

OBSERVATIONS ON GROWTH AND MOULTING OF SPINY LOBSTERS
PANULIRUS HOMARUS (LINNAEUS), *P. ORNATUS* (FABRICIUS)
AND *P. PENICILLATUS* (OLIVIER) IN CAPTIVITY

R. V. NAIR, R. SOUNDARARAJAN AND G. NANDAKUMAR

Central Marine Fisheries Research Institute Regional Centre, Mandapam Camp.

ABSTRACT

The growth and moulting of three species of *Panulirus*, namely *Panulirus homarus* (Linnaeus), *Panulirus ornatus* (Fabricius) and *Panulirus penicillatus* (Olivier) in captivity have been studied. The average growth increment per moult was 2.3-3.4 mm carapace length (6.9-9.6 mm total length) for male and 2.3-3.0 mm C.L. (6.5-9.1 mm T.L.) for female *P. homarus*, 2.7 mm C.L. (11.3 mm T.L.) for male and 3.3-4.4 mm C.L. (11.8-13.8 mm T.L.) for female *P. ornatus* and 1.5 mm C.L. (5.5 mm T.L.) for male *P. penicillatus*. The growth rate has been found to be higher in younger individuals than in older ones. *P. homarus* moulted eight times in about fifteen months, *P. ornatus* moulted seven times and *P. penicillatus* six times in about twentyone months. An instance of breeding in captivity in *P. homarus* is reported. The prospects for culturing lobsters in Mandapam area are indicated.

INTRODUCTION

Six species of spiny lobsters of the genus *Panulirus*, namely, *P. homarus* (Linnaeus), *P. ornatus* (Fabricius), *P. versicolor* (Latreille), *P. longipes longipes* (A Milne Edwards), *P. penicillatus* (Olivier) and *P. polyphagus* (Herbst) occur in Gulf of Mannar. The diagnostic characters of the above species and the lobster fishery around Mandapam region have been dealt with in detail by Nair et al (1973). Only a few studies have been made on the growth and moulting of the spiny lobsters of the Indian region, and that too on *P. homarus* only. George (1965) studied the growth rate of *P. homarus* based on the length-frequency method. Mohamed and George (1968) conducted tagging experiments on *P. homarus* and estimated the growth rate in successive years. Thomas (1972) studied the growth in relation to moulting of *P. homarus* in captivity. Recently, Kathirvel (1973) reported the growth and regeneration of a juvenile specimen of *P. polyphagus*. Kinoshita (1933) and Nakamura (1940) studied the moulting and growth of *P. japonicus*. The rate of growth of *P. argus* was investigated by Marshall (1948), Dawson and Idyll (1951) and Travis (1954). Lindberg (1955) and Bakus (1960) estimated the rate of growth of *P. interruptus*. Sheard (1962) investigated growth of *P. longipes*. Berry (1971)

studied growth and moulting of *P. homarus*. In the present work, *P. homarus*, *P. ornatus* and *P. penicillatus* were collected from Gulf of Mannar and reared in captivity. The results obtained on the growth rate and moulting frequency of the above species and spawning of *P. homarus* in captivity are dealt with in this paper.

MATERIAL AND METHODS

Live specimens of *P. homarus* with carapace lengths (C.L.) ranging from 29 mm to 65 mm were collected by handpicking from the near-shore rocky shelters of Gulf of Mannar at Seeniappa Dharga, near Mandapam Camp. These were reared in rectangular glass aquaria (1.22 X 0.61 X 0.45 m) where a constant circulation of sea water was maintained. Eventhough initially about 65 specimens were stocked, continuous observations could be made only on 12 specimens, 5 males (initial C.L. ranging from 45 mm to 56 mm) and 7 females (initial C.L. ranging from 33 mm to 57 mm). Seven live specimens of *P. ornatus*, consisting of two males (C.L. 32 mm to 48 mm) and rest females (C.L. 39 mm to 70 mm), were collected from trawl net catches off Mandapam in Gulf of Mannar. One of the females (C.L. 68 mm) was kept in a circular cement tank of 1.56 m diameter and 1.11 m depth in which circulating sea water was maintained at a constant depth of 0.75 m. The other six specimens were introduced in a rectangular glass aquarium. Two specimens of *P. penicillatus* (one male of C.L. 86 mm; one female of C.L. 99 mm), caught in a bottom-set gill net operated in Gulf of Mannar at a depth of about 18 metres off Vedalai near Mandapam Camp, were also introduced in the same cement tank where one female *P. ornatus* was kept.

The average temperature of sea water in different months fluctuated between 26°C and 32°C and the average salinity between 29 ‰ and 35 ‰. First the lobsters were marked with dart tags but the tags did not remain permanently, mainly due to damages caused by the fellow members. Therefore markings were made by punching in the soft parts of telson. These punchings were made in different patterns so that the specimens could be easily distinguished from one another. The advantage of punching is that these markings remain through successive moults. The lobsters were fed on clam meat (*Donax cuneatus* and *D. faba*) and chopped fish (*Sardinella* spp., *Leiognathus* spp., *Therapon* spp., *Upeneus* spp., sciaenids, etc.). The clam meat and chopped fish were supplied in excess quantity in the morning and the leftover was removed in the afternoon. The carapace length (C.L.) and total length (T.L.) were measured and recorded soon after each moulting and when the exoskeleton hardened. The carapace length was measured from the anterior margin of the base of postorbital spines to the posterior margin of carapace and the total length was measured from the former to the tip of telson.

OBSERVATIONS

The details of the observations are given in Table 1. The sizes of lobsters on their first moulting in the aquarium with intermoult periods are shown in Table 2 and the species-wise growth rate has been worked out based on these particulars.

Panulirus homarus

The initial sizes of five males ranged from 45 mm to 56 mm C.L. (122-150 mm T.L.) and of seven females from 33 mm to 57 mm C.L. (86-160 mm T.L.). The males survived for periods ranging from 212 to 445 days and females from 68 to 553 days. The final size ranges of males and females were 57-72 mm C.L. (163-198 mm T.L.) and 44-74 mm C.L. (126-208 mm T.L.). A male, 45 mm C.L. (122 mm T.L.) gained 24 mm C.L. (69 mm T.L.) in 445 days, after undergoing seven moults. One male of 56 mm C.L. (150 mm T.L.) lived for 415 days during which period it moulted seven times and registered a growth of 16 mm (48 mm T.L.). Another male with 50 mm C.L. (130 mm T.L.) lived for 212 days, moulted thrice and showed a growth of 7 mm (25 mm T.L.). For males in the size range 45-72 mm C.L. (120-198 mm T.L.) the estimated average growth rate was 1.41 mm (4.43 mm T.L.) per month. One female 33 mm C.L. (86 mm T.L.) moulted six times in 245 days showing a growth increment of 14 mm (48 mm T.L.). Another female 57 mm C.L. (160 mm T.L.) lived only 68 days and had a growth increment of 5 mm (13 mm T.L.) undergoing two moults. A 54 mm female (150 mm T.L.) survived 553 days, moulted eight times and showed a growth increment of 20 mm (58 mm T.L.). The average rate of growth for females with a size range of 33-74 mm C.L. (80-200 mm T.L.) was 1.37 mm (4.07 mm T.L.) per month.

With regard to growth increments between successive moults, it has been observed that in different individuals they varied from 2 mm to 4 mm C.L. (6 mm to 11 mm T.L.) for males and from 1 mm to 5 mm C.L. (5 mm to 12 mm T.L.) for females (Table 2). The average growth rate per moult for individual males ranged from 2.3 to 3.4 mm C.L. (6.9 mm to 9.6 mm T.L.) with an overall average of 2.7 mm (8.2 mm T.L.) per moult and that of females from 2.3 mm to 3.0 mm C.L. (6.5 mm to 9.1 mm T.L.) with an overall average of 2.6 mm (7.9 mm T.L.).

For different size groups the results obtained with regard to mean increase in C.L. per moult and mean percentage of increment in C.L. per moult are:

Carapace length in mm	Male		Female	
	Mean increase in C.L. per moult (mm)	Mean %-age increment in C.L. per moult	Mean increase in C.L. per moult (mm)	Mean %-age increment in C.L. per moult
30-39	—	—	2.3	6.6
40-49	3.5	7.5	2.5	5.6
50-59	3.1	5.6	3.0	5.4
60-69	2.9	4.6	2.3	3.7

TABLE 1. *Particulars of growth in relation to moulting of spiny lobsters, Panulirus homarus, Panulirus ornatus and Panulirus penicillatus.*

Sl. No.	Sex	No. of days in captivity	Initial length in mm		Final length in mm		Increase in length in mm		No. of Moults	Average growth rate per moult in mm		
			C.L.	T.L.	C.L.	T.L.	C.L.	T.L.		C.L.	T.L.	
<i>P. homarus</i>												
1	Male	445	45.0	122.0	69.0	189.0	24.0	69.0	7	3.4	9.6	
2	"	369	53.0	138.0	69.0	190.0	16.0	52.0	6	2.6	8.7	
3	"	415	56.0	150.0	72.0	198.0	16.0	48.0	7	2.3	6.9	
4	"	243	50.0	141.0	65.0	178.0	15.0	37.0	5	3.0	7.4	
5	"	212	50.0	138.0	57.0	163.0	7.0	25.0	3	2.3	8.3	
6	Female	415	43.0	118.0	63.0	182.0	20.0	64.0	7	2.8	9.1	
7	"	553	54.0	150.0	74.0	208.0	20.0	58.0	8	2.5	7.3	
8	"	243	50.0	145.0	62.0	180.0	12.0	35.0	4	3.0	8.8	
9	"	68	57.0	160.0	62.0	173.0	5.0	13.0	2	2.5	6.5	
10	"	159	35.0	96.0	44.0	126.0	9.0	30.0	4	2.3	7.5	
11	"	182	40.0	108.0	51.0	141.0	11.0	33.0	4	2.8	8.3	
12	"	245	33.0	86.0	47.0	134.0	14.0	48.0	6	2.3	8.0	
<i>P. ornatus</i>												
1	Male	119	32.0	84.0	40.0	118.0	8.0	34.0	3	2.7	11.3	
2	Female	659	68.0	181.0	93.0	264.0	25.0	83.0	7	3.6	11.8	
3	"	344	70.0	189.0	83.0	237.0	13.0	48.0	4	3.3	12.0	
4	"	291	46.0	126.0	68.0	195.0	22.0	69.0	5	4.4	13.8	
5	"	188	39.0	102.0	53.0	152.0	14.0	50.0	4	3.5	12.5	
<i>P. penicillatus</i>												
1	Male	694	86.0	207.0	95.0	240.0	9.0	33.0	6	1.5	5.5	
2	Female	198	99.0	253.0	100.0	258.0	1.0	5.0	1	1.0	5.0	

TABLE 2. Dates of moulting, duration of intermoult period in days and sizes at successive moults in mm (given in paranthesis) in *P. homarus*, *P. ornatus* and *P. penicillatus*.

	Progressive moults							
	1	2	3	4	5	6	7	8
<i>P. homarus</i>								
Male	26.2.73 (48.0)	23.4.73 56.(52.0)	27.7.73 97(54.0)	6.9.73 41(58.0)	24.10.73 48(62.0)	7.1.74 75(66.0)	19.3.74 71(69.0)	
"	21.4.73 (56.0)	22.6.73 62(58.0)	4.8.73 43(61.0)	20.9.73 47(64.0)	15.11.73 55(67.0)	10.2.74 87(70.0)	8.4.74 57(72.0)	
"	7.5.73 (55.0)	13.7.73 67(58.0)	25.8.73 43(61.0)	18.10.73 54(65.0)	22.12.73 65(67.0)	26.2.74 66(69.0)		
"	26.8.73 (53.0)	18.10.73 53(57.0)	12.12.73 53(60.0)	28.1.74 47(62.0)	18.3.74 49(65.0)			
"	9.4.73 (53.0)	4.6.73 56(55.0)	2.8.73 59(57.0)					
Female	25.11.72 (56.0)	6.2.73 73(58.0)	3.4.73 56(61.0)	26.6.73 84(62.0)	12.8.73 47(65.0)	4.10.73 53(67.0)	14.12.73 71(70.0)	27.2.74 77(74.0)
"	6.4.73 (45.0)	10.6.73 65(47.0)	23.7.73 43(49.0)	3.9.73 42(52.0)	21.10.73 48(55.0)	28.12.73 68(60.0)	27.2.74 61(63.0)	
"	11.10.72 (35.0)	22.12.72 42(37.0)	6.1.73 45(40.0)	15.2.73 40(43.0)	15.2.73 37(45.0)	24.3.73 47(47.0)	10.5.73	
"	16.10.72 (43.0)	27.12.72 72(46.0)	26.2.73 61(48.0)	13.4.73 46(51.0)				
"	19.11.72 (37.0)	3.1.73 45(40.0)	15.2.73 43(42.0)	27.3.73 40(44.0)				
"	26.8.73 (54.0)	15.10.73 51(57.0)	9.1.74 85(59.0)	14.3.74 64(62.0)				
<i>P. ornatus</i>								
Male	6.11.73 (35.0)	31.12.73 55(38.0)	19.2.74 50(40.0)					
Female	9.2.73 (70.0)	30.4.73 80(72.0)	16.8.73 108(75.0)	17.12.73 123(81.0)	26.4.74 130(85.0)	29.7.74 94(89.0)	29.11.74 123(93.0)	
"	13.7.73 (49.0)	23.8.73 41(52.0)	15.10.73 52(56.0)	22.12.73 68(63.0)	18.3.74 85(68.0)			
"	14.10.72 (43.0)	6.12.72 53(47.0)	5.2.73 60(51.0)	11.5.73 65(53.0)				
"	18.5.73 (72.0)	4.9.73 108(74.0)	16.12.73 103(79.0)	27.3.74 101(83.0)				
<i>P. penicillatus</i>								
Male	19.2.73 (89.0)	23.6.73 124(90.0)	24.10.73 123(92.0)	30.3.74 157(93.0)	6.7.74 98(94.0)	7.11.74 124(95.0)		

It may be seen that in males the mean increment and mean percentage growth in C.L. per moult progressively decreased as the size increased, but in females, the progressive decrease is only in the mean percentage growth per moult in C.L. The growth of the different individuals of *P. homarus* at successive moults is illustrated Fig. 1.

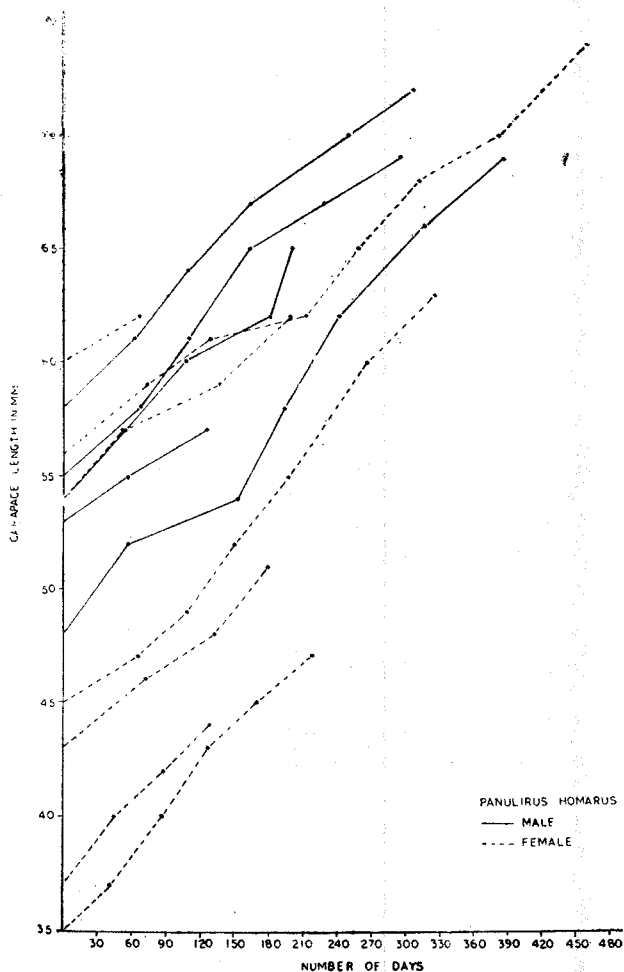


FIG. 1. The growth of males and females of *Panulirus homarus* at successive moults in carapace length in captivity.

Panulirus ornatus

Out of two males and five females, one male and one female died before moulting. The other male 32 mm C.L. (84 mm T.L.) lived 119 days and attained a size of 40 mm (118 mm T.L.). The average growth rate per month was 1.43 mm (5.14 mm T.L.) after three moults. (Table 2). The females lived

for periods varying from 188 to 659 days. The initial sizes of four females ranged from 39 mm to 70 mm C.L. (102 mm to 189 mm T.L.). A 39 mm female (102 mm T.L.) lived 188 days, moulted four times and showed a growth of 14 mm C.L. (50 mm T.L.) Another female 68 mm C.L. (181 mm T.L.) had a growth of 25 mm (83 mm T.L.), undergoing seven moults in 659 days. The estimated average growth rate per month was 1.53 mm (4.27 mm T.L.). The growth increment between successive moults in male varied between 2 mm and 3 mm (10 mm and 13 mm T.L.) with an average of 2.7 mm (11.3 mm T.L.) per moult. In females the growth increments between successive moults in different specimens varied between 2 mm and 7 mm (6 mm and 19 mm T.L.) and their average growth rates between 3.3 mm and 4.4 mm (11.8 mm and 13.8 mm T.L.) with an overall average of 3.7 mm (12.5 mm T.L.) per moult. The average percentage increment in C.L. per moult was 6.7 in male and it varied between 4.7 and 8.0 in females. The growth of different individuals of *P. ornatus* at successive moults is shown in Fig. 2.

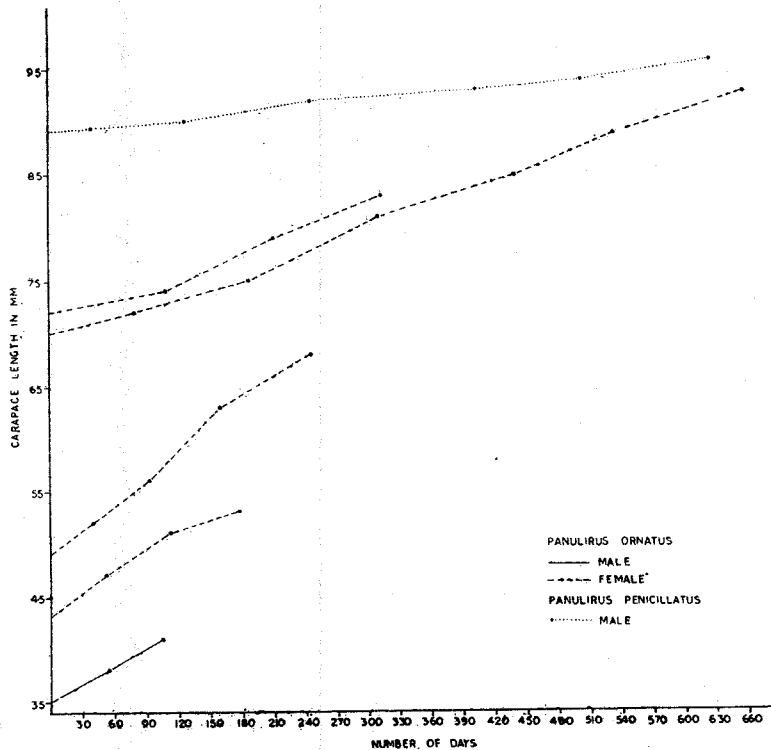


FIG. 2. The growth of male and females of *Panulirus ornatus* and male of *Panulirus penicillatus* in carapace length in captivity.

Panulirus penicillatus

The male with initial size of 86 mm C.L. (207 mm T.L.) moulted six times in 626 days and reached a size of 95 mm C.L. (240 mm T.L.) with an average growth rate of 0.29 mm C.L. (0.72 mm T.L.) per month (Table 2). The female having initial size of 99 mm C.L. (253 mm T.L.) lived for only 198 days and moulted only once, attaining postmoult size of 100 mm C.L. (258 mm T.L.). The growth increments of the male at successive moults were 1 mm to 2 mm C.L. (4 mm to 8 mm T.L.) and the average growth per moult was 1.5 mm C.L. (5.5 mm T.L.). The growth of *P. penicillatus* at successive moults is represented in Fig. 2.

OBSERVATIONS ON MOULTING

Moultings occurred mostly during nights and occasionally during day time. The lobsters about to be moulted could be detected by the softened branchiostegal region and the appearance of ecdysial line along the branchiostegites from about two days prior to moulting. The process of moulting has been described in detail by Travis (1954) in *P. argus* and by Berry (1917) in *P. homarus*.

Moulting in *P. homarus*, which were left in glass aquaria, was found to take place only during nights. Smaller individuals appear to moult more frequently than the larger ones. The period between moulting increases as the size of the lobster increases. For juvenile males these periods ranged between 41 to 97 days with an average of 57 days and for adult males 47 to 87 days, with an average of 61 days. Similarly, for females the intermoult periods ranged between 37 to 72 days in juveniles and between 47-85 days in adults with averages of 48 days and 65 days respectively. In the months of July to October and sometimes in February-March the intermoult periods were shorter than in other months, especially in females (Table 2).

While the individuals of *P. ornatus* reared in glass aquarium tanks moulted during night, the one that was reared in concrete tank along with *P. penicillatus* moulted both during night and day. As the size of the animals increased the moulting frequency decreased. A male 32 mm in C.L. moulted three times in 119 days. Two females 39 mm and 46 mm C.L. moulted four and five times, the former in 188 days and the latter in 291 days. So it is estimated that the individuals in the size range 32 to 46 mm C.L. would moult 7 to 8 times in a year. With further increase in size, moulting frequency decreased; the specimens of the size above 68 mm C.L. moulted only four times a year. For the smaller-sized lobsters (about 30 to 60 mm C.L.) the intermoult period ranged between 41 to 65 days and as they grow the intermoult period gradually extended even up to 130 days (Table 2).

Of *P. penicillatus*, the moulting cycle, for over an year, could be observed only for the male with the initial size of 86 mm C.L. It moulted 6 times in 626

days, four times in the first year of its captivity. Just like the female *P. ornatus* reared along with this male in the cement tank, it moulted both by day and night. The intermoult period varied between 98 and 157 days. The female *P. penicillatus* (99 mm C.L.) moulted in 79 days after release in aquarium and died after another 119 days without further moulting.

The male *P. penicillatus* moulted in 68 days after the date of its capture. For the second and third moults it took 124 and 123 days respectively. The fourth moult occurred after 157 days. However, it took only 98 days for the fifth moult thus compensating the excess time taken for the fourth moult. The intermoult period between fifth and sixth moults was again 124 days (Table 2). In female *P. ornatus* (70 mm C.L.) reared along with the above male *P. penicillatus* the duration of the intermoult periods gradually increased from 80 days to 130 days from the second to fifth moults and suddenly declined to 94 days for the sixth moult. The intermoult period again increased to 123 days for the seventh moult. It is of interest to note that the sudden decline in the intermoult period for both the cases was observed between April and July.

Light seems to play a role in the moulting behaviour. The specimens reared in the glass tanks moulted only during nights while those kept in concrete tank, which was deeper allowing lesser penetration of light, moulted either in the night or in the day time.

BREEDING IN CAPTIVITY

One female of *P. homarus*, 57 mm C.L. which was reared along with three males became berried on December 1, 1973. The largest male, 67 mm C.L. was found to be aggressive, and it was courting the female since a week prior to the berrying of the female. The actual mating however, could not be observed. The berried female was removed and reared in a separate glass aquarium. It shed all the eggs in the early morning of December 8, 1973.

DISCUSSION

The present study has shown that in *Panulirus homarus* and *Panulirus ornatus* the growth is faster in younger individuals than in the older ones. Similar observations have been made by Mohamed and George (1968), Berry (1971) and Thomas (1972) in *P. homarus*, Kinoshita (1933) and Nakamura (1940) in *P. japonicus*, Travis (1954) in *P. argus* and Chittleborough (1974) in *P. longipes cygnus*.

In *P. homarus*, Berry (1971) recorded average increase of 2.2 mm to 3.6 mm C.L. per moult under captivity in the specimens of the size range 40 mm to 75 mm. This is in close agreement with present observations in *P. homarus* in which the average growth increase per moult has been found to be from 2.3 mm to 3.5 mm for the specimens of the same size range. However, Thomas (1972) reported a higher rate of growth increment per moult in the same species, namely 4 mm to 9 mm for the size range of 33 mm to 71 mm. The average

growth increment per moult in *P. homarus* found in the present studied is comparable to those obtained by Travis (1954) in *P. argus* (2.6 mm to 3.6 mm), Chittleborough (1967) in *P. cygnus* (3.7 mm) and Kathirvel (1973) in *P. polyphagus* (2.5 mm). The average growth increment per moult in *P. ornatus* has been found to vary between 2.7 mm and 4.4 mm in the specimens of size range 32 mm to 89 mm which is slightly higher than those of the former species. The average growth increase per moult was 1.0 mm to 1.5 mm in 81-100 mm *P. penicillatus* and this lower rate may probably be due to its larger size.

In *P. homarus* and *P. ornatus* the intermoult periods have been found to be shorter in younger individuals than in older ones. The average number of moultings per year decreased as the size increased and these findings are in agreement with those of Berry (1971) in *P. homarus*, Travis (1954) in *P. argus* and Chittleborough (1974) in *P. longipes cygnus*. Berry (1971) has noticed in *P. homarus* a slight increase in the length of intermoult periods during the winter months as compared to other months of the year. Travis (1954) made a similar observation in *P. argus*. But in the present studies the lengths of intermoult periods in *P. homarus* have been found to increase in summer months as well as in winter months. Similar trends in the intermoult periods have not been observed in *P. ornatus* and *P. penicillatus*.

In the present case, a female *P. homarus* became berried in captivity when it was 57 mm C.L. De Bruin (1962) and Berry (1971) stated that the males and females of *P. homarus* attained first maturity at a size range of 50-59 mm C.L. therefore, the spawning of the female has taken place immediately after its attaining first maturity. Further, the spawning has been found to synchronise with the lengthy intermoult period from November to January which has been reported as a peak breeding season for the species by de Bruin (1962), George (1965) and Berry (1971).

Young ones of *P. homarus* (average 30 mm C.L.) are abundant in near-shore rocky shelters in Gulf of Mannar and these could be easily captured and utilised for culture purposes. As the rate of growth is rapid in young lobsters it may be possible to rear them to marketable size in about one-and-half years. Cannibalism has not been noticed in this species and therefore the species is favourable for culture practices. The lobsters seem to thrive well on trash fishes and bivalve molluscs which are abundant in Mandapam area. The lobster fishery in Gulf of Mannar is restricted to a particular season, October-March (Nair et al 1973) and through culture it will be possible to maintain a steady supply of lobsters to meet the demands even during the offseason.

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