

STUDIES ON BREEDING BIOLOGY OF *PANULIRUS HOMARUS* (LINNAEUS, 1758) THOOTHUKUDI, SOUTHEASTERN COAST OF INDIA

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ABSTRACT : Berried lobsters collected from Thoothukudi fish landing centers and lobster holding centers at Thoothukudi coast were used for studying the breeding biology of scalloped spiny lobsters, *Panulirus homarus* (Linnaeus, 1758). Round the year spawning season was observed with the major peak occurs in the month of December to March. Fecundity of the lobsters was calculated as the number of eggs deposited on the ovigerous setae on the pleopods. The number of eggs in a single brood in *P. homarus* (carapace length: 47- 94 mm; weight 156.75 - 900g) ranged from 95,530 to 480,590. The fecundity- carapace length relationship estimated was $F = 7.8405 CL - 283.827$ and the carapace length and egg mass weight relationship was $0.8969 CL - 31.5772$. The length at minimum maturity was 53 mm CL. There is no significant deviation in the sex ratio.

Key words: *Panulirus homarus* – fecundity - breeding season- length at first maturity-conservation.

INTRODUCTION

Crustaceans in general and spiny lobsters in particular are highly esteemed seafood delicacies. Of the nine species of spiny lobsters distributed along the Indian coast, only four species viz *Panulirus homarus*, *P. ornatus*, *P. versicolor* and *Pureulus sewelli* form sizable fishery in the Southeast coast of India (Radhakrishnan, 1995). The scalloped spiny lobster, *Panulirus homarus* (Linnaeus) is a medium tropical lobster occurring through out the South Africa, Red Sea, Southern Coast of Arabia, India and East Indies. They are represented in the shallow reef areas and rocky coasts of Gujarat, Maharashtra, Kerala and Tamilnadu. Except from past account of George (1967) on *P. homarus*, there has been only scattered information on reproductive biology of this species in Indian waters. Available literature indicates that the study on reproductive biology in spiny lobsters has been given less importance in Indian waters (Kagwadi, 1988 a & b). Studies were found only in South Africa (Berry, 1971), South Sri Lanka (Jayakody, 1994) and Sultanate of Oman (Mohan, 1997). Despite the importance of the *P. homarus* fisheries in the southeast and southwest coast of India, there have been no published detailed reports on the reproductive biology, estimates of the size at maturity and specific fecundity from Indian waters. In the present study the key reproductive biological features like size at onset of maturity, fecundity, sex ratio and spawning season of the scalloped spiny lobster population has been carried out at Thoothukudi Coast of Gulf of Mannar, India.

MATERIALS AND METHODS

Length frequency and catch effort data were collected for scalloped spiny lobsters from May 2004 to April 2006 from the Thoothukudi landing centre. Lobsters carapace length (CL) was measured (nearest to 1mm) along the mid-dorsal line from the posterior edge of the carapace to the antennae end between the postorbital spines. The weight was measured nearest to 5g using a digital balance.

Carapace length of the lobsters measured during the study period ranged from 7 mm CL to 104 mm CL. Twenty-two berried specimens of *P. homarus* measuring from 47 mm to 94 mm CL were utilized to estimate brood size. The lobsters were distinguished and segregated sex wise. Males are identified based on uniramous pleopods and have only endopodites. The gonopores are found in the base of the fifth leg. In females pleopods are biramous and ovigerous setae are reported for carrying eggs, Chi-square analysis was employed with the formula $\chi^2 = \sum (O_i^2 - E_i^2) / n$ to test the homogeneity in the population of males and females, where O is the observed frequency, E is the expected frequency and n is the total number of observation. Breeding periods is defined by the seasonal or monthly presence of berried females and the presence and state of spermatophores in the male.

In the present study, to define the maturity stages in females several characters namely ovarian development, the presence of external eggs, endopodite processes of pleopods bearing ovigerous setae, sperm within seminal receptacles or spermatophore (tar spot) and the

morphometry of the abdomen, legs or pleopod exopodite (Krouse, 1973; Plaut, 1993; Hobday and Ryan 1997; Minagawa and Sano, 1997) were taken. Presently animals with ovigerous setae on the endopodites are taken as mature individuals. Based on this criterion, size at onset of maturity in spiny lobster is ascertained (Booth, 1984; Cockcroft and Goosen, 1995; Hobday and Ryan, 1997). Further the size at first maturity is estimated from the incidence of mated but not berried and berried females adopted by majority of the authors working with *Panulirus* sp (Gregory *et al*, 1982, Mac Donald, 1982, Junio, 1987; Cavalcante Soares, 1990).

Brood size- carapace length relationship has been investigated. The fecundity of the lobster was estimated by gravimetric method. For this study, fecundity is defined as the number of external eggs carried on the tail of the female. Three sub samples weighing 0.1 g were manually counted under a magnifying lens. The average number of eggs in the 3 sub samples was then multiplied by the total weight of the egg mass to obtain the total number of eggs for a particular individual. (Macfarlane and Moore, 1986; Briones- Fourzan and Gonterazs-Ortiz, 1999). The fecundity-carapace length (CL) relationship is described by a linear function of the form

$$F = a + b CL$$

Where F is fecundity and *a* and *b* are parameters of the linear relationship. Likewise egg mass and carapace length relationship is also calculated.

RESULTS

Seasonal reproductive pattern

The seasonality of breeding was investigated both by examining the berried female and by determining presence of ovigerous setae and the occurrence of inseminated female. The percentage of matured females occurrence is given in the Table. 1. Berried females recorded through out the year and the matured females occurred up to 23.84% of the female population during the month of March. During November to April most animals were with ovigerous setae. Matured female of *P. homarus* with ovigerous setae were recorded more in the month of February and March. This indicates the animal spawn through out the year with the peak reproductive activity during November to March. Berried lobsters of larger size were collected at a depth of more than 40m.

Sex ratio

The sex ratio of *P. homarus* is given in the Table. 1. Female were reported higher during the month of February and December where as male were dominating in the month of May, June and November. It was evident

that the expected 1: 1 sex ratio was observed in all the months of the study period based on chi-square values (Table. 1). The disparity between sexes was least in the month of April and higher in the month of May.

Length at first maturity

The presence of ovigerous setae, tar spot and eggs is taken as indicator of female maturity. The length at first maturity was given in the Fig. 1. The smallest animal mature at the length of 47 mm CL and the largest animal that mature was 94 mm CL.

Fecundity

The fecundity of *Panulirus homarus* was estimated for 22 mature specimen with a size range of 47 to 94 mm CL. The observed fecundity varied between 95,530 at 47 mm CL and 480,590 at 94 mm CL. The relationship between carapace length and fecundity was $F = 7.8405 CL - 283.827 \times 10^3$. Regression analysis indicated that there was a significant relationship between egg number and CL ($r^2 = 0.9336$) (Fig. 2). The study revealed that the number of ova increased with increase in carapace length of lobster. The smallest egg-bearing female recorded was 47 mm CL. The larger females were highly fecund than the smaller ones.

Egg mass weight varied between 9.52 and 50.21g. A definite positive correlation was also evident between the CL and the egg mass weight with the linear equation $E W (\text{Egg weight}) = 0.8969 CL - 31.5772$ (Fig. 3) showing a high degree of correlation.

DISCUSSION

Seasonal reproductive pattern

Berried and matured *P. homarus* were recorded through out the year. Kagwade (1988) observed that *P. polyphagus* spawned through out the year in the east coast of India with heavy impregnated and ovigerous females (nearly 23.7%). George (1965) observed the year round spawning of *P. homarus* with a peak-breeding season of November to December. Heydron (1969) indicated that the peak spawning season for this species was January in Sri Lankan waters where as Jayakodi, 1994 observed the peak breeding in between August and January. Presently berried animals were found through out the year but with two peaks one during March and another during December to February. The availability of ovigerous females through out the year indicated the *P. homarus* are continuous spawners. The extended reproductive period indicates that multiple spawning occur in these species as indicated in the earlier study in *P. homarus* by George (1967) and Berry (1971).

The percentage of the mature females increased with

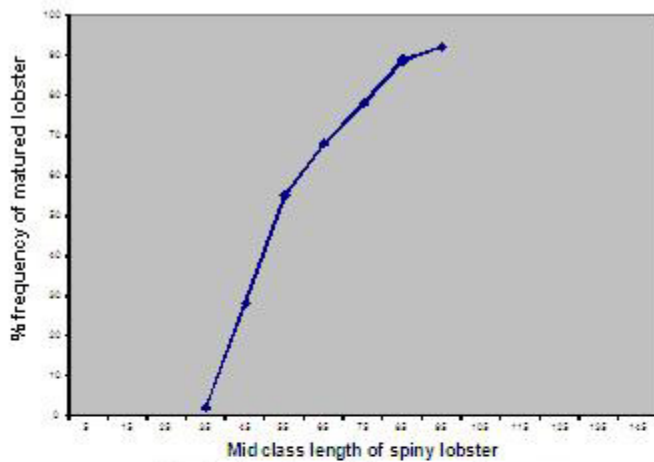


Fig. 1 : Length at minimum maturity.

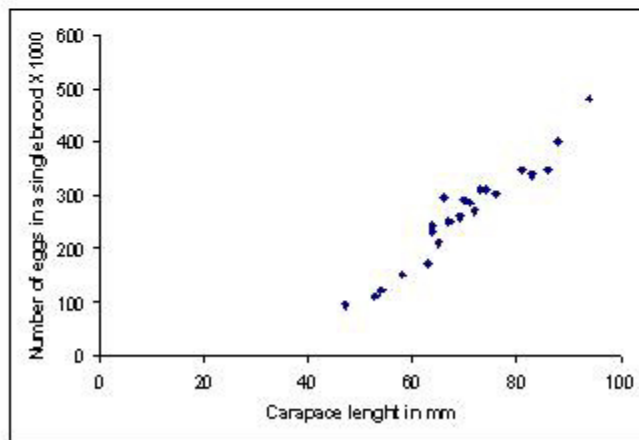


Fig. 2 : Relationship between carapace length and egg numbers in *P. homarus*.

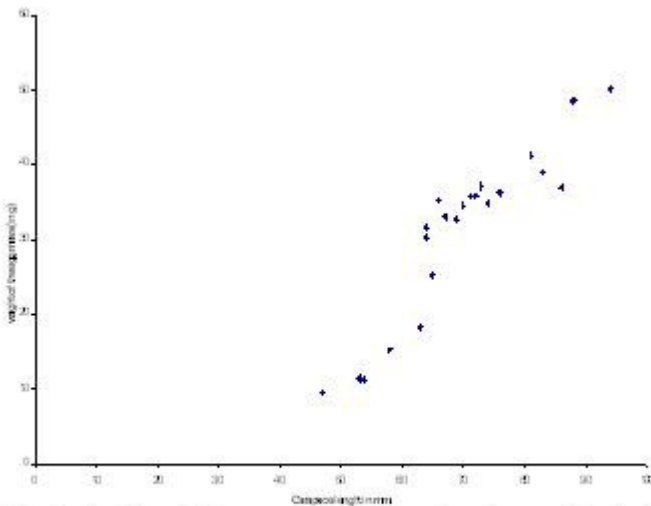


Fig. 3 : Relationship between carapace length and egg weight in *P. homarus*.

the length of the lobster. Berry (1971) stated that large females of *P. homarus rubellus* in South Africa spawn from winter to early autumn and small females from late spring to late summer. Jayakody (1994) recorded the ovigerous females during January to April and August to December and 50% of the female stock bears eggs between

August and March. De Bruin (1962) indicated that the breeding season of Sri Lankan *P. homarus* was prolonged from August to March with the peak breeding in December. Similar results on occurrence of ovigerous females were reported by George (1965) but he described November to December as the peak-breeding season for *P. homarus* in Indian waters at Muttom and Colachel which deviated from the present observation. His report further indicated that as much 81.3% of the female population was berried during November 1961. In the present study only smaller percentage (> 10%) of matured females were recorded during the month of May, June, August and September. Berried lobsters were very low numbers (>5 %). This indicated severe reduction in the breeding stock biomass, and recommends reduction in trawlers during the peak spawning season to sustain these resources.

Length at first maturity

In the present observation, females of *P. homarus* have estimated to attain the Lm_{50} at 53 mm CL (Fig. 2) that is comparable with earlier observations (De Bruin 1962; Berry, 1971; Radhakrishnan and Manisseri, 2001). A slight reduction in length at first maturity in Thoothukudi coast may be due to population density (Addison, 1986; Polovina, 1989), habitat and food availability (Cobb, 1986) and due to fishing pressure-exerted change (Davis, 1977, Warner *et al*, 1977, Aiken and Waddy, 1980, Lyons *et al*, 1981, Polovina, 1989 and Abrams and Rowe, 1996). As spiny lobsters are harvested heavily there is a possibility of fishing exerted pressure to reduce the length at first maturity in this region.

Sex ratio

The monthly sex ratio (male: female) varied between 1: 0.909 to 1: 1.168. The over all sex ratio for the study period was within the expected 1:1 ratio. Mass movement of *P. ornatus* from their juvenile habitats are reported (Bell *et al*, 1987) which cause severe change in their sex ratio. As scalloped spiny lobsters are not undergoing long distance migration as like *P. ornatus* there is no change in their sex ratios.

Fecundity

Fecundity studies conducted on various species of spiny lobsters is given in the Table.2. The size of single brood was smallest in *P. homarus* when compared with other species of *Panulirus* spp recorded in this area. The estimated fecundity was very less when compared to the findings of earlier reports. The calculated the fecundity of *P. homarus* ranged between 1.15×10^5 (44 mm CL) to 6.01×10^5 (95 mm CL) (Jayakodi, 1994) Mohan (1997) estimated the fecundity for *P. homarus* as 3.31×10^5 to 6.00×10^5 for the size range of 65-95 mm CL in the eastern

Table 1 : Sex ratio of scalloped spiny lobster *P. homarus*.

Month	No. of animals samples	Male		Female		x ² Value*	% females matured
		Number	%	Number	%		
May	204	110	53.92	94	46.08	1.24	3.19
June	193	104	53.89	89	46.11	1.16	7.86
July	206	109	52.91	97	47.09	0.69	13.40
August	181	88	48.62	93	51.38	0.12	7.52
September	233	112	48.07	121	51.93	0.34	9.09
October	218	115	52.75	103	47.25	0.66	12.62
November	195	104	53.33	91	46.67	0.86	19.78
December	217	104	47.93	113	52.07	0.37	18.58
January	263	129	49.05	134	50.95	0.08	19.04
February	252	120	47.62	132	52.38	0.56	20.45
March	253	123	48.62	130	51.38	0.18	23.84
April	210	106	50.48	104	49.52	0.02	17.03
		1324		1301			

Table X² value at 0.05 is 3.841 * insignificant at P>0.05.

Table 2 : Fecundity of various spiny lobsters reported by various authors in different localities.

Species	Fecundity range	Ovary bearing size group (CL)	Size at first maturity CL	Area	Reference
<i>Jasus edwardsii</i>	0.4x10 ⁴ -4.1x0 ⁵	74-157	—	New Zealand	Annala & Bycroft, 1987
<i>J. edwardsii</i>			72-121	New Zealand	Annala et al, 1980.
<i>Palinurus elephas</i>	2.3x10 ⁴ -2.0x10 ⁵	71-135		Western Mediterranean	Goni <i>et al</i> 2003
<i>P. argus</i>	7.5x10 ⁴ – 6.9x10 ⁵	70-105		South Florida	Gregory <i>et al.</i> 1982
<i>P. argus</i>	1.2x10 ⁵ – 1.6x10 ⁶	76-137		Caribbean	Fourza, 1998
<i>P. gilchristi</i>			59.6-64.5	South Africa	Groenveld and Melville-Smith, 1994.
<i>P. guttatus</i>	2.7x10 ⁴ – 1.9x10 ⁵	40- 72		Mexico	Briones- Fourzan and Contreras-Ortiz 1999.
<i>P. guttatus</i>		48-67.7		Venezuela	Losada-Tosteson et al, 2001.
<i>P. guttatus</i>			32	Florida Key, USA	Robertson and Butler, 2003
<i>P. interruptus</i>	5.0x10 ⁴ – 8.0x10 ⁶	—		—	Lindberg, 1955
<i>P. longipes</i>	2.6x10 ⁴ - 3.4x10 ⁵	43- 85	55-60	Philippines	Gomez <i>et al.</i> 1994
<i>P. marginatus</i>	1.1x10 ⁵ – 5.9x10 ⁵	54-105		North western Hawaiian Island	DeMartini <i>et al.</i> 2002
<i>P. marginatus</i>	1.2x10 ⁵ – 4.5x10 ⁵	54-105		Hawaii	Honda, 1980
<i>P. ornatus</i>	2.2x10 ⁵ – 8.4x10 ⁵			Papua New Guinea	Mac Farlane and Moore, 1988
<i>P. ornatus</i>			80	India	Nair et al, 1981
<i>P. ornatus</i>		107.2		India	Zakaria and Kassim, 1987
<i>P. penicillatus</i>	7.3x10 ⁴ – 5.0x10 ⁵	50-110	50	Gulf of Eilat Red sea	Plaut, 1993
<i>P. polyphagus</i>		175		Bombay, India	Kagwade, 1986
<i>P. versicolor</i>		82		Palau, Western Caroline Islands	MacDonald, 1982
<i>P. homarus</i>	1.0x10 ⁵ – 9.0 x 0 ⁵	50- 99		S. Africa	Berry, 1971
<i>P. homarus</i>	1.1x10 ⁵ -6.0x10 ⁵	44- 95	59.5	South Sri Lanka	Jayakody, 1994
<i>P. homarus</i>	3.3x10 ⁵ -6.0x10 ⁵	65- 95	69.2-75.9	Sultanate of Oman	Mohan, 1997
<i>P. homarus</i>	0.95 x10 ⁵ to 4.80x10 ⁵	47-94	57	Gulf of Mannar, India	Present report

parts of Arabian Sea. The number of ova recorded for *P. homarus* was between 1 and 7×10^5 (Berry, 1971). Among the panulirids, the brood size was reported to be very low in *Jasus edwardsii* (Annala and Bycroft, 1987), *Palinurus elephas* (Goni *et al.*, 2003), *P. guttatus* (Briones- Fourzan and Contreras-Ortiz, 1999) and *P. longipes* (Gomez *et al.*, 1994). In *P. argus* (Fourza, 1998) and *P. interupptus* (Lindberg, 1955) fecundity was highest when compared with other panulirid, with over million eggs per clutch.

Lobsters like *P. guttatus* and *P. longipes* breed smaller in their size. In the present study the smallest size that gets maturity was observed as 47 mm CL. The present observation does not deviate from earlier works (Jayakodi, 1994 and Berry, 1971). However Mohan (1997) recorded the smallest sized lobster was 65 mm CL. The size group in the range of 63-75 mm CL, the size just entering in the fishing, contributes more egg than the adult.

A good representative sample of *P. homarus* breeders of different size groups ranging from 47 to 94 mm CL indicated, a trend that the brood size is proportional to the CL of lobsters and the number of eggs produce. The number of eggs increases with the size of lobsters. The relationship between the number of eggs and carapace length of female lobsters was expressed by $F = 7.8405 CL - 283.827$.

Egg numbers expressed per g body weight indicates that the maximum number was for the size group 61-70 mm CL. About 66% of the breeders belonged to the size group of 61-80mm CL and this is the dominant size group in the fishery as evident from the export of live lobsters (Vijayakumaran and Radhakrishnan, 1997). Berry (1971) observed that 3-4 spawning per year for *P. homarus* in a breeding season. The maximum number of eggs recorded for *P. homarus*, 628,930, compares well with the maximum of 667,000 reported for the same species by Mohan (1997) in Omani waters, but is less than the estimate of 900,000 by Berry (1971) in South African waters. Similarly the lowest number of eggs recorded for the smaller berried lobster 85,000 was much lower than the reported value of Omani water lobster 309,000 (Mohan, 1997). This reduction in number of eggs is due to the method of catching, improper handling and storage at lobster holding centers.

Maximum reproductive effort of 830 eggs per g body weight was for lobsters between 90 and 95mm CL, with 500 and 700 eggs per g for the sizes below 80 and above 95 mm CL respectively. A similar trend is seen in *P. homarus* with the size group 61-70mm CL having maximum number of eggs (867-899) per g body weight (Figure 3). Lyon *et al.* (1981) noted the ability of spiny

lobsters to spawn more than once in a year suggested that a lobster that spawns more than once may contain fewer eggs in its second or third spawning.

During the period, juvenile lobsters were landed heavily at Thoothukudi region. The reduction in maximum sized specimen and higher number of smaller sized lobsters in the fishery, clearly indicate that these resources are over exploited. There is no control over lobster fishing due to open access fishery. As lobsters are slow growing animals with the extended life span of 7-10 years, these precious resources should be exploited optimally to sustain the production. Based on the present study it is suggested to fix the size of the first capture above 60 mm CL, which is higher than the L_{m50} of 53mm CL, so as to set the animal breed naturally at least once in their life span. Capturing of berried female *P. homarus* should be banned and once caught berried females and smaller once should be released into the sea to avoid recruitment overfishing as well as juvenile overfishing. Appropriate gear modification should be introduced to avoid the capture of smaller lobsters at the Thoothukudi coast. As over-exploitation of this resource to meet the demand in international market is always on the increase, conservation measures need to be initiated to protect the lobster resource.

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