AGE AND GROWTH OF SPINY LOBSTER *PANULIRUS POLYPHAGUS* (HERBST) OF BOMBAY WATERS

P. V. KAGWADE

Central Marine Fisheries Research Institute Centre, Bombay.

ABSTRACT

Age and growth of spiny lobster *Panulirus polyphagus* (Herbst) has been determined based on length-frequency method. Growth during the first 3 years is identical in both sexes; 85 mm in the I year, 145 mm in II year and 205 mm in III year. Thereafter the males grow faster than females; measuring 265 mm by the end of IV year, 315 mm by the end of V year and 355 mm by the end of VI year. Females measure 255 mm, 290 mm, 320 mm, 345 mm and 365 mm respectively by the end of successive years IV to VIII. The frequency of moulting is more and the intermoult period shorter in juveniles; with advance in age, the intermoult period lengthens and the number of moulting reduces. The length increment per moult is nearly constant over the juvenile and adult phases. Six to seven broods appear to be recruited annually to the fishery. The peak period of recruitment, of very small-sized juveniles, is November-December. The growth does not conform with the general growth pattern of fishes, but follows the pattern common to crustaceans. Values of growth parameters by von Bertalanffy's growth equation are:

L_∞ = 537 mm, K = 0.2000 and t_o = 0.6037 for males and

L_∞ = 443 mm, K = 0.2231 and t_o = 0.1985 for females.

INTRODUCTION

One of the three methods, length-frequency analysis, mark-recovery experiments and moulting in captivity, has been used to study the growth rates of spiny lobsters of India. These studies were confined mostly to *Panulirus homarus* (Linn.) of the southern coasts, where the species is in greater abundance. George (1965) employed the length-frequency method and Mohamed and George (1968) employed the mark-recovery method. Thomas (1972) studied the growth in captivity. Nair et al (1981) also studied the growth and moulting in captivity not only of *P. homarus* but also of two other species *Panulirus ornatus* (Fabricius) and *Panulirus penicillatus* (Oliver). Kathirvel (1973) recorded the growth in *Panulirus polyphagus* (Herbst) during an intermoult period of 29 days in captivity. Recently, Radhakrishnan and Vijaykumaran (1982) demonstrated by a series of experiments that an acceleration of growth is possible in the spiny lobsters by eyestalk ablation.

The present study attempts to give the age and growth of *Panulirus polyphagus* of Bombay based on the length frequency of lobsters landed by trawlers during 7 years, from January 1976 to December 1982, at the two major landing centres. One was Sassoon Dock and the other Kasara Bunder for the first 2 years and then onward New Ferry Wharf, to which the Kasara Bunder landings were shifted. The trawlers which landed the lobsters, as bycatches, were medium sized (40'-50' in length), using shrimp/fish trawl with codend mesh 25-30 mm. They were operating up to a depth of 70 m between latitudes 17°N and 20°N. They used to stay out fishing for 3-4 days normally, but during monsoon they did daily fishing.

Material and Method

Weekly measurements were taken of random samples at both the centres normally consisting of 100 specimens. However, on days when the catches were poor this number could not be maintained. Also, during the 7-year period of observation data could not be collected for 9 months, July-August 1976, May-August 1978 and Julys of 1977, 1979 and 1980.

Total lengths were measured to the nearest mm from the transverse ridge between the supra-orbital horns in front to the tip of telson. The measurements were taken on a specially designed measuring board, on which the lobster was kept straight with abdomen fully extended. Of the 36,712 specimens measured, 16,602 were males and the remaining 20,110 were females. The size range of the males was 78-390 mm and of females 71-395 mm.

The attempts with 20 mm and 15 mm class intervals having not shown any shifting of modes, the class interval was fixed at 5 mm. The monthly length frequencies by number were plotted separately for males and females. As the growth rates did not differ between the samples from the two landing centres, the data were pooled together, however, keeping them sexwise.

Observations and Discussion

Length frequency: The monthly length frequencies of *P. polyphagus* are plotted in Fig. 1. It is found that from 85 mm onwards till 205 mm the modes are shifting smoothly with an average growth of 5 mm each month in both males and females, thus recording an intermoult period of one month.

Deshmukh (1966) kept live puerulii of *P. polyphagus* of 22 mm to 23 mm in aquaria and found that they moulted within a week into typical young spiny lobsters. The puerulii of *P. polyphagus* collected from the normal and miniature bag nets during the course of this study measured between 23 mm and 24 mm. The smallest male from the trawlers measured 78 mm and the smallest female, 71 mm. The smallest mode obtained in the length-frequency distribution

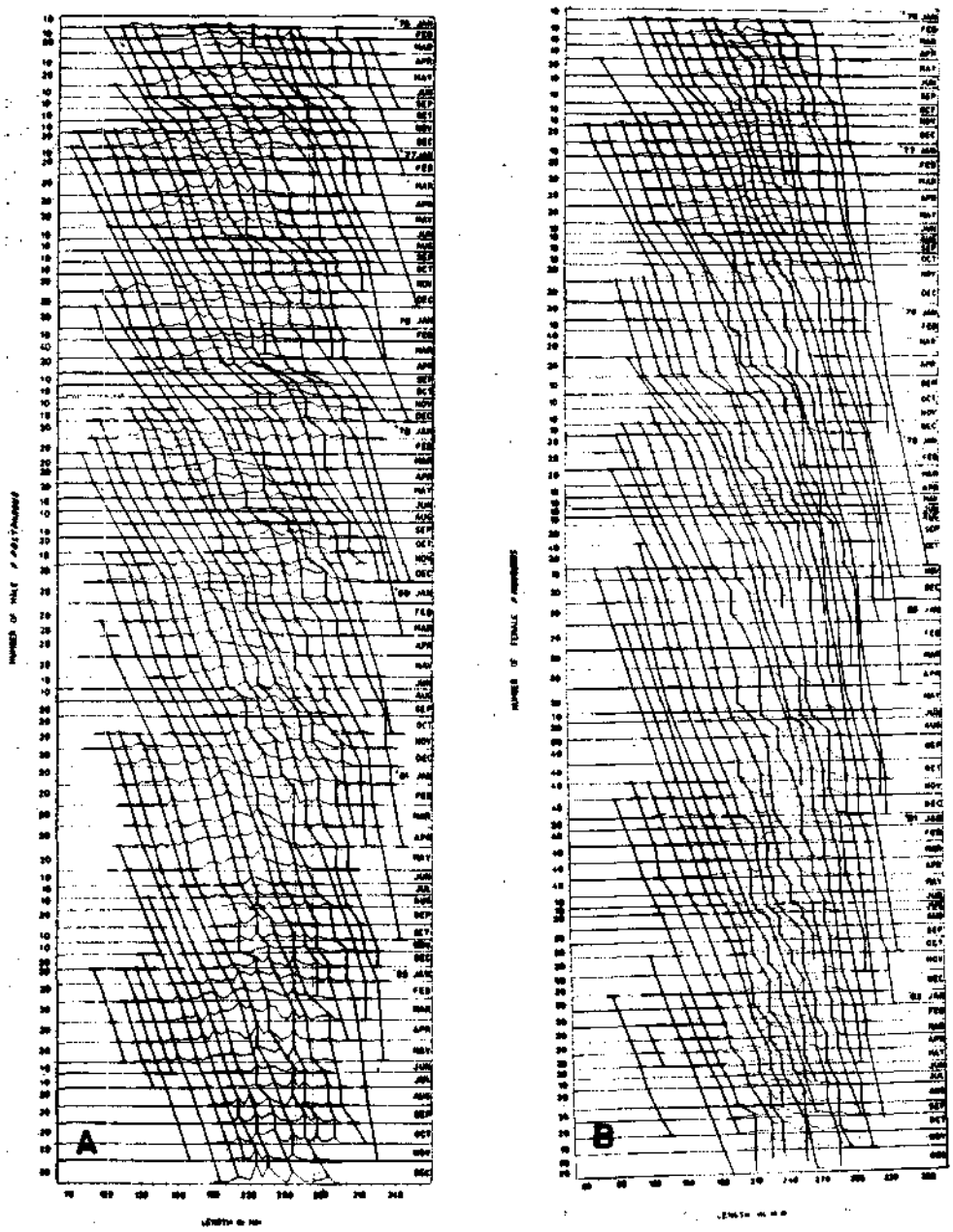

FIG. 1. Length-frequency distribution of *P. polyphagus* during 76-82.
A: male; B: female.

is 85 mm for both the sexes. In view of Deshmukh's findings, it may be inferred that the next moult of the largest puerulus (measuring 24 mm) in the bag-net collection would have been soon. Further, with the collection of the smallest

juvenile measuring 23 mm in the bag-net it is reasonable to assume that the juvenile would measure about 25 mm. It can also be inferred that the growth from 25 mm to 85 mm is at a rate of 5 mm per month and not less, as has been shown by the length-frequency distribution. Therefore to reach 85 mm, the 25 mm juvenile takes one year. Thus, keeping the rate of 5 mm per month, both the sexes would measure 85 mm, 145 mm and 205 mm respectively at the end of I, II and III years. However, in the subsequent years, the growth differs in the sexes.

The males (Fig. 1A) continue the same rate to measure 265 mm at the end of IV year. However, the shifting of modes now is not as smooth as before. Sometimes the intermoult period is extended to 2 months as is evidenced by the mode being stationary and then the increment becoming nearly double, making up for the loss due to the delay in moulting. In the months following the IV year such extended intermoult periods are repeated more often, and the lobster measures 315 mm by the end of V year. Specimens beyond 315 mm were scanty, and so the intermoult period could not be judged properly. However, attempts have been made to trace some of the modes further up with reasonable time-spacing, and it is noted that the male measures 355 mm by the end of VI year.

After 205 mm, the intermoult period increases to 2 months 3-4 times a year in female (Fig. 1B), and it measures 255 mm by the end of the IV year. The intermoult period in V year lasts for 2 or even 3 months and the female measures 290 mm by the end of that year. Then moulting frequency is further reduced and the female measures 320 mm by the end of VI year. Specimens longer than 320 mm were sparse in the fishery. However, as in the case of males, some of the modes can be traced further up with reasonable time-spacing to 345 mm and 365 mm, when the lobster is expectingly 7 and 8 years. If so, the largest female recorded during the course of this study, measuring 395 mm, should be in the tenth year.

Recruitment: From Fig. 1A and B it is evident that a number of broods contribute to the fishery. During this 7-year period of observation, the fishery is found to be supported by 46 broods in succession for males and 41 for females, giving an average of 6-7 broods per year. This suggests that the spawning in this species is throughout the year. This is further supported by the presence of high percentage of berried females throughout the year. Some of the broods can be traced from 1 through 6 years in the case of males and 1 through 8 years in the case of females. The peak period for the recruitment of the smallest size-group into the fishery is November-December. During the monsoon period of July to September mostly the adults contribute to the fishery.

Growth data when plotted according to the graphic method of Hiatt (Kurata 1962) (Fig. 2) gives straight line which could be expressed for the dimensional increase as:

$L_{n+1} = a + b\,L_n$, where L_n and L_{n+1} are dimensions before and after moulting and a and b are constants. The straight line could also be expressed as, $L_{n+1} - L_n = b\,(L_n - L_{n-1})$.

This indicates that the amount of dimensional increment at successive moultings makes a geometrical series with b as a common ratio. The points of inflexion in the straight lines (Fig. 2) caused by sexual maturity are 205 mm for males and 145 mm for females, indicating that the females mature earlier than the males.

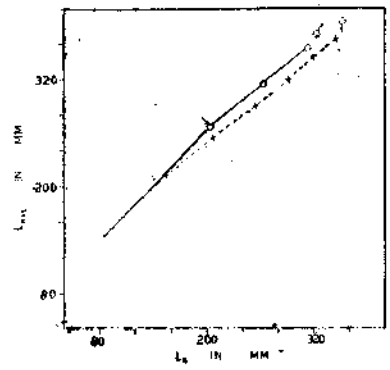

FIG. 2. Hiatt's growth diagram for the juveniles and adults of *P. polyphagus*.

In the case of growth in the larval phase, which could not be attempted here, the growth constants are worked out by the formula $L_{n+1} - L_n = b\,(L_n - L_{n-1})$, with slight modification in the units employed for the juvenile and adult phases. The linear dimensions compared here are pertaining to the cumulative increments in the preceding and following years instead of the increments before and after moulting. This method indicates that the species followed arithmetic growth in the juvenile phase, where $b = 1$, explaining the constant annual increment of 60 mm till the animal attained sexual maturity. Thereafter, in the adult phase of both sexes, retrogressive geometric growth is evident (Table 2) wherein $b<1$. Thus, the length increment gradually decreases as the lobster grows in age.

Growth parameters: Von Bertalanffy's growth formula was applied for adults only, because they alone had recorded the decrease in annual growth increments. The growth parameters obtained are:

L_∞ — 537 mm for males
443 mm for females

K — 0.2000 for males
0.2231 for females

t_o — 0.6037 for males
0.1985 for females

and the Von Bertalanffy's growth equations are —

$$L_t = 537 \left[1-e^{-0.2000\ (t-0.6037)} \right] \text{ for males}$$

$$\text{and } L_t = 443 \left[1-e^{-0.2231\ (t-0.1985} \right] \text{ for females}$$

The asymptotic growth is 537 mm for males and 443 mm for females. The largest male encountered during this observation is 378 mm, in January 1984, and the largest female is 395 mm. However, with the faster rate of growth, the males can be much larger.

That the frequency of moulting decreases with growth in *P. polyphagus* is further supported by infestation of *Balanus* on half a dozen adult specimens of both the sexes ranging in size between 235 mm and 260 mm. The size of these barnacles is an indicator of the approximate duration of intermoult period. (Bufkin et al 1974). A female measuring 260 mm in total length was encrusted with *Balanus* of size ranging from a pinhead to 9-10 mm in height. Dr. A. A. Karande of NCML has shown while a personal discussion that these represented more than a generation. Further, it was learnt that the large-sized barnacles measuring 9-10 mm would at least be 2 months old and that the time required for development from cyprid stage, at which it settles, to young adult was only 2 days.

The prolonged intermoult period of 2-3 months was also reported to be the case of tropical *P. argus* (Munro 1974) and *P. homarus* (Berry 1971). For more temperate *P. cygnus* (Morgan 1977) and *P. interruptus* (Lindberg 1955) the intermoult period is reported to be 100-180 days and for colder water *J. lalandii* (Paterson 1969) it is 180-360 days. Kurata (1962) and Berry (1971) reported that the increase per moult was fairly constant till the size of sexual maturity and thereafter decreased with gain in size or age. Heydorn (1968) reported that in the juveniles of *J. lalandii* the size frequency distributions were very similar in the sexes, because the sexual dimorphic characters were yet undeveloped in them. In *P. polyphagus* it is found that the growth increment/year is constant at 60 mm during the juvenile phase of 3 years in the case of female and 4 years in the case of male. Chittleborough (1976) noticed maximum increment per moult in *P. longipes cygnes* during III and IV year of life. Similarly, both the males and females of *P. polyphagus* had an extended intermoult period of 2-3 months in the IV and V year, when the growth increment per moult was nearly double.

TABLE 1. *Age at length of male and female P. polyphagus showing the annual growth increment*

Age	Male		Female	
	Length (mm)	Increment (mm)	Length (mm)	Increment (mm)
I	85	60	85	60
II	145	60	145	60
III	205	60	205	60
IV	265	60	255	50
V	315	50	290	35
VI	355	40	320	30
VII	—	—	345	25
VIII	—	—	365	20

Though the inflexion points in Hiatt's graphic method indicated sexual maturity at 205 mm for males and 145 mm for females, the arithmetic growth demonstrated juvenile phase till 265 mm for males and 205 mm for females. This may suggest that physiologically these lobsters are mature or in the process of maturation almost in advance of one year when they are sexually ready for reproduction. In this connection it may be mentioned that Heydorn (1968) reported that although 7% of females in the carapace length range of 5.5-5.9 cm were ovigerous, the population of *Jasus lalandii* as a whole could be regarded as sexually mature at the carapace length of 7.0 cm or more.

Kurata (1962) mentioned that life of crustaceans could be divided into 3 growth phases, larval, juvenile and mature, and each phase was characterized by different growth constant which could be derived from the formula: $L_{n+1} - L_n = b\,(L_n - L_{n-1})$ Depending on the value of b, he described 3 types of growth patterns mentioned below in crustaceans.

1. Progressive geometric growth — PG type where $b > 1$
2. Retrogressive geometric growth — RG type where $b < 1$
3. Arithmetic growth — AG type where $b = 1$

TABLE 2. *Values of growth constants for dimentional increase at two different phases in the life of P. polyphagus*

Phase	$L_{n+1} - L_n$ (mm)	$L_n - L_{n-1}$ (mm)	$b = \frac{L_{n+1} - L_n}{L_n - L_{n-1}}$
Juveniles	145-85	85-25	60/60 — 1
	205-145	145-85	60/60 — 1
Adults			
Male	315-265	265-205	50/60 — 0.83
	355-315	315-265	40/50 — 0.80
Female	255-205	205-145	50/60 — 0.83
	290-255	255-205	35/50 — 0.70
	320-290	290-255	30/35 — 0.85
	345-320	320-290	25/30 — 0.83
	365-345	345-320	20/25 — 0.80

Based on the value of *b*, he showed PG type of growth in the larval phase and AG type in the juvenile and mature phases in *Cambaroides japonicus*. Among crabs, both mature male and female *Hemigrapsus sanguineus* had AG type of growth, whereas juveniles of *Paralithodes camtschatica* and *Paralithodes brevipes* had PG type. Similarly, he found different types of growth in the lobster *P. japonicus*, too, which had PG type in the juvenile phase and AG type in the adult phase. This shows that crustaceans do not conform to the general pattern of biological growth in fishes, in which the growth is maximum in the early part and then gradually decreases with advance in age so as to reach the asymptot.

As regards to the growth rate of Indian lobsters, George (1965) has estimated an average growth of 30-40 mm per year, Mohamed and George (1968) observed relatively faster rate of growth in males than in females, and Thomas (1972) found the growth per moult to be 4 to 9 mm in carapace length in *P. homarus*. In the aquarium-held *P. polyphagus* measuring 88 mm, Kathirvel (1973) has noticed 5 mm and 2 mm increases in carapace length and 11 mm each time in total length in the two successive moults; the first one

in 2 days of captivity and the second after 29 days. Nair et al (1981) noticed the growth increment per moult of 6.5-9.6 mm in *P. homarus*, 11.3-13.8 mm in *P. ornatus* and 5.5 mm in *P. penicillatus*. Radhakrishnan and Vijayakumaran (1982) observed that removal of eyestalk accelerated that frequency of moulting in *P. homarus*. But the intermoult period increased with size in both the ablated and control lobsters; the increase, however, being lower in the former. So it seems that *P. polyphagus* is more like *P. homarus* in the growth increment per moult.

The author thanks Shri M. Shriram, Technical Assistant for his collection of puerulii and to Shri M. Aravindakshan, Scientist, for his collection of the smallest juvenile of *P. polyphagus*.

References

BERRY, P. F. 1971. The biology of the spiny lobster *Panulirus homarus* (Linnaeus) of the east coast of southeren Africa. *S. Afr. Oceanogr. Res. Inst. Invest. Rep.* 28: 1-75.

BUFKIN, B. G., R. D. BOUNDS AND S. F. THAMES. 1974. Fighting marine organisms. *Paint and varnish production*: 25-29.

CHITTLEBOROUGH, R. G. 1976. Growth of juvenile *Panulirus longipes cygnus* George on coastal reefs compared with those reared under optimal environmental conditions. *Aust. J. Mar. Freshwater Res.* 27: 279-295.

DESHMUKH, S. 1966. The puerulus of spiny lobster *Panulirus polyphagus* (Herbst) and its metamorphosis into the post-puerulus. *Crustaceana*, 10(2): 137-150.

FIELDER, D. R. 1964. The spiny lobster *Jasus lalandii* (H. Milne Edwards) in South Australia. I. growth of captive animals. *Aust. J. Mar. Freshwater Res.* 15: 77-92.

GEORGE, M. J. 1965. Observations on the biology and fishery of the spiny lobster *Panulirus homarus* (Lin.) *Proc. Symp. Crustacea* 4: 1308-1316. Marine Biological Association of India.

HEYDORN, A. E. F. 1968. The rock lobster of the South African west coast *Jasus lalandii* (H. Milne-Edwards). 2. Population studies, behaviour, reproduction, moulting, growth and migration. *Invest. Rep. Div. Sea Fish S. Afr.* 71: 1-52.

KATHIRVEL, M. 1973. The growth and regeneration of an aquarium held spiny lobster, *Panulirus polyphagus* (Herbst) *Indian J. Fish* 20(1): 219-221.

KURATA, H. 1962. Studies on the age and growth of crustacea. *Bull Hokkaido Reg. Fish. Res. Lab.* (24): 1-115.

*LINDBERG, R. G. 1955. Growth, population dynamics and field behaviour in the spiny lobster, *Panulirus interruptus* (Randall) *Univ. Calif. Berkeley. Publ. Zool.* 59: 157-231.

MOHAMED, K. H. AND M. J. GEORGE. 1968. Results of the tagging experiments on the Indian spiny lobster, *Panulirus homarus* (Linnaeus) movement and growth *Indian J. Fish* 15: 15-26.

*MORGAN, G. R. 1977. Aspects of the population dynamics of the western rock lobster and their role in management. Ph.D. Thesis, University of Western Australia.

*MUNRO, J. L. 1974. The biology, ecology, exploitation and management of Caribbean reef fishes, Scientific Report of the ODA/UNI fisheries ecology research project. 1962-73. Part-VI. The biology, ecology and bionomics of Caribbean reef fishes — Crustaceans (spiny lobsters and crabs) *Univ. West. Indies. Zool. Dep. Res. Rep.* 3: 1-57.

NAIR, R. V., R. SOUNDARARAJAN AND G. NANDAKUMAR. 1981. Observations on growth and moulting of spiny lobsters *Panulirus homarus* (Linnaeus), *P. ornatus* (Fabricius) and *P. penicillatus* (Olivier) in captivity. *Indian J. Fish.* 28: 25-35.

*PATERSON, N. F. 1969. The behaviour of captive Cape rock lobsters, *Jasus lalandii* (H. Milne Edwards) *Ann. S. Afr. Mus.* 52: 225-264.

RADHAKRISHNAN, E. V. AND M. VIJAYAKUMARAN, M. 1982. Unprecedented growth induced in spiny lobsters. *Mar. Fish. Infor. Service. T & E Ser.* No. 43: 6-8.

THOMAS, M. M. 1972. Growth of the spiny lobster, *Panulirus homarus* (Linnaeas) in captivity. *Indian J. Fish.* 19: 125-129.

---

* Not seen in original.