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STUDIES ON THE PHYLLOSOMA LARVAE FROM THE INDIAN OCEAN : I - DISTRIBUTION AND GROWTH

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ABSTRACT

The paper deals with the growth pattern, numerical abundance and depth-wise distribution in relation to the stage of development and day and night hauls of palinurid and scyllarid phyllosoma larvae. The vertical distribution of these larvae in relation to the density of the water is also discussed. The study is based on the material collected from the Indian Ocean by the *DANA* Expedition, 1928-30.

INTRODUCTION

THE EARLIER studies by Tampi and George (1975) and Prasad *et al.* (1975) have provided some knowledge, mainly on the systematics and general distribution of phyllosoma larvae occurring in the Indian Ocean as a whole. Amongst these works, Prasad *et al.* (1975) had also indicated briefly the distribution of the larvae in relation to certain oceanographical factors. Saisho (1966) studied the horizontal distribution of phyllosomas in the Indian Ocean with reference to oceanographical conditions based on material collected during the International Indian Ocean Expedition by the Research Vessel *Kagoshima-maru* in 1963-64. While this study included several species of phyllosoma larvae, as in the case of material collected by the *DANA* Expedition, detailed studies on the dispersal and distribution in relation to environmental factors have been made only on one or two species *viz.*, *Panulirus interruptus* (Johnson, 1960) and *P. cygnus* (Chittleborough and Thomas, 1969 ; Ritz, 1972 ; Rimmer and Phillips, 1979). The investigations of Rimmer (1980) on the spatial distribution of the early stages of the phyllosoma of *P. cygnus* have shown that it is contagious or 'patchy'. The patchiness has been attributed partly to the uneven distribution of the breeding females on the bottom at the time of the release of the larvae which form a dense patch in the water column above the area of release. Rimmer (1980) also observed

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that the offshore transport of the larvae is rapid after hatching and recorded large numbers of the first stage of phyllosoma more than 110 km beyond the shelf edge.

Further to the results of the studies already reported, the material collected during the *DANA* Expedition is now examined more critically with particular emphasis on the growth of the larval stages of selected species, distribution of palinurid and scyllarid phyllosoma larvae in relation to the stage of development, depth, time of collection (day or night) and the density of water.

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Growth Pattern

In order to ascertain whether the various stages assigned to the different species form a regular series, growth curves were constructed in the case of seven species of palinurids and five species of scyllarids. These have been selected owing to the fact that data on a fairly complete series of the stages were available. In constructing these growth curves the range of the total body length of the larvae assigned to the different stages was plotted against each stage and mid points of the range were connected by a curve. The species thus studied are *Panulirus homarus* (Fig. 1 a), *P. penicillatus* (Fig. 1 b), *P. polyphagus* (Fig. 1 c), *P. versicolor* (Fig. 1 d), *P. ornatus* (Fig. 2 a), *P. longipes* (Fig. 2 b), *P. weineckii* (Fig. 2 c) amongst the palinurids and *Scyllarus cultrifer* (Fig. 2 d), *S. rugosus* (Fig. 3 a), *S. martensii* (Fig. 3 b), *S. batei* (Fig. 3 c) and *Parribacus antarcticus* (Fig. 3 d).

It will be seen from these figures that in all species mentioned above the growth curve conforms to the general pattern. By and large the rate of growth appears to be faster in palinurids than in scyllarids with the exception of *S. batei*, *S. cultrifer* and *P. antarcticus* which resembles that of the palinurids. The growth rate of *S. rugosus* and *S. martensii* appears to be rather slow. This could perhaps be related to the maximum size attained by the adults. Most of the species seem to have 11 to 12 stages before the phyllosoma larvae metamorphose into the puerulus or the nisto as the case may be.

In the field laboratory of the Central Marine Fisheries Research Institute at Kovalam near Madras it has been possible to rear the larvae of *P. homarus* in aquaria up to the sixth stage. In order to check whether the series of larvae collected during the Expedition and described as *homarus* by Prasad *et al.* (1975) belong to this species, a comparison of the ratio of the cephalic disc length/cephalic disc width of the two sets of larvae was made. In this context it should be mentioned, however, that in the case of the aquarium reared ones stages III, IV and V have been sub-divided as III a, III b and III c; IV a and IV b and V a and Vb. In calculating the ratios for the present comparison the averages of the ratios of these sub-divided stages have been taken*. It would be seen from

* Thanks are due to S/Shri E. V. Radhakrishnan and M. Vijayakumaran for the data of cephalic disc length/width ratio of the aquarium grown phyllosoma larvae.

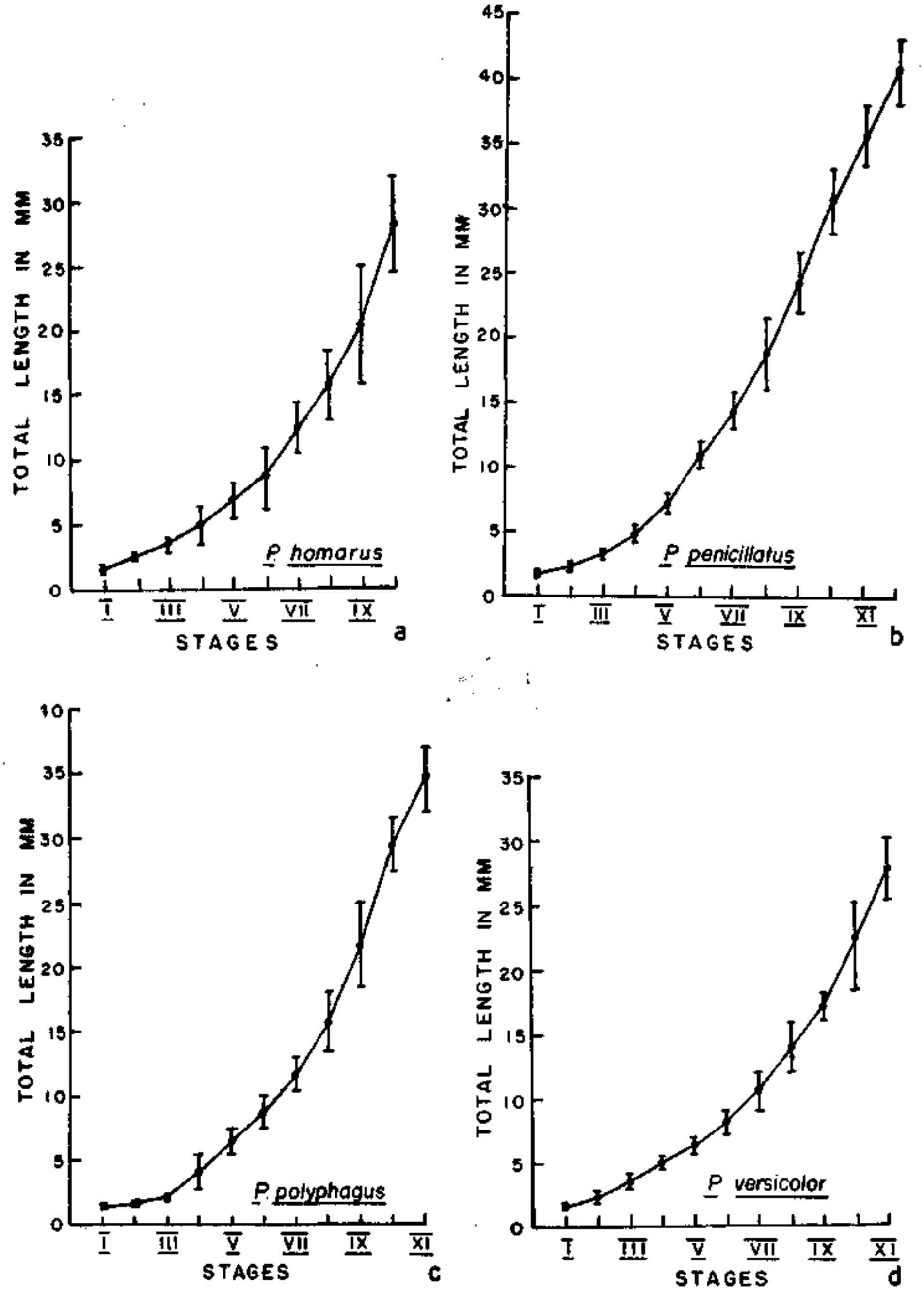


Fig. 1. The growth pattern of : a. *Panulirus homarus*, b. *P. penicillatus*, c. *P. polyphagus* and d. *P. versicolor*.

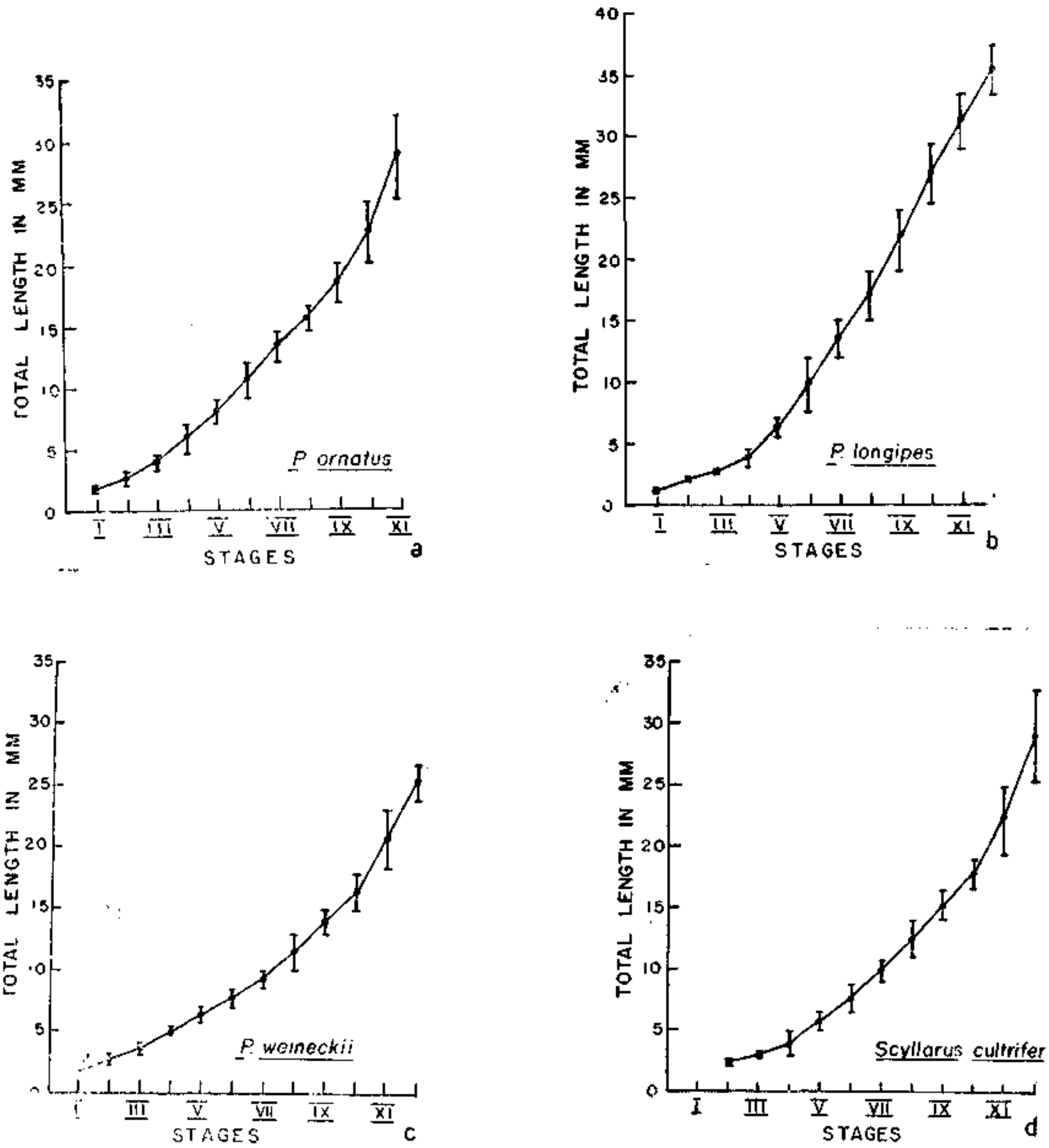


Fig. 2. The growth pattern of: a. *Panulirus ornatus*, b. *P. longipes*, c. *P. weineckii* and d. *Scyllarus cultrifer*.

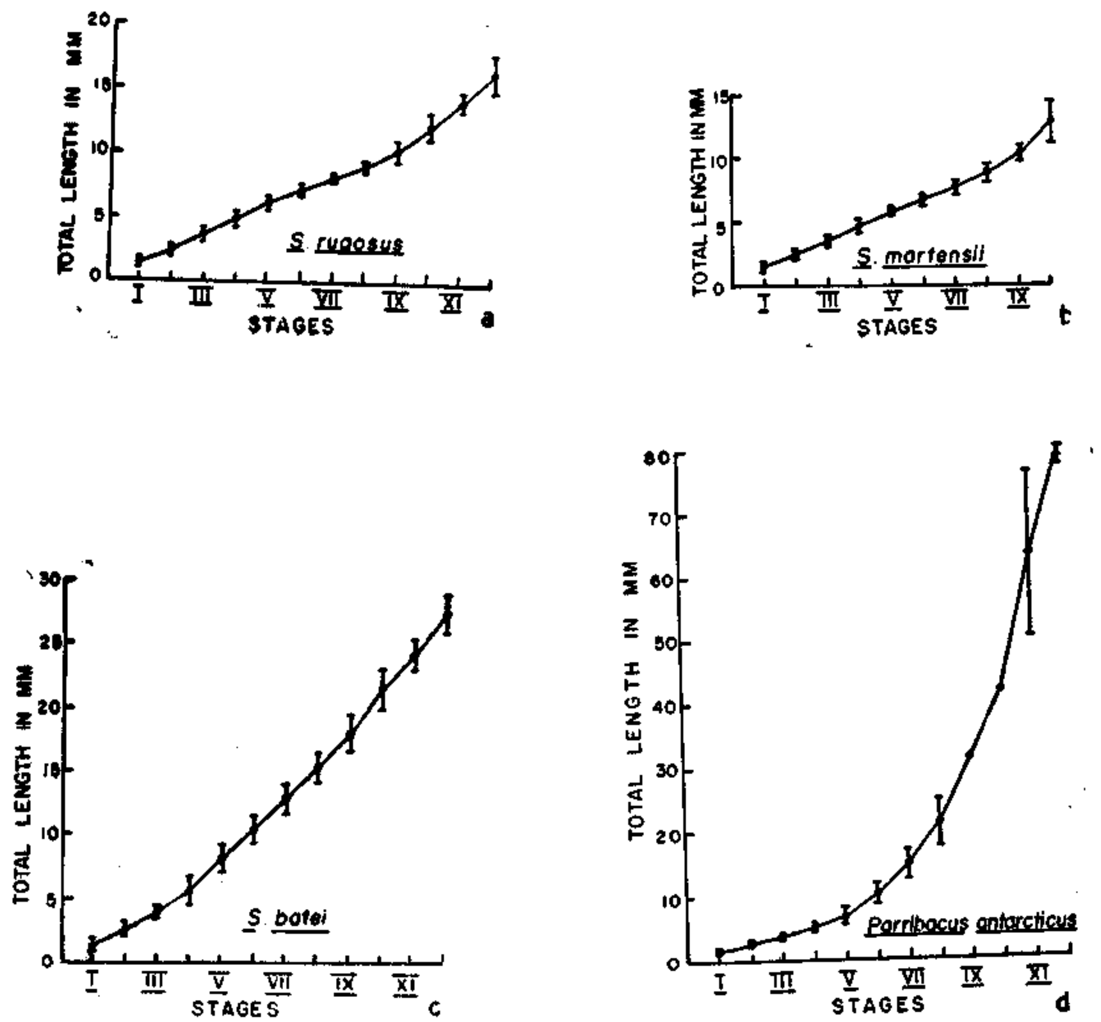


Fig. 3. The growth pattern of : a. *Scyllarus rugosus*, b. *S. martensii*, c. *S. batei* and d. *Parraibacus antarcticus*.

Fig. 4 that there is a close similarity in the trend as well as the actual ratios. This would further seem to confirm that the stages of larvae assigned are those of *P. homarus*.

similar as regards palinurids and scyllarids are concerned (Table 1). It would be seen that there is a concentration of larvae at 50 and 100 m and to a lesser extent at 200 and 300 m. At

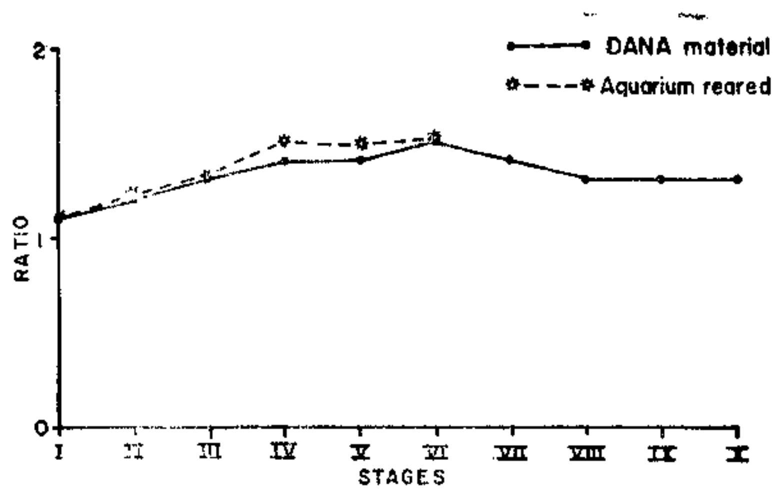


Fig. 4. The ratio of the cephalic disc length/cephalic disc width of the larvae of *Panulirus homarus* of the *DANA* collection and those grown in the aquarium.

Numerical Abundance and Vertical Distribution

The collection, as reported earlier, comprises 1983 phyllosoma larvae consisting of 1087 palinurids and 896 scyllarids (Prasad *et al.*, 1975). As 103 larvae amongst these were damaged and appropriate stages could not be determined these have not been included in the present study. The total number of larvae dealt with in this paper is therefore only 1880 of which 1076 are palinurids and 804 scyllarids.

It is seen that the first stage as well as the last two or three stages *viz.*, stages X to XII are few. Sixty-six per cent of the total number of larvae are accounted for by the stages II to VI, while 90 per cent constitute stages II to IX. Generally speaking the relative numerical abundance of the different stages of larvae is

all these depths the first stage as well as the advanced stages are few, the dominant ones being stages II to IX.

The occurrence of the larvae has been classified according to day and night hauls. This has shown the interesting fact that there were extremely few larvae which were collected during the day time. Out of the 1076 palinurid phyllosomas only six were present in the day hauls and similarly only 40 larvae were obtained in the day hauls out of a total of 804 scyllarid phyllosomas. This shows that out of the total number of larvae of all stages collected only 2.4 per cent were taken in the day time. The stage-wise distribution of these during day and night hauls is shown in Fig. 5. It would be seen from this figure that in the case of palinurids stages II, VI, IX, X and XI alone were present in the day hauls, while in the case of scyllarids I to VI were present and the later stages were not represented. The very low percentage of larvae represented in the day hauls of the present series is not surprising since out of the 88 stations from which 210 samples were collected only in 5 stations day hauls were taken. Consequently the distribution pattern during the day and night hauls is not comparable because of the very few samples taken in the day time and it is not possible to say whether the larvae have a tendency to move upward at night. In the case of *P. longipes*, Sheard (1949) observed in Australian waters Conception to the southern end of the survey area, 57 per cent were taken at night, and of 3,358 larvae (all stages) taken, 55 per cent were taken at night. An additional analysis considering individual stages indicates that most stages of development were caught in larger total numbers at night than in the day time (Fig. 3). Also, for each stage the percentage of night stations yielding larvae was larger in all instances, especially so for the later stages (Table 1). Thus the data do suggest some migration upward at night.'

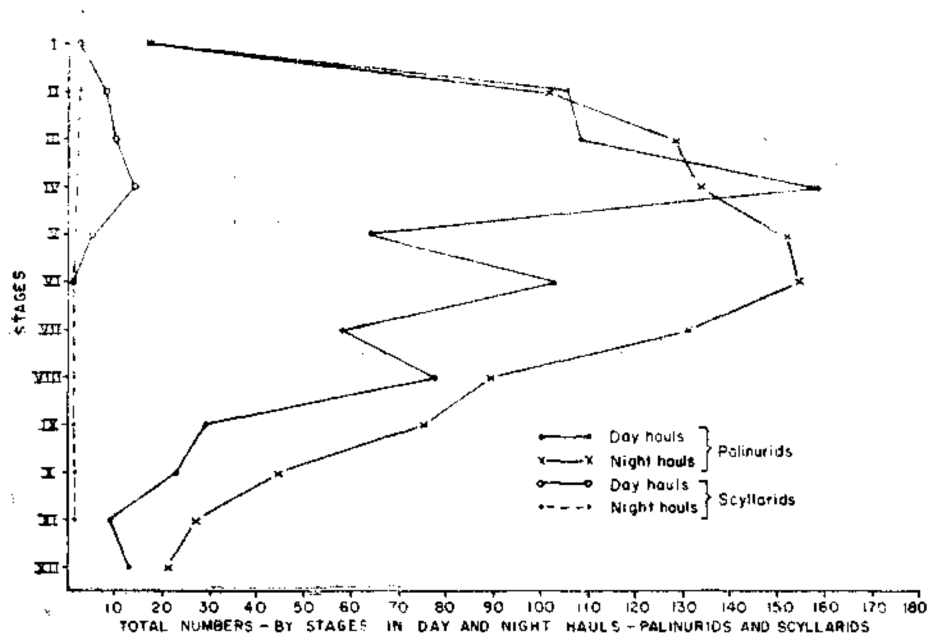


Fig. 5. The stage-wise distribution of palinurid and scyllarid phyllosoma larvae in day and night hauls.

that the early phyllosoma stages of this species are strongly attracted by bright light. Smith (1958) also reported the same sort of reaction to light in so far as the larvae of the different species off Florida. Johnson (1960) has reported that 'Of 790 stations that were successful for phyllosoma larvae over the area from Point

Chittleborough and Thomas (1969) and Rimmer and Phillips (1979) observed that the phyllosoma of *P. cygnus* undergo a diel vertical migration in the upper part of the column of water, moving up towards the surface at dusk and descending as dawn approaches. Chittleborough and Thomas (1969) has suggested that

TABLE 1. *Depth-wise distribution of Palinurid (P) and Scyllarid (S) phyllosoma larval stages*

Stages / Depth (m)	I		II		III		IV		V		VI		VII		VIII		IX		X		XI		XII		Total		Total of P & S
	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	
Surface	—	—	—	—	—	1	—	—	1	—	1	—	1	—	1	—	1	—	1	—	—	—	—	—	6	1	7
50	4	7	52	55	80	62	83	85	109	33	99	44	71	18	45	30	16	7	12	3	8	2	7	6	586	352	938
100	2	4	30	32	24	32	25	51	23	23	41	34	25	17	26	19	35	9	14	7	5	2	7	6	257	236	493
150	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2
200	2	—	6	2	2	2	10	3	5	1	7	5	16	6	9	4	14	3	7	3	4	—	2	—	84	29	113
250	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	1	1	2
300	6	7	3	18	13	12	9	28	8	10	4	15	14	14	5	22	7	8	5	8	7	3	4	1	85	146	231
400	—	—	—	1	—	1	—	1	—	—	—	2	—	—	—	—	—	—	1	—	—	—	—	—	1	5	6
500	—	—	4	1	6	2	4	1	3	1	1	1	3	1	1	1	1	—	—	1	1	1	—	—	24	10	34
600	1	1	8	4	3	6	2	3	1	1	—	3	—	1	1	1	—	2	1	—	1	—	—	—	18	22	40
1000	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	2	1	1	—	—	—	5	1	6
2000	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—	2	1	3
2500	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	2	—	2
3000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	1
3500	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	2	—	2
Total	16	19	103	113	128	118	133	172	151	69	155	104	131	58	89	77	76	29	45	23	28	9	21	13	1076	804	1880
Total of P & S	35		216		246		305		220		259		189		166		105		68		37		34		1880		

the phototactic responses of these larvae change as they develop, the advanced larvae being probably more strongly negatively phototropic than the earlier stages. This has been confirmed by Rimmer and Phillips (1979). It is further observed that early stages of the phillosoma tend to concentrate at the surface at night, regardless of the intensity of the moonlight and between 30-60 m depth during the day. Mid and late stages of phyllosoma of *P. cygnus*, on the other hand, concentrate at the surface only on dark nights avoiding the surface when the moonlight illuminance exceeds 5 per cent of the moon light (Ritz, 1972; Rimmer and Phillips, 1979). Phillips (1981) has stated that 'It is hypothesized that the phyllosoma follow isolumes of optimal illuminance, the depth to which the larvae descend during the day being related to the lower limit of the euphotic layer (1% irradiance at the surface) (Rimmer and Phillips, 1979) . . . Because of the increased turbidity near the coast the isolumes tend to be deeper offshore and this may partly account for the deeper distribution of the mid and late stages.'

Vertical Distribution in Relation to Density

Table 1 shows that there is a greater concentration of larvae of both palinurids and scyllarids at 50 and 100 m and again on a lower magnitude at 200 and 300 m. The bulk of this, as mentioned earlier, is composed of stages II to IX which would mean mostly the early and mid stages and a lesser number of the late stages. Irrespective of the stage, the available data seem to indicate that the phyllosomas avoid strong light by moving away from it. However, the concentration of the larvae at 50 and 100 metres and further down at 200 m and 300 m during night (as most of the collections were made at night) raises the question whether factors other than light play any significant role in the pattern of vertical distribution. In this connection the vertical distribution of the larvae in relation to σt has been plotted for selected stations where hydrographic observations have been made and where fairly good number of larvae have been taken. These include station numbers 3809, 3824, 3828, 3844, 3860, 3922, 3962 and 3971 (Figs. 6 to 13). These figures clearly suggest that the density of water exerts an influence in the matter of vertical distribution of the larvae. In this connection Prasad *et al.* (1975) had stated that 'Almost at all stations the pycnocline was strong and well stratified in the vertical. The presence of a surface mixed layer, where the vertical gradients are weak, was found only up to 10 ° S latitude on the eastern part of the Indian Ocean. In areas where there was a mixed layer, the pycnocline started at about 100 m, whereas in the other areas the average depth where pycnocline started was 40-50 m. The density increase was very small from 200-300 m downwards compared to the upper layers. Therefore, the greater concentration of larvae in the upper 100 m seems to be closely related to the distribution of the pycnocline which acts as an effective barrier for the vertical movements of the phyllosomas.'

According to Chittleborough and Thomas (1969) and Rimmer and Phillips (1979) the thermal discontinuity does not appear to act as a barrier for the vertical diel movements of phyllosoma larvae. Austin (1972) has, however, observed to the contrary in the case of phyllosoma larvae of *Panulirus* spp. in the Gulf of Mexico. Further detailed investigations based on samples collected specifically with a view to understanding the effect of various environmental factors on the distribution and migration of the phyllosoma larvae would be required to draw more precise conclusions.

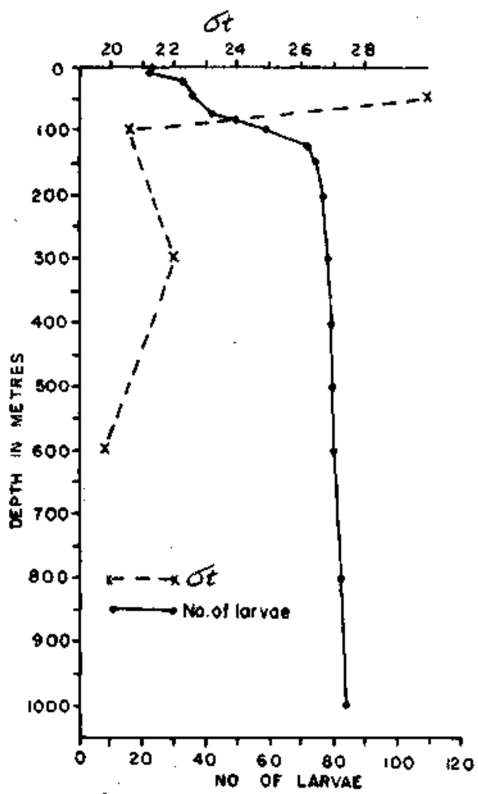


Fig. 6. The vertical distribution of total phyllosoma larvae in relation to density at Station No. 3809.

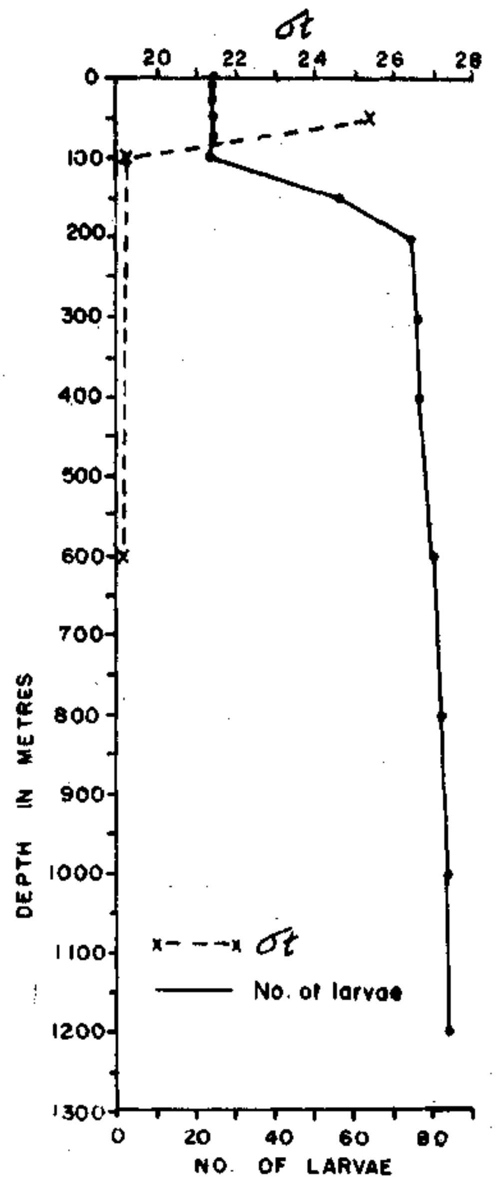


Fig. 7. The vertical distribution of total phyllosoma larvae in relation to density at Station No. 3824.

Erratum : In figures 6 to 13 the broken line represents the number of larvae and the continuous line represents σt.

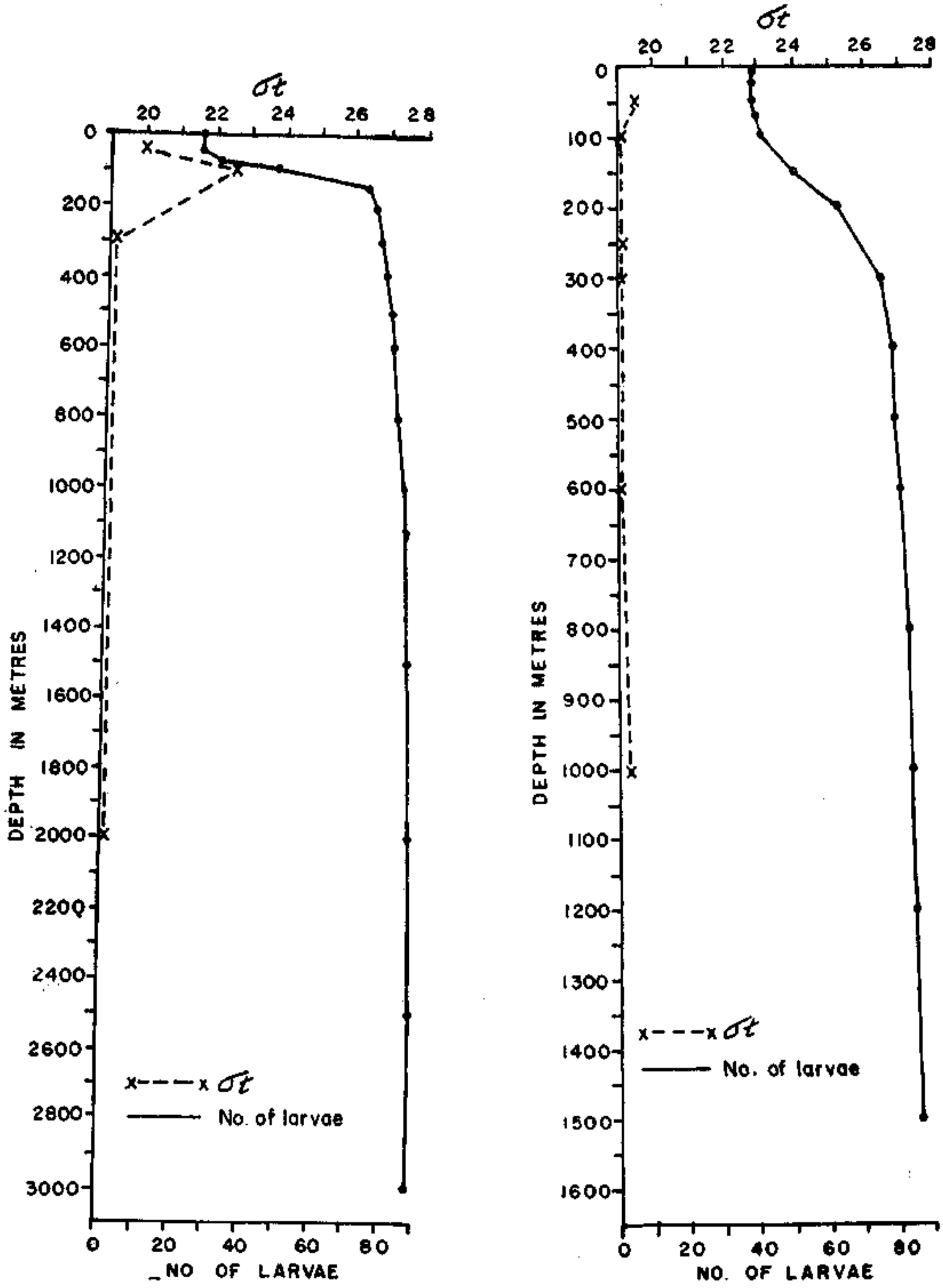


Fig. 8 & 9. The vertical distribution of total phyllosoma larvae in relation to density at Station No. 3828 & 3844.

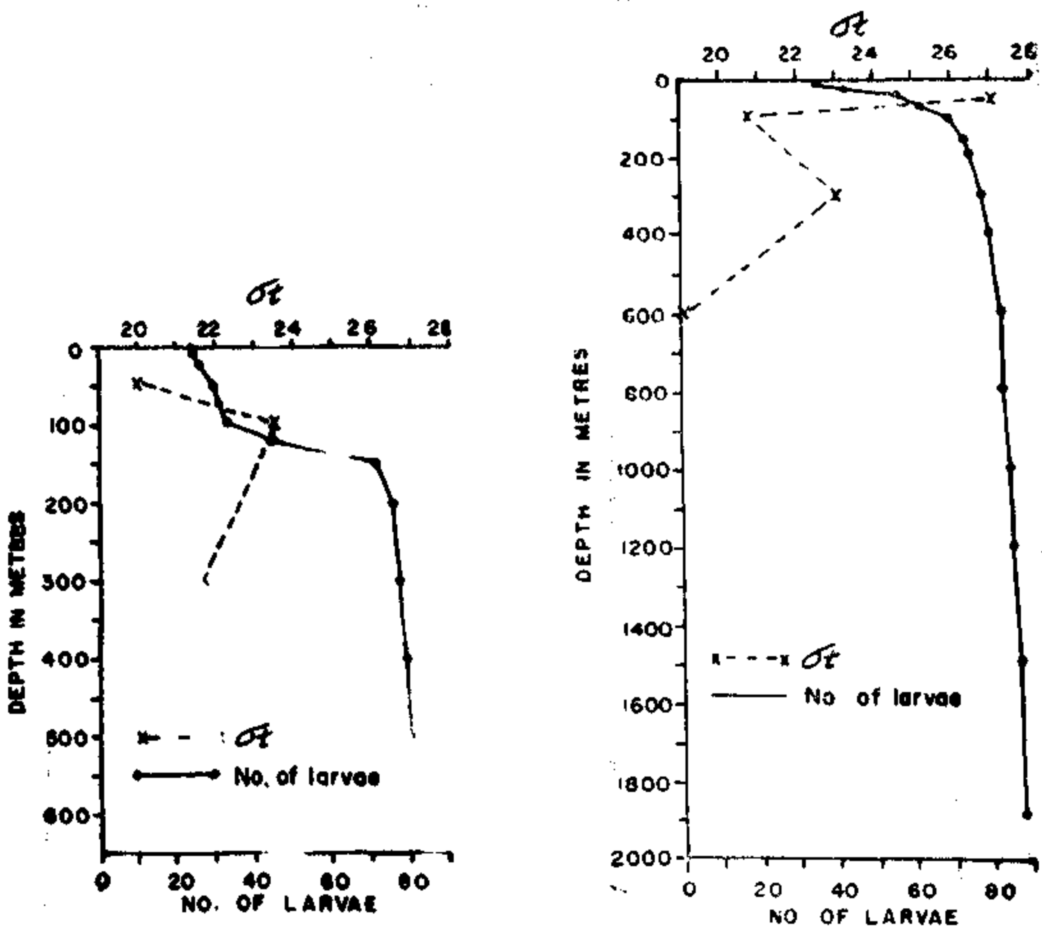
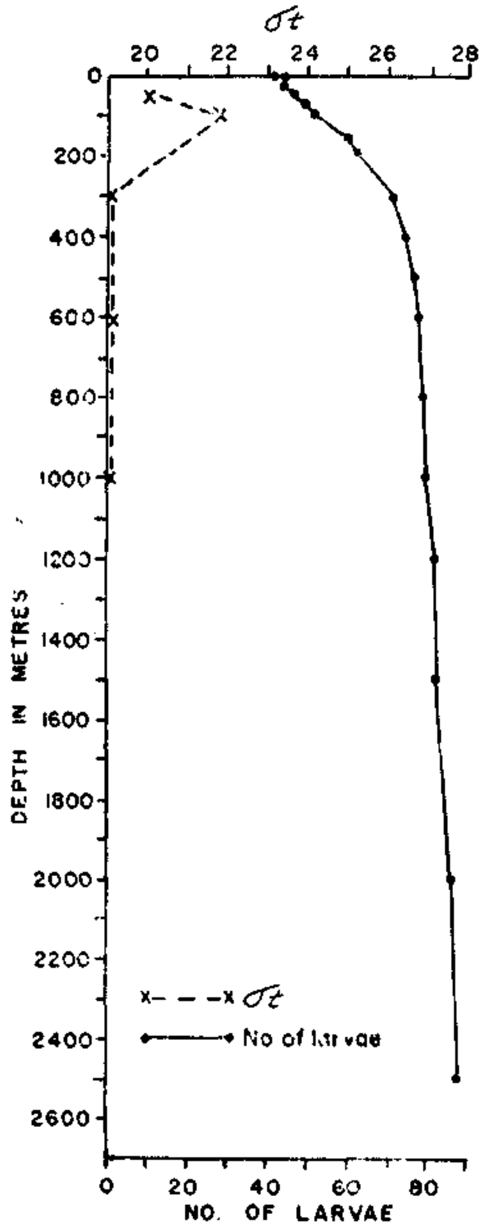


Fig. 10 & 11. The vertical distribution of total phyllosoma larvae in relation to density at Station No. 3860 & 3922.



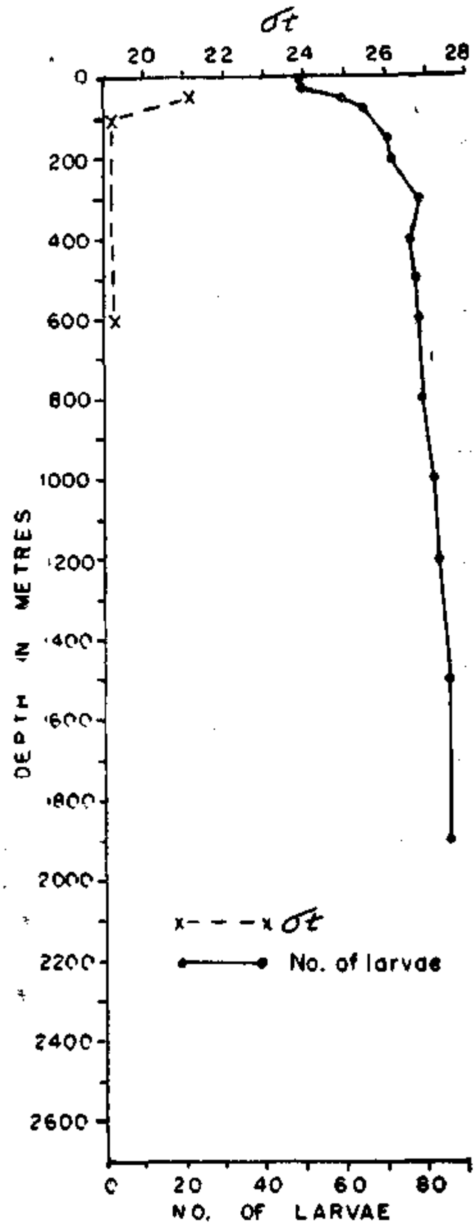


Fig. 12 & 13. The vertical distribution of total phyllosoma larvae in relation to density at Station No. 3962 & 3971.

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