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Growth of the spiny lobster *Panulirus ornatus*, in the Torres Strait.

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Summary

The spiny lobster, Panulirus ornatus, is abundant in the Torres Strait and it supports commercial dive fisheries in both Australia and Papua New Guinea.

Information has been collected on the timing of settlement of lobsters in the field, growth of lobsters in aquaria and growth of lobsters in the field. These data have been combined to estimate the age of lobsters in the Torres Strait.

It appears that the lobsters enter the commercial dive fishery in the second year after hatching and that one and two year old animals form the bulk of the catch. Female lobsters leave the reefs of the Torres Strait to breed at and age of 2.5 years. Although some males probably also leave at this age it appears that a large proportion of males remain on the reefs for one or more years.

The fishery relies on two year classes for the bulk of the catch and is therefore sensitive to annual variation in recruitment success.

Introduction

The life-cycle of Panulirus ornatus in the Torres Strait is characterised by an annual emigration, in which juvenile lobsters leave the reefs in the Torres Strait and walk up to 500 km north-east into the Gulf of Papua before breeding. The entire catch of the fishery in the Torres Strait consists of juvenile lobsters and there are no restrictions on size, however, the fishery is only able to exploit pre-emigratory lobsters. The results of several, separate studies on recruitment and growth have been used to determine the growth of lobsters in the field and estimate the age at which the lobsters in the Torres strait enter the dive fishery and the age at which they leave on the breeding emigration.

Methods

Settlement

- Cairns Harbour
Once a month, between 1982 and 1985 all newly settled Panulirus ornatus were removed (carapace length) from a set of 10 wooden wharf-pilings in Cairns Harbour and measured. The newly-settled lobsters shelter in holes in the pilings and among the fouling growth. They are fairly easily seen because their antennae are disproportionately large and they can be removed from their shelter with a fine piece of wire. Settlement in the sampling area was concentrated in the

- Torres Strait
Between 1981 and 1986, records of the size, date and location of newly settled lobsters were obtained from fishermen and from observations in the course of fieldwork.

Aquarium growth

An initial total of 20 newly-settled lobsters were held in aquaria in Cairns for up to three years. The lobsters were maintained in large (1,000 - 3,000 litre) aquaria in a recirculating water system, fed five times a week and held at ambient light and temperature regimes. Growth was determined by measuring the size increments of newly moulted lobsters.

Field growth

An extensive lobster tagging program has been carried out in both Australia and Papua New Guinea. Animals were tagged with inert, plastic streamer tags inserted dorsally between the carapace and abdomen. The details of the tagging technique and the movements have been reported in Moore and MacFarlane (1984) and Bell et. al (1987). Carapace length was measured at the time of tagging and field growth rates were determined from the size increase of recaptured lobsters. Size increments of 1 mm or less were excluded from the analysis.

Size frequency distributions

The size-frequency distributions of commercial catches were obtained from two different areas. The animals were grouped in 2mm size classes and the distributions were smoothed using a moving average of three. In June 1984, the carapace length of 1404 lobsters was measured from the catch of the diver fishery in the Torres Strait. These animals were taken from the reefs in the Torres Strait and consisted of lobsters that had not yet undertaken the annual emigration. In September, 1984 a second sample of 2,500 lobsters from the catch of commercial prawn trawlers operating in the Great North-East was measured. These lobsters were mainly animals that had left the reefs and begun the emigration, although a small proportion of the catch would have been resident, non-migratory lobsters.

Results

Settlement in Cairns harbour

Settlement of P. ornatus was seasonal, although it may extend over a period of seven months (Fig. 1). Newly settled lobsters appeared in April and May each year and were most abundant between June and August. Newly settled animals were observed as late as October. The lobsters that were removed from the pilings included animals larger than 10mm, which would have been more than one month old. It was assumed that these lobsters had moved into the sampling area from adjacent pilings. The size-frequency distribution of the collected animals confirmed a settlement peak between June and August (Fig. 2) and indicated that, at the end of their first six months in the field recently-settled lobsters had reached a size of at least 20 mm carapac length.

Settlement in Torres Strait

The size-frequency distribution of small lobsters from the Torres Strait suggests that there was slightly earlier settlement than was observed at Cairns Harbour (Fig. 2). However, there were comparatively small sample sizes and it is not possible to determine the precise timing of settlement in the Torres Strait.

Aquarium growth

Of the 20 animals at the start of the aquarium study only five (2 males, 3 females) survived past the first 250 days and there were only four (1 male, 3 females) that survived past day 600.

The growth of the aquarium lobsters was rapid and they reached a size of approximately 40 mm CL after one year, 70 mm in the second year and 100 mm in the third year (Fig. 3). The single male lobster grew more rapidly grew more rapidly than the female lobsters after the second year.

The growth curve was sigmoid, with an initial period of slower growth, followed by rapid growth between 30 and 70 mm CL and then slower growth in larger animals.

Field growth rates

A total of 126 recapture records were available for analysis of growth rates (T le 1). These lobsters were between 38 and 125 mm CL and had been at large for periods between one month and three and a half years (Table 1). A separate growth rate was calculated for each sex and within each sex all lobsters were pooled, regardless of the length of time at large or size at release. Because the animals used in the analysis had undergone different numbers of moults and were recaptured at different stages in the moult cycle there was wide variation in their averaged growth over the period between release and recapture (Fig 4).

A Von Bertalanffy growth curve (Kirkwood and Somers, 1984) was fitted to the data from the recaptured lobsters (Fig. 5). There was little difference between the growth of male and female lobsters until a size of approximately 120 mm CL, after which male lobsters grew to a larger size than females.

Size-frequency distributions

The sample of lobsters from the Torres Strait reefs indicated four distinct size classes in male lobsters and two in females. In the Torres Strait trawl samples there was evidence of two distinct size classes in both males and females (Fig. 6, Table 2).

Discussion

The age of lobsters in the Torres Strait has been estimated by combining the results of all the studies.

Each year class hatches between December and March and January has been used as a an average (MacFarlane and Moore 1986, Bell et al. 1986). After hatching the distribution and movements of larvae are unknown but the timing of settlement indicates that the pelagic stage of the life-cycle may last between three and nine months. It is not known if the source of recruitment to the Torres Strait is the concentration of breeding lobsters in the Torres Strait or the scatttered breeding population along the east coast of Queensland. The timing of reproduction is the same in both locations (MacFarlane and Moore, 1986; Bell at al. 1987)

The newly-settled lobsters have a carapace length of approximately 8 mm and, to estimate generalised growth, May has been used as the time of settlement (Fig 7). The results of the aquarium study have been used as the best estimate of growth immediately after settlement. The small sample sizes in this work make it unreliable

for estimating growth above a size of 50 mm. Using these data it was estimated that, one year after hatching (and seven months after settlement) a lobster would be approximately 30 mm CL (Fig. 7).

The Von Bertalanffy curve from the tagging data has been used to describe the growth of lobsters larger than 45 mm CL. The selection of 45 mm was based on the minimum size of lobsters in the tagging study. From the aquarium work a lobster of 45 mm CL is approximately 15 months old. Using the Von Bertalanffy growth curve from an age of 15 months it is estimated that a two year old animal would be approximately 80mm CL and a three year old lobster would be 110 mm (Table 3).

The Von Bertalanffy curve indicates that there is little difference in the growth of male and female lobsters up to an age of approximately three years. In most spiny lobsters there is sexual dimorphism, with males growing to a larger size than females (Phillips et al. 1983). Because immature lobsters made up the majority of animals used for the Von Bertalanffy curve it is likely that the analysis underestimates the timing and extent of growth differences between the sexes. In any case, the growth rates estimated for P. ornatus in this study are very rapid for a palinurid lobster. Figure 8 summarises the growth of two other species, Panulirus cygnus (Chittleborough 1976, Phillips et al. 1983) and P. homarus (Berry 1971 a,b).

Using these estimated growth rates and the size-frequency distributions from the commercial fishery it appears that the diver fishery is principally exploiting one and two year-old female lobsters and one, two and three year-old male lobsters (Table 4). The size-frequency distribution of the lobsters that had started the breeding emigration (Torres Strait Trawl) indicates a predominance of two year-old females and three-year old males. The start of the emigration is asssociated with the onset of maturity (Moore and MacFarlane, 1984). It would appear that, in the Torres Strait, virtually all female lobsters mature at approximately 2.5 years of age and leave the reefs on the emigration. Some males also mature at that age and follow the same movements, however, the majority of males remain on the reefs in the Torres Strait until the following year. These animals would not breed, although they may mature before the next emigration. Because few 2.5 year-old males participate in the emigration the size-frequency distributions of males in the Torres Strait includes three and four year-old classes.

A characteristic of the lobsters that undertake the emigration is a sex-ratio biased strongly against males. In some cases there may be twice as many females as males (Moore and MacFarlane 1984). This reflects the fact that, in any given year-class, the majority of females leave the reefs to breed but only a proportion of males.

Because all the lobsters caught by the diver fishery are immature there is no biological reason to impose a minimum size on the fishery. There is an economic benefit associated with a minimum size-limit because it would allow animals to grow to a larger size at capture and increase the yield per lobster. It is possible that the fishermen will see a minimum-size limit as desirable and request it's introduction.

The most important feature of the Panulirus ornatus fishery in the Torres Strait is that it exploits only two main year-classes. A single year of poor recruitment will affect the catch of the fishery in the following two years and this makes the fishery very sensitive to fluctuations in recruitment. At present the principal determinants of recruitment success are thought to be the environmental influences on the pelagic stage of the life-cycle, but changes in fishing effort, and particularly the increasing use of compressed-air diving equipment are being monitored carefully.

References

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Table 1

Numbers of lobsters tagged and recaptured in the Torres Strait and which were used for analysis of growth

Sex	Number	Days at Large	Size at release (CL)
Males	67	27 - 651	38.1 - 125.5
Females	59	34 - 1331	41.8 - 124.3

Table 2

Modal size-classes in the length-frequency distributions of commercial lobster catches from the reefs in the Torres Strait and from a trawl sample of lobsters which had receptly started the breeding emigration.

		Mode 1	Mode 2	Mode 3	Mode 4
Torres Strait Reef					
	Males	64-66	108-110	123-125	138-140
	Females	60-62	100-102		
Torres Strait Trawl					
	Males		70-72	120-122	
	Females		70-72	108-110	

Table 3

Estimated carapace length of Panulirus ornatus in the Torres Strait. a = aquarium growth data, t = tagging growth data

Data	Age (years)	Males	Females
	0	0.0	0.0
a	0.33	6.3	6.3
a	0.50	9.6	9.6
a	0.75	17.1	17.1
a	1.00	29.9	29.9
t	1.25	46.1	47.0
t	1.50	58.1	60.3
.	1.75	69.0	71.7
.	2.00	78.8	81.5
.	2.25	87.6	90.1
.	2.50	95.6	97.5
.	2.75	102.9	103.9
.	3.00	109.4	109.3
.	3.25	115.3	114.1
.	3.50	120.7	118.2
.	3.75	125.5	121.7
.	4.00	129.9	125.8
.	4.25	133.9	127.4
.	4.50	137.4	129.7
.	4.75	140.7	131.7
.	5.00	143.6	133.4

Table 4

Principal features of the growth of Panulirus ornatus in the Torres Strait

Stage	Age	Size (Carapace length)
Hatching		
Settlement	3 - 9 months	6 - 8 mm
Enter fishery	18 months	60 mm
Start emigration		
Females	2.5 years	100 mm
Males	2.5 and 3.5 years	100 and 125 mm

List if Figures

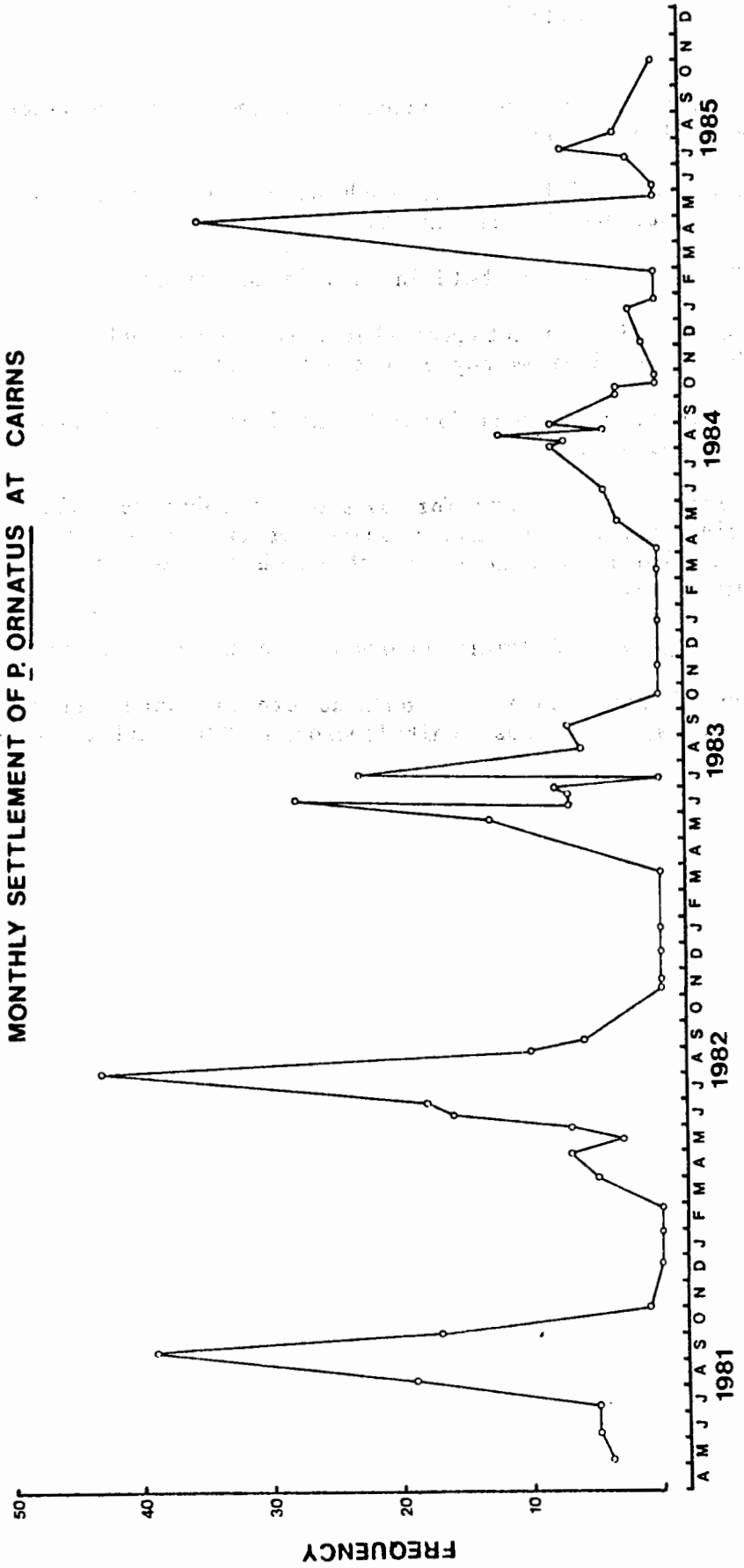

MONTHLY SETTLEMENT OF P. ORNATUS AT CAIRNS
FREQUENCY
50
40
30
20
10
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1981
1982
1983
1984
1985

FIGURE 1

Size frequency of juvenile Panulirus ornatus 1981 - 1985

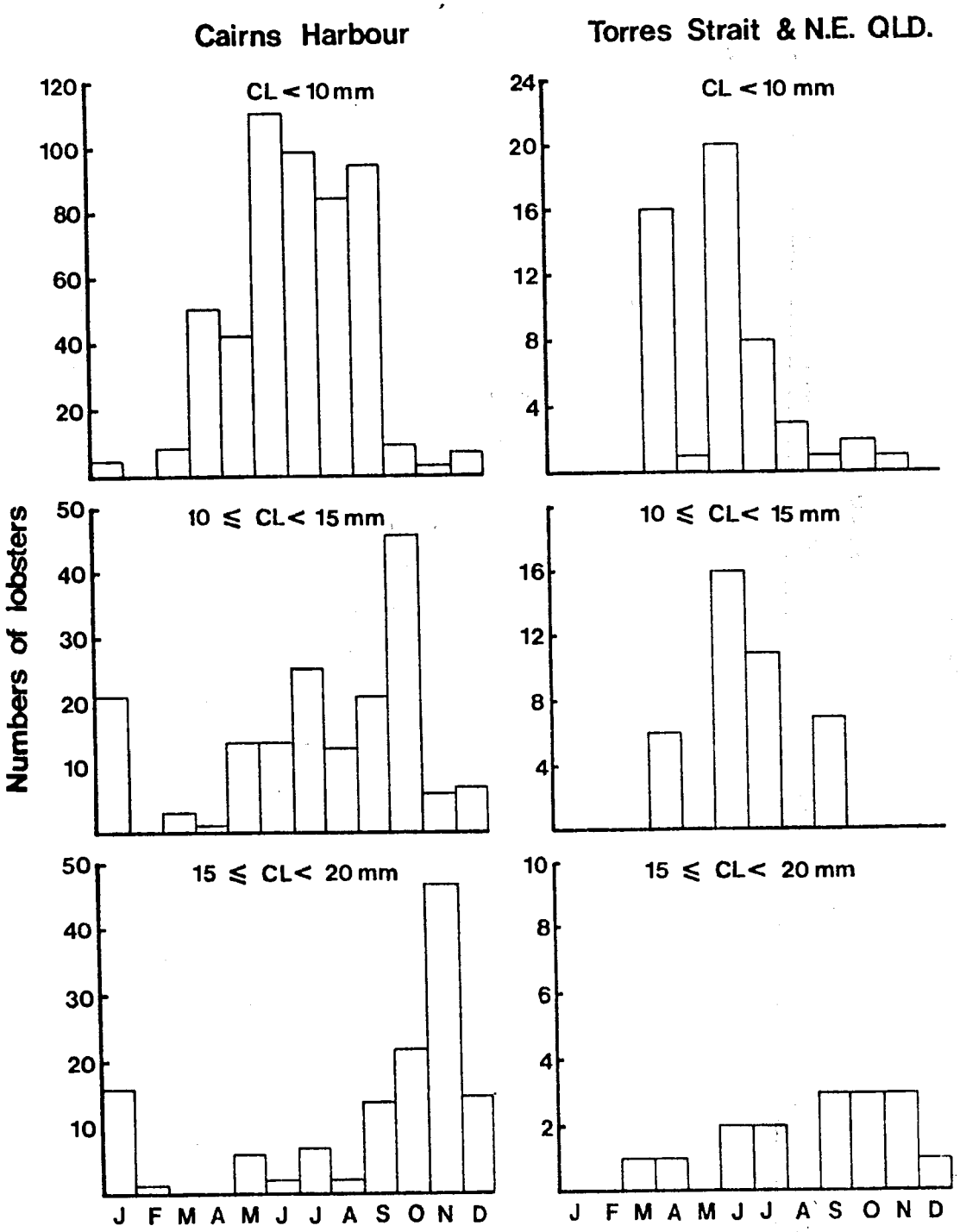


FIGURE 2

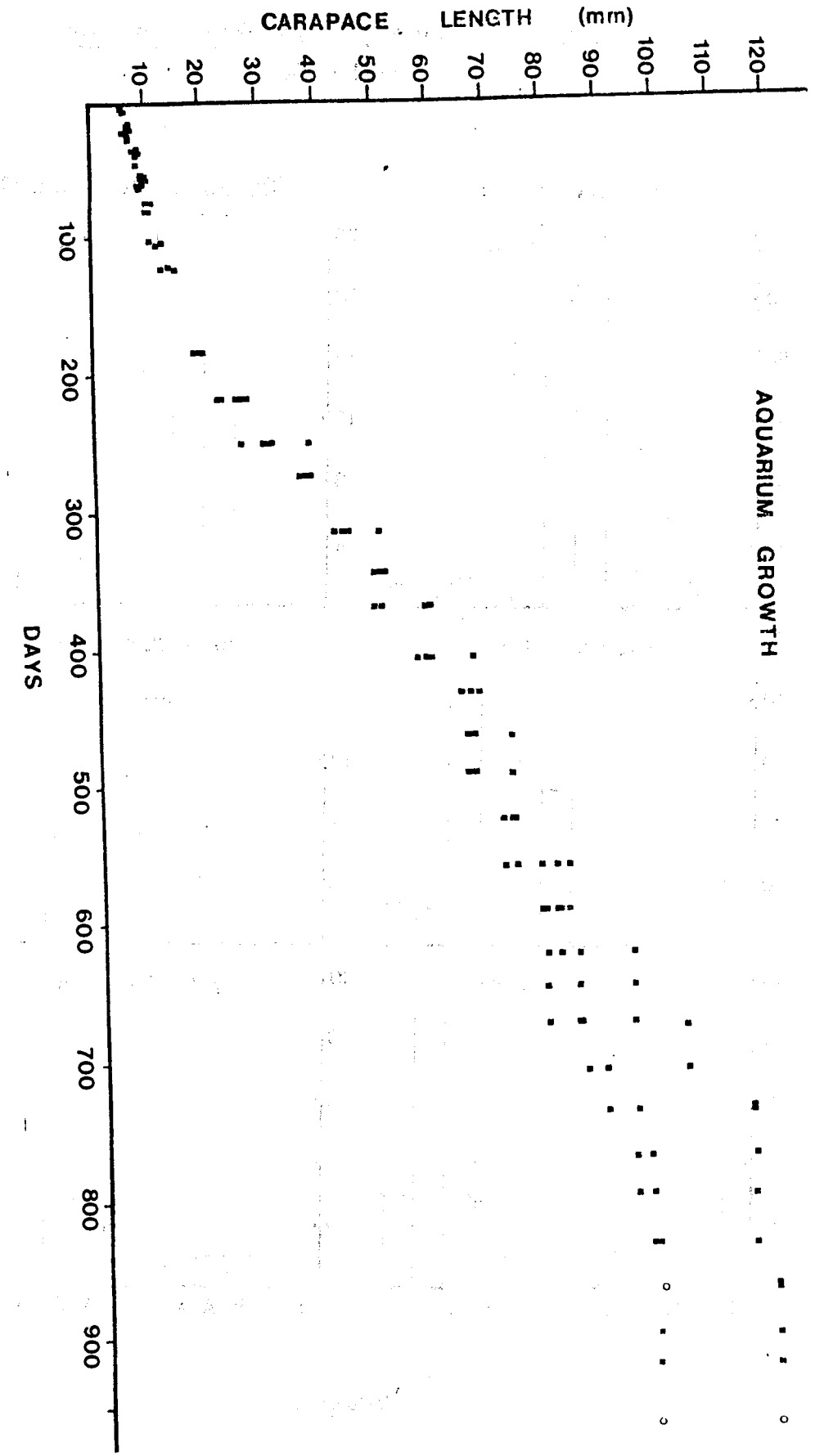

CARAPACE LENGTH (mm)
10
20
30
40
50
60
70
80
90
100
110
120
DAYS
100
200
300
400
500
600
700
800
900
AQUARIUM GROWTH

FIGURE 3

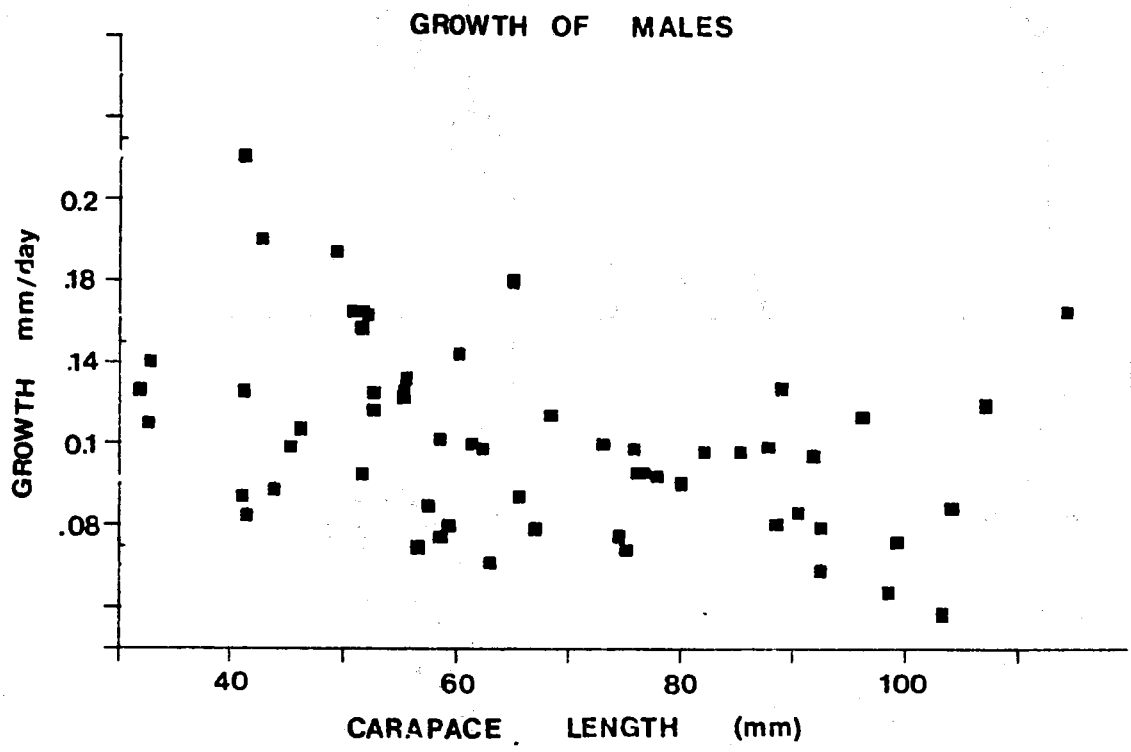

GROWTH OF MALES
GROWTH mm/day
0.2
.18
.14
0.1
.08
40
60
80
100
CARAPACE LENGTH (mm)

FIGURE 4

LENGTH – FREQUENCY DISTRIBUTIONS

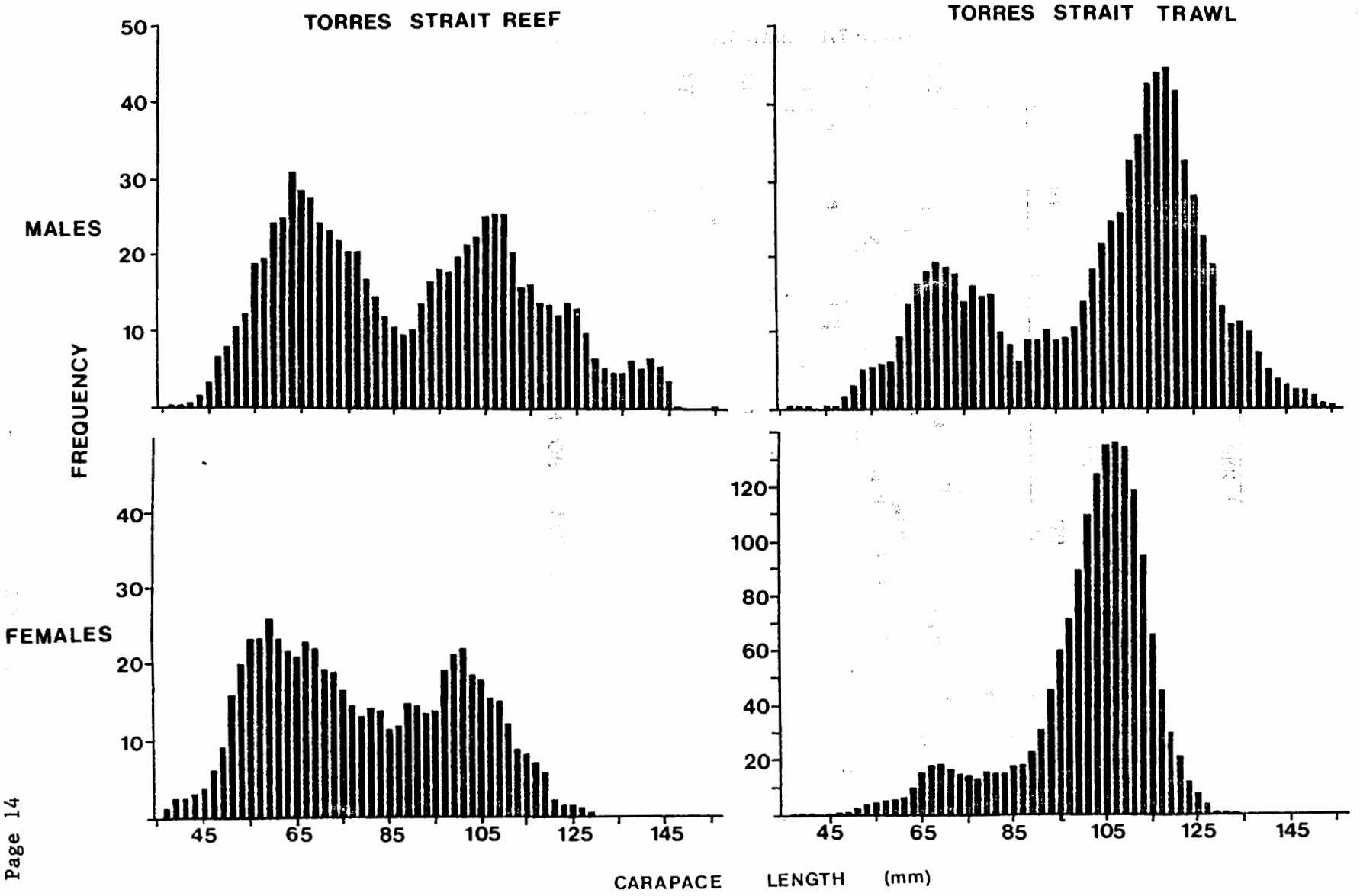
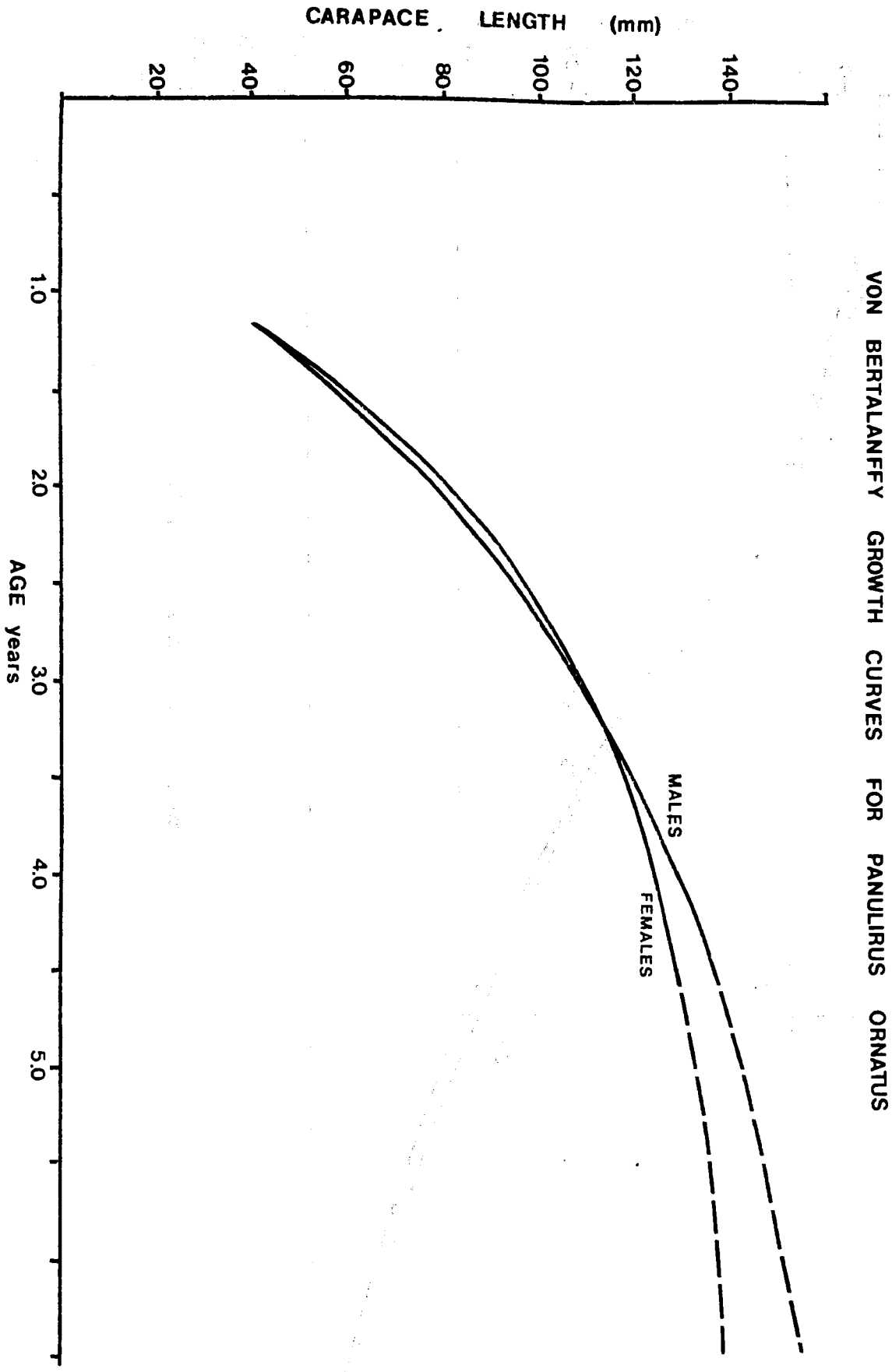


FIGURE 5



VON BERTALANFFY GROWTH CURVES FOR PANULIRUS ORNATUS

FIGURE 6

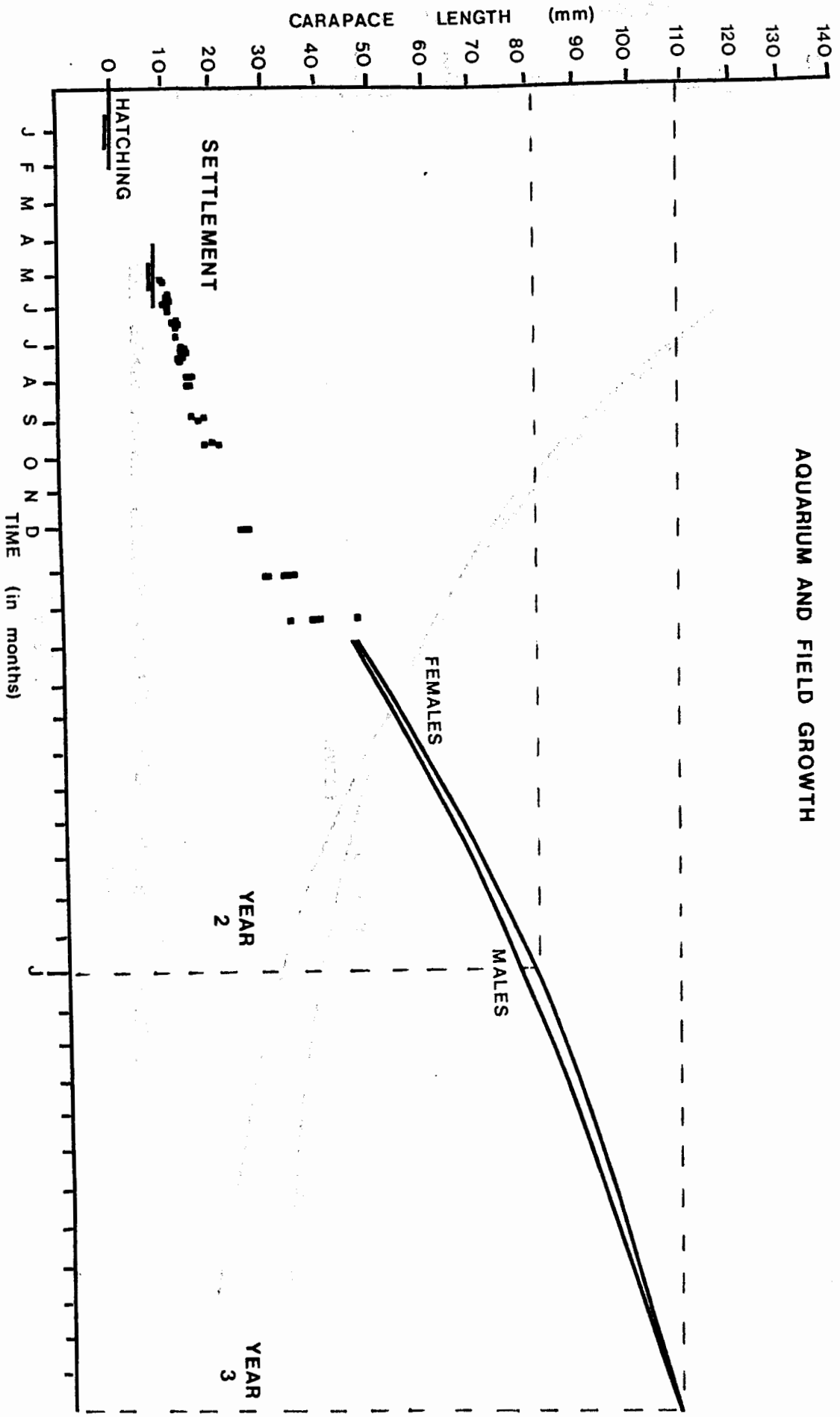

CARAPACE LENGTH (mm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
HATCHING
SETTLEMENT
J F M A M J J A S O N D J
TIME (in months)
YEAR 2
YEAR 3
FEMALES
MALES
AQUARIUM AND FIELD GROWTH

FIGURE 7

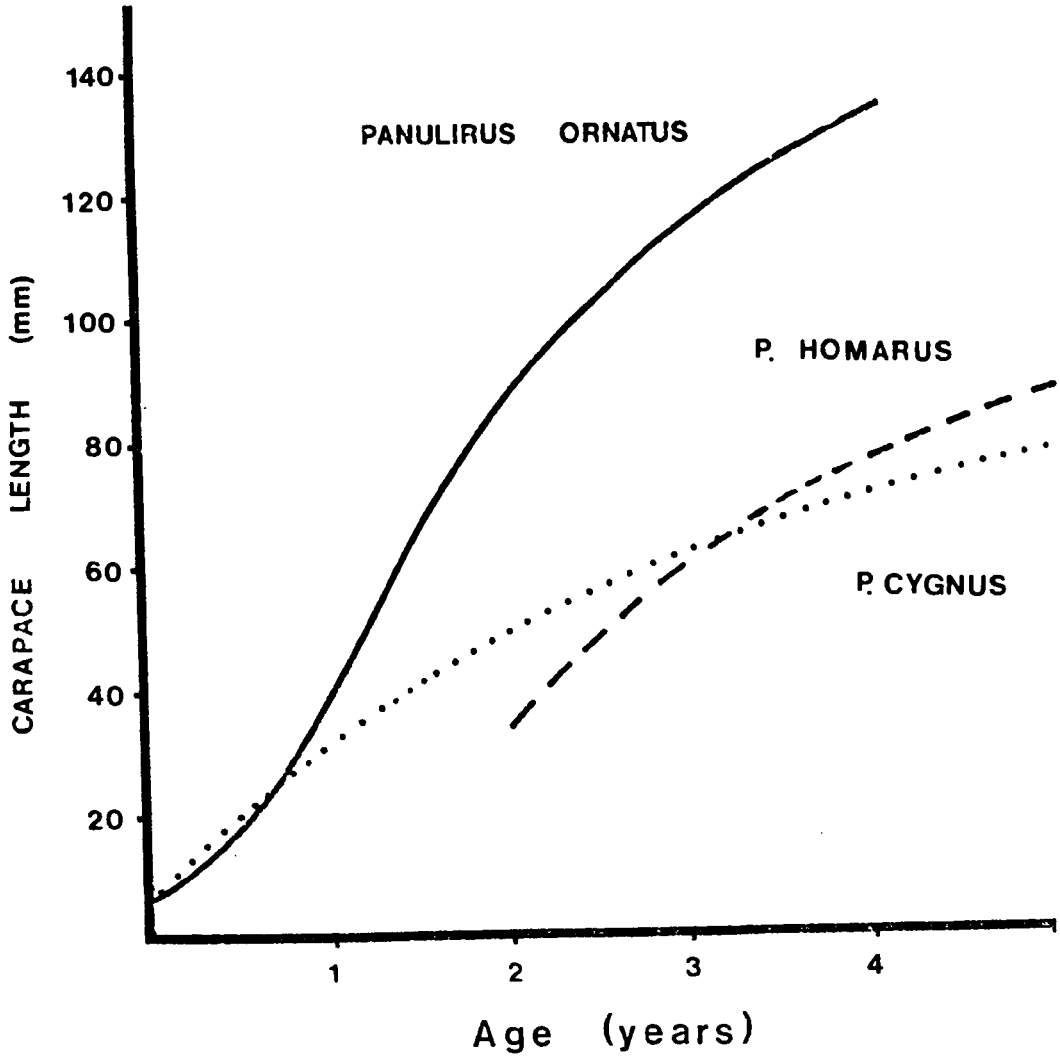

140
120
100
80
60
40
20
CARAPACE LENGTH (mm)
PANULIRUS ORNATUS
P. HOMARUS
P. CYGNUS
1
2
3
4
Age (years)

FIGURE 8