triple Beam balance (Model 700) was used to determine the weight of each specimen to the nearest mg.

Monthly average percentage species compositions were computed taking the number of specimens of each species in the samples from different gear on a particular day. The study is based on 470 samples comprising 42,792 penaeid prawns.

Besides determining the sex ratio, the prawns in each species were grouped into 05 mm intervals and the monthly length – frequencies were calculated.

The stomach was removed intact from randomly selected specimens and the contents of the stomach of each specimen were then spread on a mm grid. Each item was separated into one of the assigned food categories (Table 1), identified as far as possible, the number of each items counted and an estimate made of the volume occupied by each item. The percentage contribution of each food item, in terms of the volume occupied and category were then calculated.

Table 1. Percentage composition of food of the different species of Penaeid prawns from the Jaffna lagoon in 1986 and 1987. A– *P. monodon*, B–*P. indicus*, C–*P. semisulcatus*, D–*P. latisulcatus* and E–*M. monoceros*.

	A	B	C	D	E
Numbers investigated	132	124	126	107	113
		% composition of food items			
Angiosperm	29.50	28.60	38.35	29.31	31.30
Algae :					
Centric diatoms	0.04	0.83	1.80	0.05	1.41
Pennate diatoms	0.61	0.77	0.15	0.61	0.21
Oscillatoria sp.					0.18
Gleocapsa sp.					0.11
Lyngbya sp.		0.42			
Cladophora sp.		2.03			1.01
Chlorella sp.	0.44	0.21	0.08	0.40	0.51
Cosmarium sp.		0.12	0.08		
Padina sp.		0.25			
Animals :					
Annelida		1.80	2.37	5.41	2.10
Mollusca	7.33	2.40	5.57	11.40	3.14
Insecta	15.40	3.35	10.60	3.31	10.66
Crustacea	10.51	24.51	3.40	7.46	7.18
Miscellaneous chitin		2.34			0.37
Animal matter unidentified	12.16	8.07	8.00	2.45	9.49
Detritus	24.01	24.30	29.60	39.60	32.24
Total	100.00	100.00	100.00	100.00	100.00

Results and Discussion

Hydrographic factors

The monthly variations of air and surface water temperatures and rainfall are shown in Fig. 1. Fig. 2 gives the monthly variation in pH and salinity. The air temperature was the lowest in November 1986 (20.05°C) and September 1987 (25.20°C). In 1986, the lowest temperature of surface water was recorded in December (22.3°C). March recorded the lowest surface water temperature of 23.6°C in 1987.

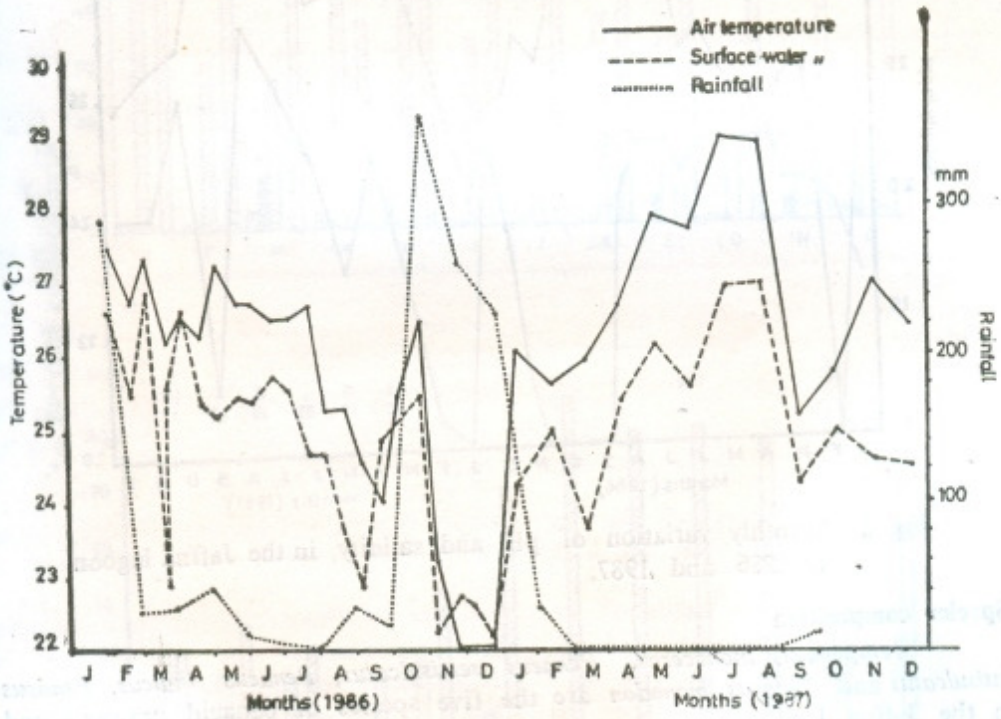

Fig. 1. Monthly variation of air and surface water temperature and rainfall in 1986 and 1987 in the Jaffna lagoon.

The Jaffna lagoon had the lowest salinity of 16.5 ppt. in January 1986 (Fig. 2). In the same year highest salinities were recorded during August and September and were in the range of 34.5 ppt and 34.75 ppt. In 1987, the lowest salinity of 20.25 ppt. was recorded in January and the highest of 36.3 ppt. in August (Fig. 2).

The lagoon water was either neutral or slightly alkaline during 1986 and 1987 (Fig. 2). In 1986, the lowest pH of 7.00 was in February, September, October and November; the highest pH of 7.63 was in March. During 1987, the lowest pH of 7.00 was recorded in January and the highest of 7.72 in August. Highest rainfall in 1986 was during January, October, November and December. In 1987 there was rain only during January and September.

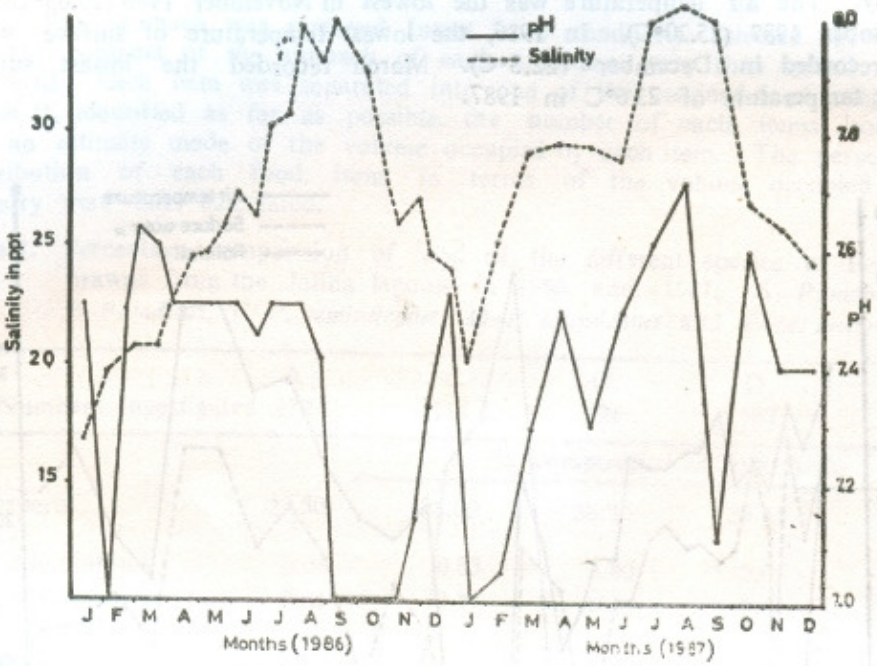

Fig. 2. Monthly variation of pH and salinity in the Jaffna lagoon in 1986 and 1987.

Species composition

Metapenaeus monoceros, *Penaeus semisulcatus*, *Penaeus indicus*, *Penaeus latisulcatus* and *Penaeus monodon* are the five species of penaeid prawns found in the Jaffna lagoon.

The monthly variations in percentage species composition obtained from the cumulative catches for 1986 and 1987 are shown in Fig. 3a and 3b. From the monthly cumulative catches it is apparent that *M. monoceros* is the predominant species during all the months in 1986 except April (Fig. 3a). In April, *P. semisulcatus* dominated in species composition with 59.5% followed by *M monoceros* with 36.5%. In 1987, *M. monoceros* was the dominant species throughout the year with species composition varying from 35.9% to 89.0% (Fig. 3b). In 1986, the highest species composition of *M. monoceros* was 82.5%.

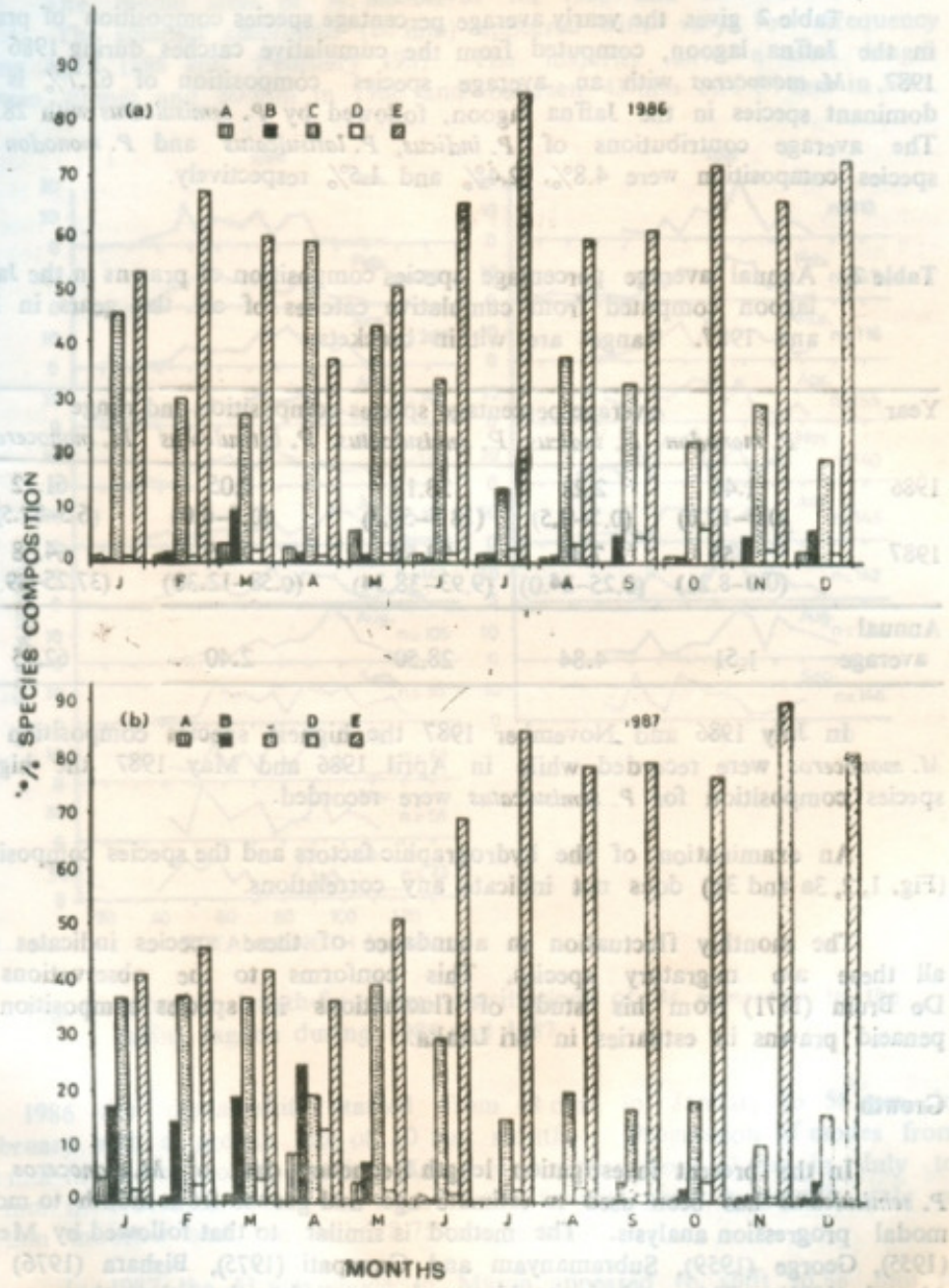

Fig. 3. Average monthly variations of percentage composition of the different species of Penaid prawns in the Jaffna lagoon during (a) 1986 and (b) 1987. A-*P. monoden*, B-*P. indicus*, C-*P. semisulcatus*, D-*P. latisulcatus*, E-*M. monoceros*.

Table 2 gives the yearly average percentage species composition of prawns in the Jaffna lagoon, computed from the cumulative catches during 1986 and 1987. *M. monoceros* with an average species composition of 62.7% is the dominant species in the Jaffna lagoon, followed by *P. semisulcatus* with 28.5%. The average contributions of *P. indicus*, *P. latisulcatus* and *P. monodon* to species composition were 4.8%, 2.4% and 1.5% respectively.

Table 2. Annual average percentage species composition of prawns in the Jaffna lagoon computed from cumulative catches of all the gears in 1989 and 1987. Ranges are within brackets.

Year	Average percentage species composition and range				
	P. monodon	*P. indicus*	*P. semisulcatus*	*P. latisulcatus*	*M. monoceros*
1986	1.46 (0.0–12.0)	2.22 (0.5–9.5)	33.15 (18 5–59.5)	2.05 (0.5–6.0)	61.12 (6 5–82.5)
1987	1.55 (0.0–8.21)	7.46 (0.25–24.0)	23.86 (9.93–38.34)	2.75 (0.58–12.30)	64.38 (37.25–89.0)
Annual average	1.51	4.84	28.50	2.40	62.75

In July 1986 and November 1987 the highest species composition for *M. monoceros* were recorded while in April 1986 and May 1987 the highest species composition for *P. semisulcatus* were recorded.

An examination of the hydrographic factors and the species composition (Fig. 1, 2, 3a and 3b) does not indicate any correlations.

The monthly fluctuation in abundance of these species indicates that all these are migratory species. This conforms to the observations of De Bruin (1971) from his study of fluctuations in species composition of penaeid prawns in estuaries in Sri Lanka.

Growth

In the present investigation length frequency data of *M. monoceros* and *P. semisulcatus* has been used to estimate age and growth from month to month modal progression analysis. The method is similar to that followed by Menon (1955), George (1959), Subramanyam and Ganapati (1975), Bishara (1976) and Ahmed (1981). This analysis could not be applied to the other three species due to insufficient length frequency data.

The modal sizes of *M. monoceros* for 1986 and 1987 are shown in Fig. 4. The smallest specimens (20 mm) appeared with very low frequency during April 1986 and February 1987. The majority have a total length between 40 mm and 80 mm in 1986 and between 43 mm and 84 mm in 1987.

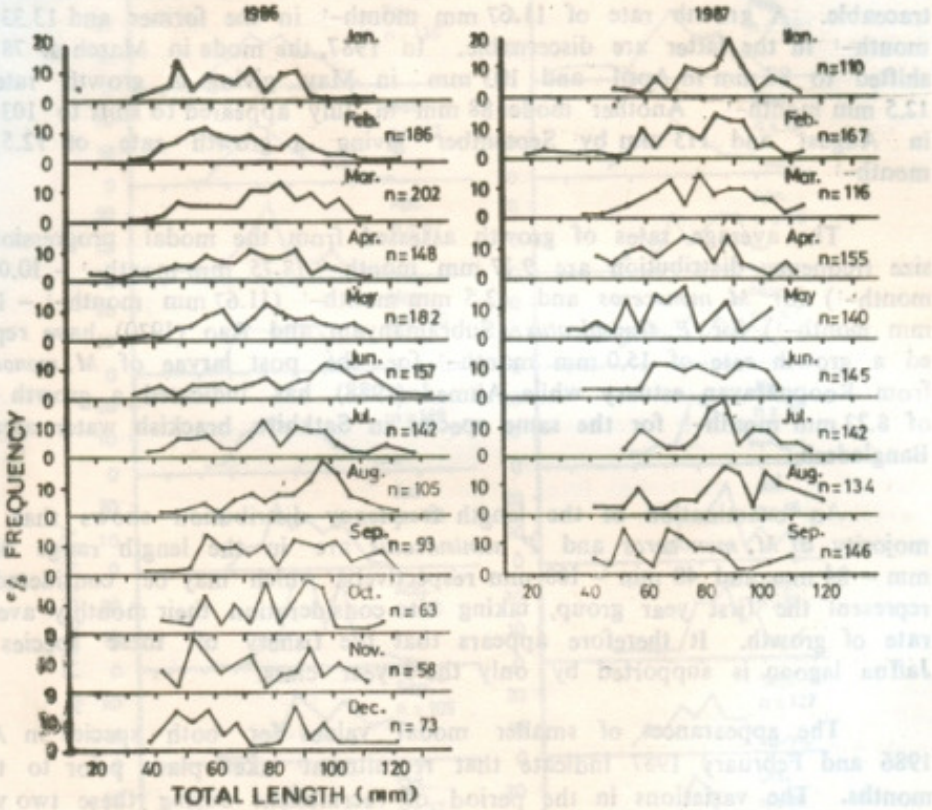

Fig. 4 Monthly length-frequency distributions of *M. monoceros* in the Jaffna lagoon during 1986 and 1987

In 1986 the modal shift started from 48 mm in January to 58 mm in February with a growth rate of 10 mm month^{-1}. Progression of modes from 48 mm in March to 68 mm in May and another from 53 mm in July to 88 mm in November could be traced: the former gives a growth rate of 10 mm month^{-1} and the latter 8.75 mm month^{-1}.

In 1987 the 53 mm mode in March appeared to shift to 88 mm in July giving a growth rate of 8.75 mm month^{-1}. The highest modal sizes of *M. monoceros* which appeared in the fishery were 93 mm in 1986 and 88 mm in 1987

The smallest specimens of *P. semisulcatus* (20 mm) appeared with very low frequency in April 1986 and February 1987. The majority have a total length between 48 mm and 104 mm in 1986 and between 53 mm and 108 mm in 1987 (Fig. 5). In 1986 progression of modes from 48 mm in January to 118 mm in July and from 58 mm in September to 98 mm in December are traceable. A growth rate of 11.67 mm month^{-1} in the former and 13.33 mm month^{-1} in the latter are discernable. In 1987, the mode in March at 78 mm shifted to 88 mm in April and 103 mm in May giving a growth rate of 12.5 mm month^{-1}. Another mode 88 mm in July appeared to shift to 103 mm in August and 113 mm by September giving a growth rate of 12.5 mm month^{-1}

The average rates of growth assessed from the modal progression in size frequency distribution are 9.17 mm month^{-1} (8.75 mm month^{-1} – 10.0 mm month^{-1}) for *M. monoceros* and 12.5 mm month^{-1} (11.67 mm month^{-1} – 13.33 mm month^{-1}) for *P. semisulcatus*. Subramanyam and Rao (1970) have reported a growth rate of 15.0 mm month^{-1} for the post larvae of *M. monoceros* from Roopnarayan estuary while Ahmed (1988) has indicated a growth rate of 8.22 mm month^{-1} for the same species in Satkhira brackish water area in Bangladesh.

An examination of the length frequency distribution shows that the mojority of *M. monoceros* and *P. semisulcatus* are in the length range of 40 mm – 84 mm and 48 mm – 108 mm respectively, which may be considered to represent the first year group, taking into consideration their monthly average rate of growth. It therefore appears that the fishery of these species in Jaffna lagoon is supported by only the 0–year class.

The appearances of smaller modal values for both species in April 1986 and February 1987 indicate that recruitment takes place prior to these months. The variations in the period of recruitment during these two years are apparently due to different intensities of rain (Fig. 1).

Sex – ratio and maximum total lengths

In 1986, both *M. monoceros* and *P. semisulcatus* showed a predominance of females during seven months (Table 3). *M. monoceros* showed a predominant female ratio throughout 1987 while *P. semisulcatus* showed female dominance during eight months (Table 4). Among other species *P. indicus* showed more female dominance both during 1986 and 1987. Subramanyam and Ganapati (1975) have also reported a female dominance in the Godavari estuarine system.

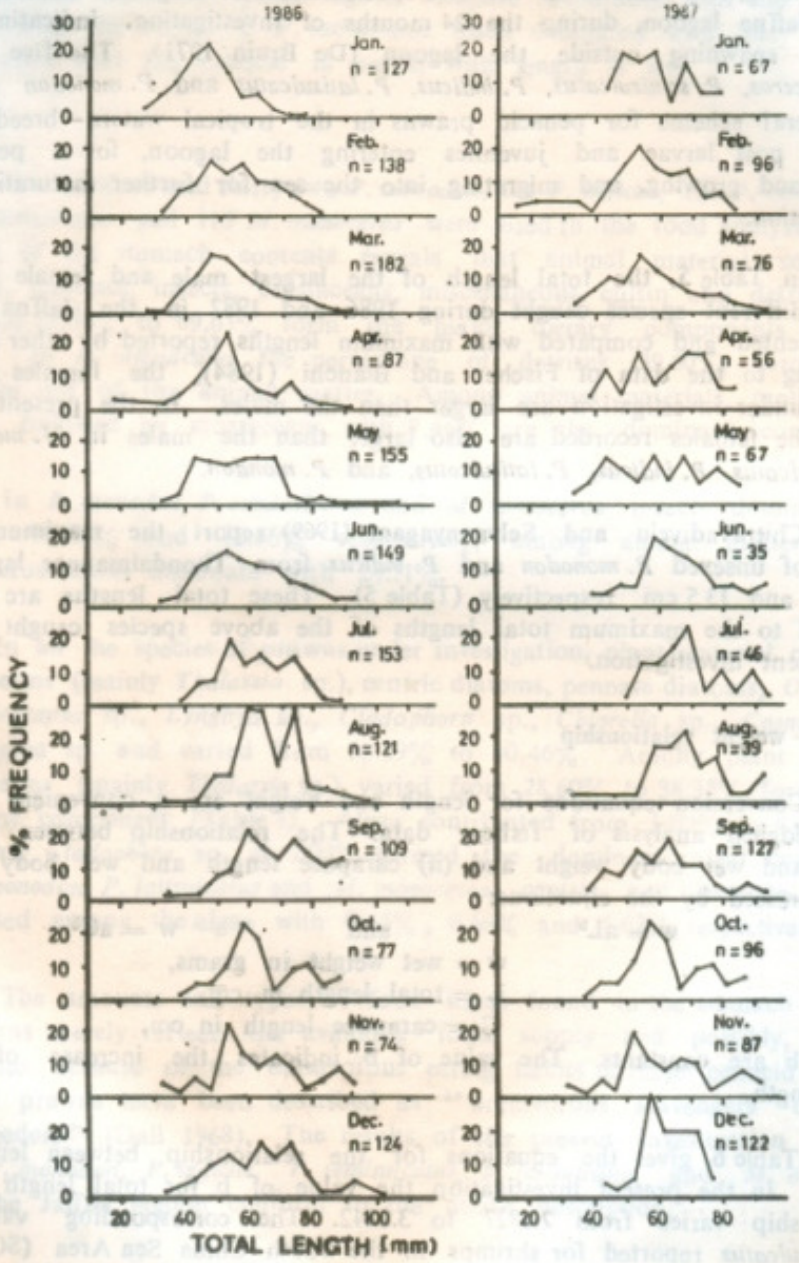

Fig. 5 Monthly length-frequency distributions of *P. semisulcatus* in the Jaffna lagoon during 1986 and 1987.

No gravid females of the five species under investigation were recorded in the Jaffna lagoon, during the 24 months of investigation, indicating that they are spawning outside the lagoon (De Bruin 1971). The five species *M. monoceros*, *P. semisulcatus*, *P. indicus*, *P. latisulcatus* and *P. monodon* fall in the general scheme for penaeid prawns in the tropical waters – breeding in the sea, post larvae and juveniles entering the lagoon, for a period of feeding and growing, and migrating into the sea for further maturation and reproduction.

In Table 5, the total length of the largest male and female prawns of the different species caught during 1986 and 1987 in the Jaffna lagoon are presented and compared with maximum lengths reported by other authors. According to the data of Fischer and Bianchi (1984), the females of the species under investigation are larger than the males. In the present investigation the females recorded are also larger than the males in *M. monoceros*, *P semisulcatus*, *P. indicus*, *P. latisulcatus*, and *P. mondon*.

Chitravadivelu and Selvanayagam (1969) report the maximum total length of unsexed *P. monodon* and *P. indicus* from Thondaimannar lagoon as 18.5 cm and 13.5 cm respectively (Table 5). These total lengths are almost identical to the maximum total lengths of the above species caught during the present investigation.

Length – weight relationship

Conversion equations for length and weight are a convenient tool in the biological analysis of fishery data. The relationship between (i) total length and wet body weight and (ii) carapace length and wet body weight are expressed by the equations:

$$w = aL^b \quad \text{and} \quad w = aC^b$$

where

w = wet weight in grams,
L = total length in cm,
C = carapace length in cm,

a and b are constants. The value of b indicates the increase of weight with length.

Table 6 gives the equations for the relationship between length and weight. In the present investigation the value of b for total length – weight relationship varies from 2.6827 to 3.0242. The corresponding values for *P. semisulcatus* reported for shrimps in the South China Sea Area (SCS/GEN/81/30, 81) ranges from 2.952 to 3.013 for male and 3.142 to 3.160 for female. In the case of *P. latisulcatus* the figures reported range from 3.001 to 3.057 in male and 3.063 to 3.136 in female. The b values of male and female

P. semisulcatus from the Jaffna lagoon compare favourably with the reported values while the values of *P. latisulcatus* when compared with the reported values show that the increase in weight with length is less.

Food

One hundred and thirty two *P. monodon*, 124 *P. indicus*, 126 *P. semisulcatus*, 107 *P. latisulcatus* and 113 *M. monoceros* were used in the food analysis. Food analysis of the stomach contents reveals that animal material comprising annelids, molluscs, insects, crustaceans, miscellaneous chitin and detritus varying from 59.54% to 69.63% form the major dietary components (Tables 1 and 7). In *P. latisulcatus* the percentage of detritus (39.60%) forms more than the rest of the animal matter. Among animal materials, molluscs with 11.40% followed by crustaceans with 7.46% are the dominant components.

In *P. monodon*, *P. semisulcatus* and *M. monoceros* insects dominate with 15.40%, 10.60% and 10.66% respectively, among animal matter. In *P. indicus* crustaceans dominate with 24.51%.

In all the species of prawns under investigation, plant material comprised angiosperms (mainly *Thalassia* sp.), centric diatoms, pennate diatoms, *Oscillatoria* sp., *Gleocapsa* sp., *Lyngbya* sp., *Cladophora* sp., *Chlorella* sp., *Cosmarium* sp. and *Padina* sp. and varied from 30.59% to 40.46%. Among plant material, angiosperms (mainly *Thalassia* sp.) varied from 28.60% to 38.35% forming the dominant component (Table 1). Algae contributed from 1.09% to 4.63%. In *P. indicus*, *Cladophora* sp. at 2.03% formed the dominant algal component. In *P. monodon*, *P. latisulcatus* and *M. monoceros*, centric and pennate diatoms dominated among the algae with 0.65%, 0.66% and 1.62% respectively.

The amounts and types of food items found in the stomach contents of prawns merely reflects the available food supply and possibly, biotype preference, because of the omnivorous eating habits of these penaeid prawns. Penaeid prawns have been described as "omnivorous scavengers" or "detritus feeders" (Dall 1968). The results of the present investigation indicate that *P. monodon*, *P. indicus*, *P. semisulcatus*, *P. latisulcatus* and *M. monoceros* from the Jaffna lagoon conform to the above description.

Table 3. Percentage of females in the cumulative catches during different months in 1986

Species	Percentage of females during different months												
	J	F	M	A	M	J	J	A	S	O	N	D	Average & range
P. monodon	18.5	50.0	59.2	28.0	29.6	00.0	66.7	00.0	—	100	—	40.0	39.2 (00.0–100)
P. indicus	46.0	46.7	55.0	34.0	36.7	100	52.5	62.0	45.3	100	50.0	52.4	56.7 (34.0–100)
P. semisulcatus	40.7	43.5	42.9	46.3	50.0	51.0	58.1	52.8	50.0	60.5	49.5	52.6	46.1 (40.7–60.5)
P. latisulcatus	25.0	54.2	42.0	71.4	48.5	—	53.0	42.4	49.0	51.8	50.0	47.6	48.6 (25.0–71.4)
M. monoceros	33.2	64.9	40.3	61.2	46.0	—	58.0	53.7	57.7	48.5	55.5	41.8	50.9 (33.2–61.2)

Table 4. Percentage of females in the cumulative catches during different months in 1987

Species	Percentage of females during different months												
	J	F	M	A	M	J	J	A	S	O	N	D	Average & range
P. monodon	83.8	37.5	00.0	69.0	44.4	27.3	—	—	—	95.0	52.0	—	51.1 (00.0–95.1)
P. indicus	60.4	51.1	48.6	54.0	42.6	100	—	100	100	90.6	42.6	57.5	67.9 (42.6–100)
P. semisulcatus	51.4	24.9	49.7	55.5	47.3	42.1	64.9	88.9	89.4	63.0	55.6	58.4	57.6 (24.9–89.4)
P. latisulcatus	11.4	47.5	38.9	66.7	44.4	50.0	81.3	45.0	88.9	53.0	50.2	47.3	52.1 (11.4–88.9)
M. monoceros	46.9	70.5	75.4	67.1	70.6	70.3	66.9	50.9	61.7	57.6	61.3	62.0	63.4 (46.9–75.4)

Table 5. Maximum total length of the different species caught in the Jaffna Lagoon during 1986 and 1987 compared with other data.

Species	Maximum total length in cm				
	Present investigation 1986 and 1987		Reported by Fischer and Bianchi (1984)		Reported by Chitravadivelu and Selvanayagam (1969)
	Male	Female	Male	Female	Unsexed
P. monodon	16.0	18.9	26.8	33.7	18.5
P. indicus	13.0	13.5	18.4	23.0	13.5
P. semisulcatus	13.8	17.8	18.0	23.0	—
P. latisulcatus	13.0	16.0	16.2	20.2	—
M. monoceros	10.2	10.5	15.0	20.0	—

Table 6. Length-weight relationship of the different species of Penaeid prawns from the Jaffna lagoon.

Species	Sex	Total length - weight relationship	Carapace length-weight relationship
P. monodon	M	$w=0.0084567\ L^{3.0058}$	$w=0.71973\ C^{2.9022}$
	F	$w=0.0083445\ L^{3.0078}$	$w=0.71080\ C^{2.8634}$
P. indicus	M	$w=0.0057597\ L^{3.0242}$	$w=0.84917\ C^{2.9202}$
	F	$w=0.0063285\ L^{2.9794}$	$w=0.87791\ C^{2.8213}$
P. semisulcatus	M	$w=0.0090740\ L^{2.9674}$	$w=0.89326\ C^{3.0125}$
	F	$w=0.0112050\ L^{2.8836}$	$w=1.02620\ C^{2.7501}$
P. latisulcatus	M	$w=0.0145310\ L^{2.7386}$	$w=0.68344\ C^{2.7758}$
	F	$w=0.0169940\ L^{2.6827}$	$w=0.85994\ C^{2.5303}$
M. monoceros	M	$w=0.0090469\ L^{2.9351}$	$w=0.83946\ C^{2.7002}$
	F	$w=0.0081470\ L^{3.0041}$	$w=0.76809\ C^{2.8908}$

w = weight in g L = total in cm C = carapace length in cm

Table 7. Percentage composition of the different food categories in the different species of Penaeid in the Jaffna lagoon during 1986 and 1987.

	% composition of food categoreis				
Plant material :					
Angiosperm	29.50	28.60	38.35	29.31	31.30
Algae	1.09	4.63	2.11	1.06	3.52
Animal material	45.40	42.47	29.94	30.03	32.94
Detritus	24.01	24.30	29.60	39.60	32.24
Total	100.00	100.00	100.00	100.00	100.00

Acknowledgements

The financial assistance provided by the Natural Resources, Energy and Science Authority of Sri Lanka on Research grant No. RG/86/B/01 is acknowledged with thanks. Particular thanks are due to the Technical Assistants Mr. G. Illangovan and Mr. S. A. Gladstone for their helpful assistance in the field and laboratory.

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Received for publication October 1992