

REPRODUCTION IN THE SPINY LOBSTER *PANULIRUS POLYPHAGUS* (HERBST)

P. V. KAGWADE*

Central Marine Fisheries Research Institute, Cochin-682 031

ABSTRACT

Breeding in *Panulirus polyphagus* (Herbst) as evidenced by the high percentage of impregnated and ovigerous females was throughout the year. Size at which 50% of the females matured, was 175 mm. Majority of the females matured at 205 mm and the males at 265 mm. A mature ovary showed 4 batches of ova in different stages of development. Impregnated females showed 3-5 peaks and the ovigerous ones 3-4 peaks in a year; the release of the embryonated eggs from the pleopods appeared to be in batches. All these supported the view that spawning and recruiting took place repeatedly in this species. Though spawning was throughout the year, the major spawning was in January and September and the minor in March and June. Occasional spawning was observed in April, May, August and October to December. The least spawning was in February and July. A female became ovigerous in a month or two after impregnation and the eggs took 2-3 months for incubation and hatching. Female preponderance was marginal during most of the months and in most of the years. They dominated when they were very small and then in the active reproductive phase. Segregation of sexes was not pronounced.

INTRODUCTION

REPRODUCTIVE biology is a very fascinating subject in the studies relating to the biology of spiny lobsters. The description of reproductive systems and organs in spiny lobsters and informations on the various aspects of reproduction in them are available for the past fifty years. But rapid progress in their studies is made only during the last 2 decades. To mention some are the studies on reproduction in *Jasus lalandei* by Fielder (1964) and Heydorn (1965), on fecundity in *Panulirus longipes* by Morgan (1972) on the comparison of spermatophoric masses and mechanisms of fertilization in the Southern African spiny lobsters by Berry and Heydorn (1970), on the biology of *Panulirus homarus* by Berry (1971), *Pallinurus gilchristi* by Pollock and Augustyn

(1982) and *Jasus lalandii* by Pollock *et al.* (1982). While studying the biology and fishery of *Panulirus homarus* along the southwest coast of India, George (1965) has mentioned about the breeding season of this species. Hussain and Amjad (1980) have studied the breeding and fecundity of *Panulirus polyphagus* along the Pakistan Coast. A glance at the literature shows that the least attempted is the reproductive aspect of biology in the spiny lobsters of India. *P. polyphagus*, the most abundantly available species throughout the year along the northwest coast, has been chosen here for the detail study on its reproductive behaviour.

MATERIAL AND METHODS

Weekly samples of about 100 specimens of *P. polyphagus* were examined at each of the landing centres, Sassoan Dock and Kasara

* Present address: Bombay Research Centre of CMFRI, Bombay-400 001.

Bunder for 10 years from 1976 to 1985. The landings at Kasara Bunder were shifted after 2 years to a nearby centre, the New Ferry Wharf.

Total length and sex were noted first. Females were further examined in the field for the presence or absence of spermatophoric masses deposited on the plastron and for the presence or absence of eggs on the pleopods in the abdomen. The developmental stages of the fertilized eggs on the pleopods were also recorded. Beheading of the lobster was not always permitted in the field because of the high cost paid for intact specimens. Hence, it was not possible to examine each and every female for its gonadal condition. However, whenever the lobsters were cut opened by the traders, the gonads were collected and examined in the laboratory for further details.

MATURITY

There is no external indication to decide about the maturity stage in male *P. polyphagus*. Presence of spermatozoa in testis is a factor to decide that it is mature. The testes do not show colour changes at the various stages of development. However, the external characters indicating maturity in the females are the presence of spermatophores deposited on the plastron between the last three pairs of thoracic legs and the development of ovigerous setae on the endopodites of the pleopods for carrying the eggs. Internally during the process of maturation, the developing ovary increases in size in relation to the body size of the lobster and exhibits a cycle of colour changes. The maturity cycle is differentiated into 7 stages in the present study and they are described as follows—

1. Immature—Ovary thin, flattened, transparent or whitish; ova transparent with distinct nuclei and measuring upto 0.19 mm,

2. Early Maturing I—Ovary slightly enlarged and white; small transparent, immature ova of 0.14 mm in diameter and also some other larger ones of 0.2 to 0.3 mm in which yolk deposition has started.
3. Early Maturing II—Ovary more enlarged and orange in colour; transparent, immature ova of 0.10 to 0.14 mm in diameter and orange-opaque, maturing ova of 0.2 to 0.6 mm in diameter.
4. Late Maturing—Ovary orange, fully enlarged and occupying the entire cephalothorax region; orange, opaque ova measure 0.6 to 0.8 mm in diameter.
5. Mature—Ovary fully ripe and bright orange or brick red in colour; opaque, brick coloured ova measure 0.8 to 1.1 mm in diameter.
6. Semispent—Ovary not full, light orange or orange with white patches; opaque, smaller orange ova measuring about 0.6 mm in diameter.
7. Spent—Ovary white or with light orange shade and flabby residual opaque ova and a number of immature ova measuring upto 0.14 mm in diameter.

SIZE AT MATURITY

Neither internal nor external maturity indicators were used to determine the size at maturity for males because they were not found satisfactory. A female lobster when it becomes capable of carrying fertilized eggs in the abdomen is recognised as sexually mature. Different authors have adopted different criteria to decide about the size at sexual maturity. The ovigerous setae on the abdominal pleopods are meant to carry fertilized eggs. Thus, the presence of these setae also helps in recognising mature females (Fielder, 1964; Pollock, 1982). In some species like *J. lalandii*, it is reported

that there is a regular cycle of appearance and disappearance of these setae (Paterson, 1969). Others, like Heydorn (1969) have taken into account the ovigerous condition to determine the size at maturity of the female. When the percentage of ovigerous females in the various size groups was analysed, Heydorn (1969) noticed in *J. lalandii* that after a certain size there was a sharp increase in the percentage occurrence of ovigerous condition and the same continued in higher lengths. However, Berry (1971) did not observe a similar pattern in the case of *P. homarus*. The percentage of ovigerous females showed no marked increase at any particular size and the larger size classes did not even show a very high incidence of ovigerous condition. This he attributed to repetitive breeding in this species during a year which is not the case in *J. lalandii*.

An attempt in the present study was made to distribute 2600 ovigerous *P. polyphagus* into

The stage of maturity of a female, not carrying eggs can be known only by the maturity stage of the ovary. This was found to be advantageous over the above two mentioned criteria. Hence, 400 specimens of *P. polyphagus* with the size range of 121-345 mm were cut opened and the developmental stages of their ovaries were noted and distributed at 15 mm class interval.

Fig. 1 shows that 50% of females matured at 175 mm. The smallest impregnated specimen observed was 123 mm and the smallest ovigerous specimen noticed was 146 mm during the course of this study. Almost all the specimens were mature beyond the size of 203 mm.

SPAWNING

The implantation of the spermatophores by the male lobster on the plastron of a female precedes spawning. Freshly deposited sper-

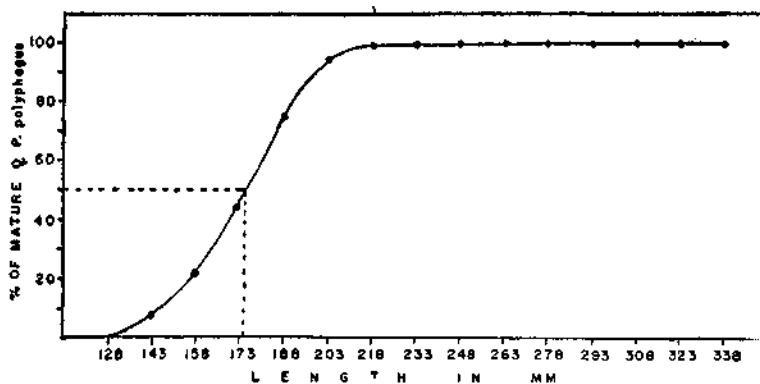


FIG. 1. Frequency of occurrence of mature female *P. polyphagus* at each 15 mm class interval.

length group of 15 mm class interval. It was noticed that the percentage frequency was erratic at the various class intervals and at no length the percentage reached beyond 20.7. This may be because of the repetitive breeding as was found in the case of *P. homarus* (Berry, 1971). Thus the presence of ovigerous specimens was not suitable for determining the size at maturity for this species.

matophoric mass on the impregnated female *P. polyphagus* is white and soft which soon darkens to lichen green and becomes hard. It is also known as tar spot. Before the eggs are released from the ovary, the surface of the spermatophoric mass is scrapped by the chelate part of the 5th leg to release the sperms. The eggs from the oviduct pass over this sperm mass and get fertilized in the brood chamber and

attach themselves securely to the ovigerous setae on the pleopods. After the spermatophoric mass is scrapped out completely 3 pairs of dark scars are left behind on the plastron. The ovaries of majority of such specimens are spent and very rarely semi spent.

P. polyphagus was found to spawn throughout the year. Impregnated and ovigerous conditions were encountered in high percentages throughout the year. Table 1 shows the

TABLE 1. Percentage of impregnated and ovigerous females of *P. polyphagus* during 1976-85

Year	No. of females	Impregnated		Ovigerous	
		No.	%	No.	%
1976	443	68	15.3	168	34.0
1977	1304	145	11.1	435	30.9
1978	1154	117	10.1	487	40.7
1979	1793	232	12.9	731	35.0
1980	4096	547	13.3	1099	26.8
1981	3359	444	13.2	833	24.8
1982	3597	460	12.8	1114	31.0
1983	2831	406	14.3	1072	37.9
1984	3837	326	8.5	1430	37.3
1985	3680	474	12.9	1329	36.1
Average			12.4		33.4

annual percentage of impregnated and ovigerous females for the 10 year period from 1976-1985. Females above 180 mm only were considered for this study. The percentage of impregnated females range from 8.5 in 1984 to 15.3 in 1976 giving an annual average of 12.4% and the ovigerous females from 24.8 in 1981 to 40.7 in 1978 giving an annual average of 33.4%.

Impregnated females

High incidence of ovigerous females in impregnated condition was encountered in the catch. Among the impregnated females (Table 2), annually 20.7% to 30.7% were found to be ovigerous during the 6 year period from 1980 to 1985 giving an annual average of 23.7%. Further, among these ovigerous

TABLE 2. Percentage of ovigerous and embryonated among the impregnated females of polyphagus during 1980-85

Year	No. of impregnated	Ovigerous		Embryonated	
		No.	%	No.	%
1980	547	168	30.7	24	14.3
1981	444	96	21.6	8	8.3
1982	460	115	25.0	1	0.9
1983	406	84	20.7	7	8.3
1984	326	80	24.5	5	6.2
1985	474	94	19.8	13	13.8
Average			23.7		8.6

impregnated individuals, embryonated eggs were observed in 0.9% to 14.3% giving an annual average of 8.6%. Similarly, the embryonated eggs in ovigerous females were discernible in 2.7% to 18.4% of the specimens examined during the different years of the 10 year period from 1976 to 1985 giving an annual average of 8.9% Table (3).

TABLE 3. Percentages of embryonated among the ovigerous females of *P. polyphagus* during 1976-85

Year	No. of ovigerous	Embryonated	
		No.	%
1976	168	31	18.4
1977	435	59	13.6
1978	487	53	10.9
1979	731	169	23.1
1980	1099	77	7.0
1981	833	56	6.7
1982	1114	30	2.7
1983	1072	32	3.0
1984	1430	57	4.0
1985	1329	97	7.3
Average			8.9

Impregnated females were found all round the year. During the 6 year period from 1980 to 1986, the impregnated condition displayed 3 to 5 peaks in a year (Fig. 2). The ovaries of impregnated specimens not carrying eggs were either fully mature occupying the entire body cavity or semispent with reduced or

fully spent ovaries. However, the ovaries of the ovigerous impregnated specimens were found to be either fully spent or semi-spent and the latter would likely develop further and spawn again.

There seemed a close relationship between these 3 phases. A peak for the impregnated female could be traced as the arrow shows to the ovigerous one in a month or two and the latter to the embryonated one in another 2 or 3 months. It was inferred from this that females became ovigerous in a month or two after impregnation and the fertilized eggs were

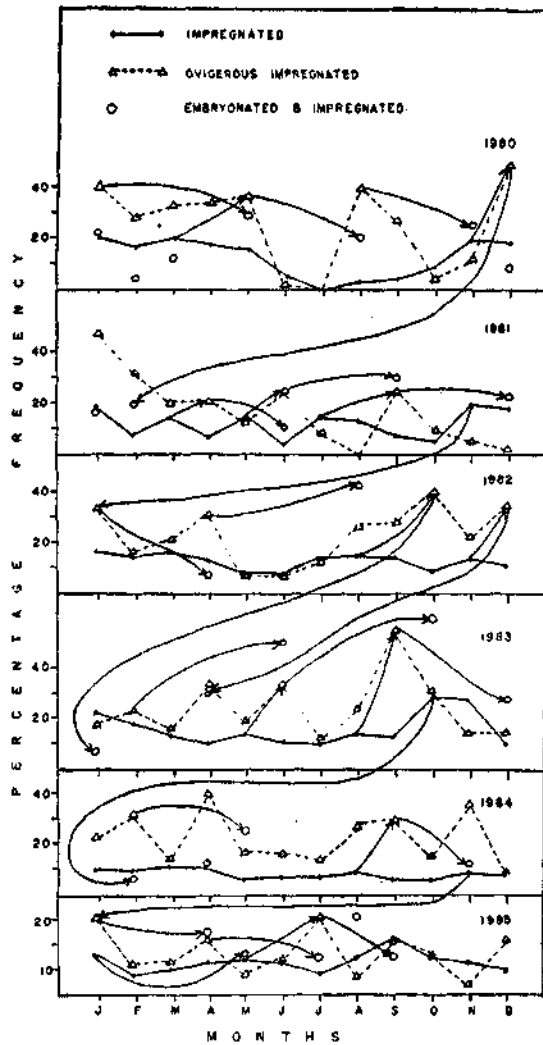


FIG. 2. Monthly percentage frequency of impregnated, ovigerous impregnated and embryonated & impregnated *P. polyphagus* during 1980-'85.

A regular sequence in the appearance of peaks (Fig. 2) for impregnated, ovigerous impregnated and embryonated impregnated females was noticed in all the 5 years studied,

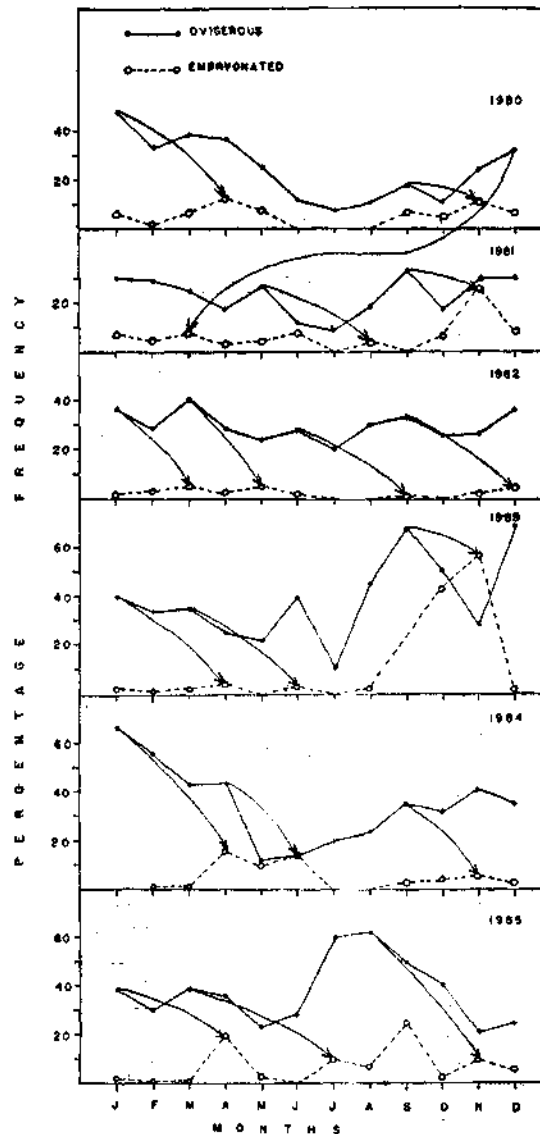


FIG. 3. Monthly percentage frequency of ovigerous and embryonated *P. polyphagus* during 1980-'85.

retained on the pleopods for incubation and hatching for 2-3 months after which the embryos in the advanced stages of development were released into the water. Similarly, Fig. 3 for ovigerous and embryonated females also showed that the incubation and hatching period was 2-3 months. Thus after impregnation it took about 4-5 months for releasing the eggs. Fig. 3 also indicated that the ovigerous females showed 3-4 peaks in a year.

Further, it was noted that all the embryonated eggs were not released simultaneously in the water because pleopods carried eggs which were in well advanced stage of development along with less developed ones. It is probable that the development and release of eggs might be in batches.

Spawning season

Although ovigerous females occurred throughout the year there were definite major and minor peaks of spawning for this species. Over the 10 year period of observation high percentage of ovigerous females were recorded in certain months. Table 4 shows the number

TABLE 4. Number of times a particular month formed peak showing high percentage of ovigerous females during the 10 year period from 1976-85

Month	No. of years the peak appeared	Intensity of spawning
January	7	Major
February	0	—
March	5	Minor
April	2	Occasional
May	2	Occasional
June	4	Minor
July	0	—
August	2	Occasional
September	6	Major
October	2	Minor
November	2	Minor
December	3	Minor

of times a particular month showed high percentage of ovigerous specimens during the

10 year period from 1976 to 1985. January recorded peaks in 7 years and September in 6 years and hence these could be regarded as the major spawning months while March showing peaks in 5 years and June in 4 years could be regarded as the minor spawning months. Each of the months April, May, August and October to December recorded peaks in 2-3 years only. Hence, these could be considered as the occasional spawning months. In none of the years, a peak was noticed in February and July.

Spawning periodicity

The ova diameter measurements of 31 ovaries in various stages of development were taken. An immature ovary shows (Fig. 4)

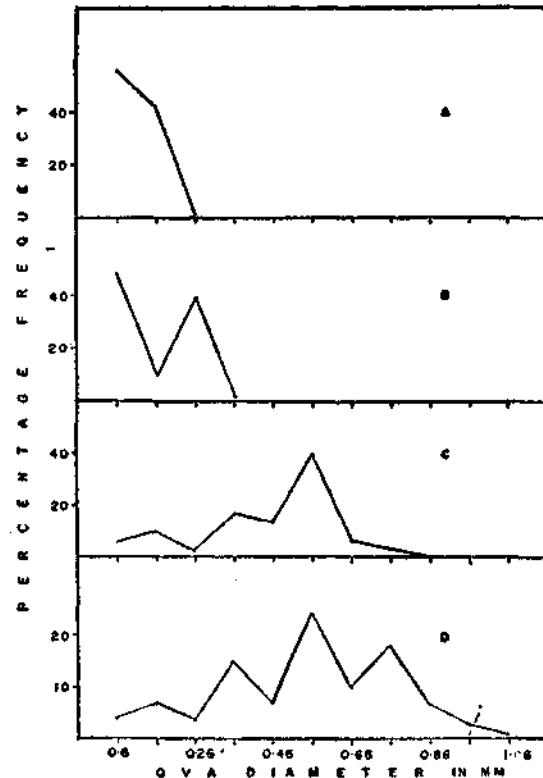


FIG. 4. Percentage frequency of ova diameter measurements.

one mode of immature ova at 0.05 mm, early maturing and spent recovering ones

also show one mode of ova just beginning to mature at 0.16 mm. As the maturation advances, 2 to 3 modes are noticed at different diameters. A fully mature ovary presents 4 modes of maturing and mature ova of different diameters suggesting that an individual spawns 4 batches of eggs.

Fig. 5, presents the monthly modes of ovigerous females occurring at 5 mm class intervals during 1981 and 1982. Making use of the

SEX RATIO

Sex ratios on annual basis (Table 5) showed preponderance of females in all the years except in 1976 when the males formed 52.3% and in 1977 and 1978 when both the sexes were equally represented. The females in rest of the years, ranged between 54.55% and 58.33%.

The month-wise distribution of the data pooled together for 10 years (Table 6) recorded

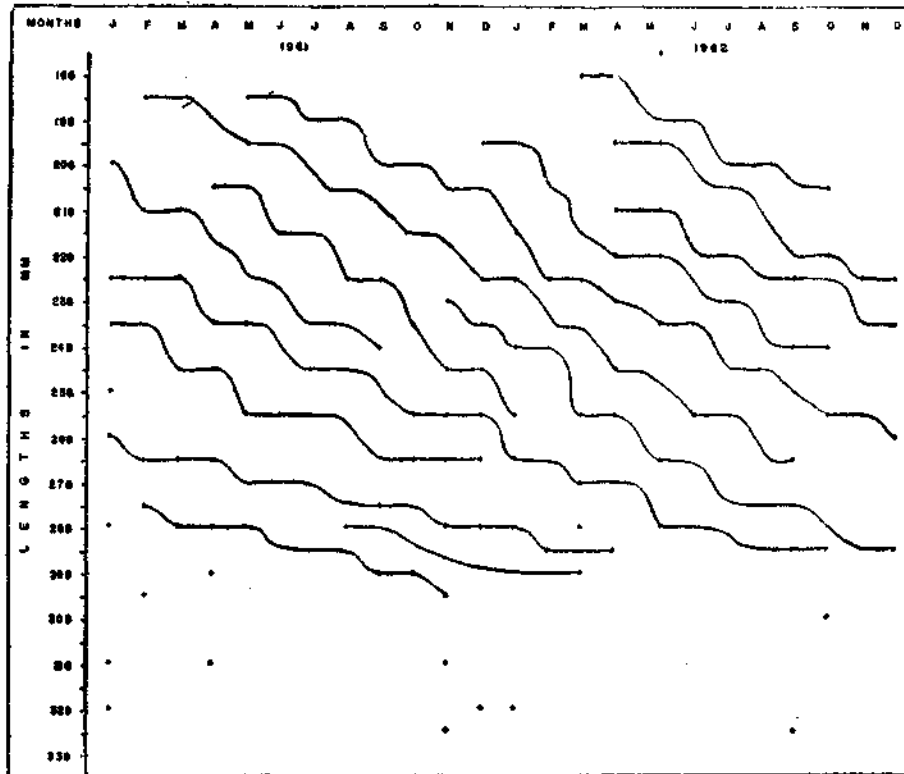


FIG. 5. Monthly modes of ovigerous *P. polyphagus* at 5 mm class interval during 1981 and 1982.

growth rates at different ages described by Kagwade (1986), these modes were traced in order to find out the periodicity of spawning in a year for a particular brood. An individual appeared to spawn 4 times in a year since there were 4 sets of peaks during that period. The incubation and hatching period was of 2-3 months because the peaks remained steady at a particular length during this period.

more females than males in all the months except March when they were in the ratio of 1 : 1. In rest of the months the females ranged between 52.38% and 64.29%.

Males and females of the 10 year period when distributed into size groups at 15 mm class interval (Table 7), the females predominated in the lower sizes till 97 mm. This was

followed by male predomination in higher size groups till 202 mm during which the percentage of males ranged between 52.38 and 56.32. After the size of 202 mm, the females predominated again till 322 mm when they formed 52.38% to 62.96% and this length range is of potential spawners. In higher groups beyond

TABLE 5. Annual percentage of male and female *P. polyphagus* with their ratios during 1976-85

Year	Percentage		Sex ratio
	Male	Female	Male : Female
1976	52.38	47.62	1.1 : 1
1977	50.00	50.00	1 : 1
1978	50.00	50.00	1 : 1
1979	45.45	54.55	1 : 1.2
1980	43.48	56.52	1 : 1.3
1981	41.67	58.33	1 : 1.4
1982	41.67	58.33	1 : 1.4
1983	45.45	54.55	1 : 1.2
1984	41.67	58.33	1 : 1.4
1985	43.48	56.52	1 : 1.3

this, in which the number of specimens encountered in the catch was small, the sex ratio did not reflect on any difference in the mortality rates between the two sexes. When the males dominated, the ratio never crossed 1.3 : 1

TABLE 6. Monthly percentage of male and female *P. polyphagus* with their ratios for the entire period of 1976-85

Month	Percentage		Sex ratio
	Male	Female	Male : Female
January	45.45	54.55	1 : 1.2
February	47.62	52.38	1 : 1.1
March	50.00	50.00	1 : 1
April	47.62	52.38	1 : 1.1
May	45.45	54.55	1 : 1.2
June	41.67	58.33	1 : 1.4
July	43.48	56.52	1 : 1.3
August	40.00	60.00	1 : 1.5
September	38.46	61.54	1 : 1.6
October	35.71	64.29	1 : 1.8
November	41.67	58.33	1 : 1.4
December	43.48	56.52	1 : 1.3

TABLE 7. Sex-ratio of *P. polyphagus* for the period 1976-85 at 15 mm class interval

Mid point in mm	Number of		Sex ratio
	Males	Females	Male : Female
67	—	1	0 : 100.0
82	7	10	41.67 : 58.33
97	48	54	47.62 : 52.38
112	173	145	54.55 : 45.45
127	308	289	52.38 : 47.62
142	609	505	54.55 : 45.45
157	947	742	56.52 : 43.48
172	1431	1109	56.52 : 43.48
187	1963	1453	56.52 : 43.48
202	2881	2358	54.55 : 45.45
217	3393	3741	47.62 : 52.38
232	4002	5460	41.67 : 58.33
247	3400	5548	38.46 : 61.54
262	2544	4356	37.04 : 62.96
277	1597	2650	38.46 : 61.54
292	1170	1999	37.04 : 62.96
307	298	430	41.67 : 58.33
322	112	138	45.45 : 54.55
337	45	44	50.00 : 50.00
352	19	10	34.48 : 65.52
367	5	—	100.00 : 0
382	1	1	50.00 : 50.00
397	—	1	0 : 100.0

and whenever the females dominated, especially in the active reproductive phase, it never crossed 1 : 1.7. Extreme sex ratios were not observed. Segregation of sexes, if any, in their movements was not pronounced. Preponderance of males in larger sizes was attributed to differential growth rates of males and females in *P. argus* by Munro (1974) and in *P. homarus* by Smale (1978). Berry attributed it to the greater maximum size attained by the males in *P. homarus*. However, in *P. polyphagus*, though males grow at a faster rate than the females, preponderance of males in larger sizes was not noticed in the present study.

DISCUSSION

Maturity indicators, either internal or external for males, have proved not useful to determine the size at maturity in the case of lobsters.

The presence of sperms in the testis may indicate maturity at a size smaller than the size at which the male can perform the mating act, as was witnessed in *J. lalandii* by Fielder (1964) and Heydorn (1965). However, Berry (1971) reported that males reach maturity at a similar or slightly larger size in relation to the female size at maturity in *P. homarus*.

The maturity size of *P. Polyphagus* varied with the method employed to determine it. While a specimen as small as 123 mm was impregnated and another of 146 mm was ovigerous, both of which might have been freak cases, 50% of the females were mature at 175 mm by the sigmoid curve method and majority of them were mature beyond 203 mm. Kagwade (1986) reported sexual maturity by Hiatt's graphic method at 205 mm for males and 145 mm for females and by arithmetic method at 265 mm for the former and 205 mm for the latter. Such variations noticed in the size at maturity might be due to the difference between the actual gonadal maturity and the physical maturity required for mating. This posed a question whether biological maturity is a necessity for the physical maturity. However, from all these it could be safely said that nearly all females matured beyond 205 mm and corresponding to this, the males beyond 265 mm, a size larger than that of female and a finding in concurrence with what is reported by Berry (1971) in the case of *P. homarus*.

Repetitive breeding in *P. polyphagus* was evidenced by several facts. Impregnated and ovigerous females were found all round the year with 3-5 peaks for the former and 3-4 peaks for the latter. Ova diameter measurements also showed that an individual spawned 4 times in a year. Condition of the ovaries in the impregnated and ovigerous impregnated specimens added to the view that this species bred several times in a year. Berry (1971) noted *P. homarus* to breed 2, 3 and even 4 times in a year depending on the size. He did not observe repetitive breeding in smaller specimens. Kagwade (1986) reported 6-7 broods entering the fishery in a year. This is because an individual spawned up to 4 times in a year in batches.

George (1965) observed ovigerous *P. homarus* throughout the year but described November-December as the peak breeding season by their high incidence in the catch at Mutton and Colachel on the south west coast of India. Hussain and Amjad (1980) reported extensive breeding from October to May for *P. polyphagus* from Karachi harbour with the major breeding during March and April and again in October and December. Though ovigerous females of *P. polyphagus* were discernible throughout the year in Bombay, the major spawning was in January and September, the minor in March and June and the occasional one in rest of the months.

REFERENCES

- BERRY, P. F. 1971. The biology of the spiny lobster *Panulirus homarus* (Linnaeus) of the east coast of Southern Africa. *S. Afr. Oceanogr. Res. Inst. Invest. Res.*, 28 : 1-76.
- AND A. E. F. HEYDORN 1970. A comparison of the spermatophoric masses and mechanisms of fertilization in the Southern African Spiny lobsters (Palinuridae). *Ibid.*, 25 : 1-18.
- FIELDER, D. R. 1964. The spiny lobster *Jasus lalandii* (H. Milne-Edwards) in South Australia : II Reproduction. *Aus. J. Mar. Freshw. Res.*, 15 : 133-144.
- GEORGE, M. J. 1965. Observations on the biology and fishery of the spiny lobster *Panulirus homarus* (Lin.) *Proc. Symp. Crustacea*, MBAL, 4 : 1308-1316.
- HEYDORN, A. E. F. 1965. The rock lobster of the South African west coast *Jasus lalandii* (H. Milne-Edwards). 1. Notes on the reproductive biology and the determination of minimum size limits for commercial catches. *Invest. Rep. Div. Sea, Fish. S. Afr.*, 53 : 1-32.
- 1969. The rock lobster of South African West coast, *Jasus lalandii* (H. Milne-Edwards). 2. Population studies, behaviour, reproduction, moulting, growth and migration. *Ibid.*, 71 : 1-52.

- HUSSAIN, M. AND S. AMJAD 1980. A study of breeding and fecundity of the spiny lobster *Panulirus polyphagus* Herbst (Decapoda; Palinuridae) occurring along the Pakistan Coast. *Pakistan J. Agric. Res.*, 1(1): 9-13.
- KAGWADE, P. V. 1986. Age and growth of the spiny lobster *Panulirus polyphagus* (Herbst) in the commercial catches landed at Bombay in the northwest coast of India. *Indian J. Fish.* (in press).
- MORGAN, G. R. 1972. Fecundity in the western rock lobster *Panulirus longipes cygnus* (George) (Crustacea: Decapodae: Palinuridae) *Aust. J. Mar. Freshw. Res.*, 23: 133-141.
- *MUNRO, J. L. 1974. The biology, ecology, exploitation and management of Caribbean reef fishes. Scientific Report of the ODA/UNU fisheries ecology, research project, 1962-1973. Part VI. The biology, ecology and bionomics of Caribbean reef fishes - Crustaceans (Spiny lobsters and crabs). *Univ. West Indies, Zool. Dept. Res. Rep.*, 3: 1-57.
- *PATERSON, N. F. 1969. The moulting frequency (in captive adult Cape rock lobsters *Jasus lalandii* H. Milne-Edwards). *S. Afr. J. Sci.*, 65(3): 72-74.
- POLLOCK, D. E. 1982. The fishery for and population dynamics of west coast rock lobster related to the environment in the Lambert's Bay and Port Nolloth areas. *Invest. Rep. Sea. Fish. S. Afr.*, 124: 1-57.
- AND C. J. AUGUSTYN 1982. Biology of the rock lobster *Palinurus gilchristi* with notes on the South African fishery. *Fish. Bull. S. Afr.*, 16: 57-73.
- , ————— AND P. C. GOOSEN 1982. The rock lobster *Jasus lalandii* and its environmental biology on the Saldanha-Columbine fishing ground off the Cape west coast, 1978-1981. *Invest. Rep. Sea. Fish., S. Afr.*, 125: 1-30.
- SMALE, M. J. 1978. Migration, growth and feeding in the Natal rock lobster *Panulirus homarus* (Linnaeus). *S. Afr. Assoc. Mar. Biol. Res. Invest. Rep.*, 47: 1-56.

* Not referred in original.