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PHYLLOSOMA LARVAE FROM THE INDIAN OCEAN COLLECTED BY THE *DANA* EXPEDITION 1928 - 1930

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ABSTRACT

The systematics of the phyllosoma larval forms collected by the DANA Expedition in 1928–30 from the Indian Ocean region is dealt with in the contribution. Out of the 1983 larvae, 1087 were those of species belonging to the family Palinuridae and 896 of the family Scyllaridae. Among the palinurids, 10 species belonging to 4 genera, namely, *Panulirus versicolor, P. homarus, P. longipes, P. ornatus, Palinurellus weineckii, Panulirus polyphagus, P. penicillatus, Palinustus mossambicus, Panulirus* sp. I and *Puerulus angulatus* were recorded in the order of abundance. The scyllarids belonged to 12 species under 5 genera and in their order of abundance they were *Scyllarus martensii, S. rugosus, S. cultrifer S. amabilis, S. batei, Parribacus antarcticus, Scyllarides* sp., *Scyllarus* sp. I, *Thenus orientalis, Scyllarus* sp. II, *Scyllarus* sp. III and *Evibacus* sp. Based on the material available in the collection and in a few cases on descriptions of certain stages given by earlier authors, the salient features in the different stages of development of the different species are summarised in Tables. A higher concentration of larvae contributed by palinurids was observed in the western half of the Indian Ocean.

INTRODUCTION

THE INDIAN OCEAN has some of the richest lobster fishing grounds, apparently on account of the ideal habitats provided by the rocky coasts or the coral reefs fringing the continents of Africa, Asia and Australia. The numerous offshore islands in this region also afford colonisation of a variety of crustaceans, especially the spiny lobsters. The general account of the distribution of the lobsters in the Indian Ocean (Prasad and Tampi, 1968) would reveal the diversity of species inhabiting this region. Consequent on the occurrence of many species it is only natural to expect a large number of larval forms also. But our knowledge of these larvae had remained quite meagre largely because of the problems connected with their proper identification. Ever since Gurney (1936) published an account of the phyllosoma collections of the Discovery Expedition, there has been a spate of publications on the phyllosoma from many other regions. However, in regard to the positive identification of the larvae of the different species, only limited publications such as those of Von Bonde (1936), Aikawa and Isobe (1955), Feliciano (1956), Harada (1957), Prasad and Tampi (1959, 1960), Saisho (1964), Ong (1967), Mohamed *et al.* (1971) and Sankolli and Shenoy (1973) are valuable in as much as these are based largely on larvae hatched from the eggs. Even in these cases only the newly hatched larva, or at best two or three early stages alone, have been described while in many others the subsequent larval stages have been worked out by correlating the characters or from circumstantial evidence. On this basis we now have some fairly reliable information on the diagnostic characters of phyllosoma larvae of many species, of both palinurids and scyllarids.

In so far as the Indian Ocean phyllosomas are concerned, the DANA collections dealt with in the present account appear to be the most exhaustive, both in variety and number. A preliminary account was already published by Prasad and Tampi (1965). Although these collections were actually made in 1928-30, the material even to this day, remains in an excellent state of preservation. In the meanwhile, the larvae obtained in the Standard Net collections during the IIOE Expedition have also been studied (Tampi and George, 1975). The present account deals mainly with the systematics of the various larval forms. Even here, the account has been rendered as concise as possible, avoiding descriptions of well-known diagnostic characters of individual larvae and emphasising more on discussions regarding affinities or divergences. At this stage only an attempt could be made to surmise the general pattern of occurrence of these larvae with reference to the oceanographic conditions of this region. Some information of this type is available in the work of Saisho (1966) based on the collections made in 1963-64 by the *KAGOSHIMA-MARU* engaged in the IIOE Expedition.

The authors are grateful to the authorities of Carlesburg Foundation, particularly to Dr. E. Bertelsen, for placing this magnificent collection at their disposal. The considerable time taken in utilising this material was somewhat unavoidable as the authors who are located at different places of work in different institutions had to undertake this work in addition to their own official assignments.

Family: PALINURIDAE

1. **Panulirus homarus** (Linnaeus, 1758) (Fig. 1 a-i)

Material

Stage I-1.4, 2.0-4, 1.5; II-2.75-3, 2.25-2, 2.3-6, 2.2-3, 2.6-2, 2.7-2, 2.8-3; III-3.0-5, 3.25-3, 3.1-2, 3.9, 3.75, 3.8-4, 3.6-2, 3.3-4, 3.5, 3.2-3, 3.4-4, 3.7; IV-4.25-2, 4.0-7, 4.4-3, 4.3-2, 4.5-5, 4.6-3, 4.7-2, 4.8-4, 4.9-2, 4.75-3, 5.0-5, 5.1-2, 5.2-2, 5.6, 5.8-2, 5.75, 5.7, 5.25-4, 5.5-5, 6.0-6, 6.25-3, 6.5-3, 6.3, 6.6, 6.2; V-6.75-8, 5.7, 5.6, 5.9, 6.0-3, 6.1-2, 6.3-4, 6.5-4, 6.6, 6.25, 7.0-7, 7.3-3, 7.2, 7.4-2, 6.9-2, 7.25-2, 7.5-2, 7.75-2; VI-8.25, 10.2, 8.5-6, 8.2, 9.0-2, 9.7, 10.4, 8.0-2, 9.25-5, 10.0; VII-11.25, 12.0, 12.5-4, 13.5, 14.0, 10.75, 12.25-2, 12.75, 11.2, 11.5, 11.0-2; VIII-15.5, 15.75; IX-23.0-3, 22.0, 24.0; X-29.0, 30.0, 32.0, 27.5, 29.5, 25.0

3814 III*-2 (VI), 3817 IV-4 (II-2, III, IV), 3817 V-11 (II-2, III-6, V-3), 3821 V-1 (V), 3824 VIII-11 (III, IV-2, V-8), 3828 IV-2 (IV, V,) 3828 XIX-1 (V), 3860 XI & XV-5 (VII), 3860 XXII-2 (V, VI), 3860 XXIII-2 (II, V), 3893 IX-1 (V), 3902 II — 1 (II), 3903 V-1 (V), 3919 IV-1 (V), 3919 V-1 (V), 3931 III-2 (I), 3931 IV-1 (I), 3936 IV-1(I), 3941 III-1 (IX), 3941 V-3 (VIII, IX, X), 3944 V-2 (V, VI), 3946 I-1 (II), 3949 II-3 (III, IV-2), 3949 V-29 (III-19, IV, V-6, VI-3), 3951 V-17 (V-7, VI-5, VII-5), 3953 I-1 (III) 3953 IV-1 (IV), 3953 V-2 (III, VI), 3954 III-1 (II), 3954 IV-15 (III-2, IV- 13), 3954 V-13 (II-6, III-2. IV-5), 3955 I-5 (II, III, IV-2, VIII), 3955 II-4 (III-3, IV), 3955 III-2 (II, IV), 3955 V-12 (II-3, III-5, IV-4), 3956 IV-1 (III), 3956 V-12 (III, IV-3, V-4, VI-2, VII-2), 3957 II-1(V), 3957 IV-1 (V), 3957 V-2 (III, V), 3958 I-1 (V), 3958 II-8 (II-2, III-3, IV-2, V), 3958 III-1 (IV), 3959 I-1 (V), 3959 IV-3 (V, X-2), 3960 II-1 (IX), 3961 I-1 (IX) 3961 II-1 (X), 3962 I-1 (X), 3965 I-1 (X), 3969 II-4 (II-3, III), 3969 IV-1 (III). 3970 II-5, (IV-2, V-2, VI), and 3971 V-18 (II-4, III-10, IV-2, VI, IX).

Description

The features of this series of larvae belonging to the species *P. homarus* are quite in agreement with the previous descriptions given by Perry (1974) and others. The summary of the features of the different stages is given in Table 1.

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* For position and other details of stations reference may be made to *Dana Report* No. 1 (1934).

+ Larval stage and numbers shown in parenthesis, in Roman and Arabic numerals respectively. Length measurements are given in millimetre under '*Material*' of each species.

TABLE 1. *Principal changes in successive phyllosoma stages 1 to 10 of* **Panulirus homarus**

	Length range (mm)									
	1.4-2.0	2.1-2.9	2.8-3.9	3.6-6.7	5.6-8.4	6.2-11.0	10.5-14.5	13.0-18.5	16.0-25.0	24.5-32.0
a-1	1 seg.	..	..	..	end bud	4 seg	..	..	..	exo
a-2	1 seg. < a-1	..	..	..	.. > a-1	2 seg	4 seg	..	..	..
m-1	ant. br. 2 sp.	..	..	..	..	ant. br. 3 sp.	..	..	..	..
m-2	2 seg. dist. 4 setae	..	..	5 setae	7 setae	many setae	..	..	..	..
mpd-1	0	0	bud	..	..	..	..	..	bilobed	..
mpd-2	no exo	..	..	..	..	exo	exo setose	..	..	..
mpd-3	exo-setose vcs	..	..	..	..	..	..	..	..	..
p-1	exo-setose vcs ses	..	..	..	..	..	vcs, ses ss	..	vcs ss	..

p-2	exo-setose vcs, ses	..	vcs, ses dcs	..	ses dcs	ses, dcs ss	..	..	..	..
p-3	exo bud vcs, ses	..	exo setose vcs, ses dcs	..	ses dcs	ses dcs ss	..	..	..	..
p-4	0	0	bud	biramous	exo setose	end 3 seg dcs	end 5 seg dcs	dcs ss	..	..
p-5	0	0	0	0	bud	..	3 seg.	5 seg, ss	..	..
pleo	0	0	0	0	bud	..	biramous	..	end, exo	..
uro	0	0	0	0	bud	..	biramous	..	end, exo lat. sp	..

a-1 — antenna-1
a-2 — antenna-2
end — endopodite
exo — exopodite
dcs — dorsal coxal spine
dts — dorsal thoracic spine

m-1 — maxilla-1
m-2 — maxilla-2
mpd-1 — maxilliped-1
mpd-2 — maxilliped-2
mpd-3 — maxilliped-3
0 — absent

p-1 — pereopod-1
p-2 — pereopod-2
p-3 — pereopod-3
p-4 — pereopod-4
p-5 — pereopod-5
pleo — pleopod

sp — spine
ses — subexopodal spine
ss — sternal spine
uro — uropod
vcs — ventral coxal spine
.. — same as in the previous stage

Remarks

The description of the first stage larvae of *P. homarus* (as *P. burgeri*) by Prasad and Tampi (1959), the last stages of the species by Michel (1971), the series of all stages by Berry (1974) and a few stages by Tampi and George (1975) were considered in fixing up the stages of the species. Berry (1974) delineates only 9 stages in his series of larvae of *P. homarus* from the Natal Coast. However, from detailed examination of the present specimens it is felt that one more stage may be present in the development of the species and accordingly 10 stages are included in Table 1.

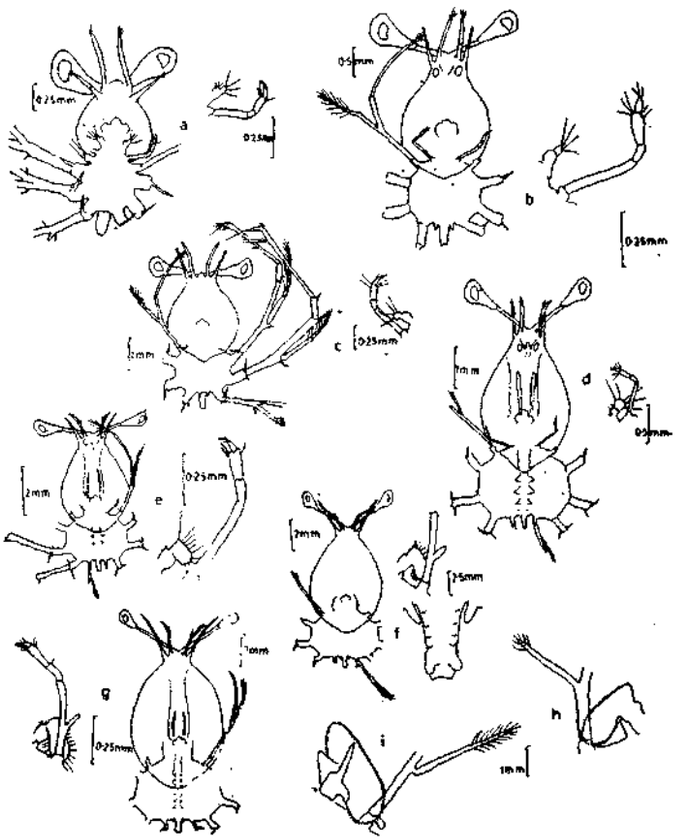

Fig. 1. Phyllosoma of *Panulirus homarus* – a. Stage 1 (1.4 mm); b. Stage 2 (3.0 mm); c. Stage 3 (3.3 mm); d. Stage 4 (5.0 mm); e. Stage 5 (5.7 mm); f. Stage 6 (9.25 mm); g. Stage 7 (10.2 mm); h. appendages stage 8 (15.5 mm) and i. appendages stage 9 (22.0 mm).

Distribution

With 226 specimens of larvae of various stages present in the collection, this species is next in abundance to *P. versicolor*, the larvae of which have the maximum representation. Out of the total 226 specimens, only 44 are from stations

situated in the eastern half of the Indian Ocean, thereby indicating that *P. homarus* has a larger distribution in the western half of the Indian Ocean like *P. versicolor*. The majority of these specimens were collected from stations located between Madagascar and East African Coasts and also off the coast of South Africa. 3949 V is the station with maximum number of larval specimens, namely 29. The existence of this species in large numbers in the fishery of South African Coast would explain the abundant occurrence of its larvae in these waters.

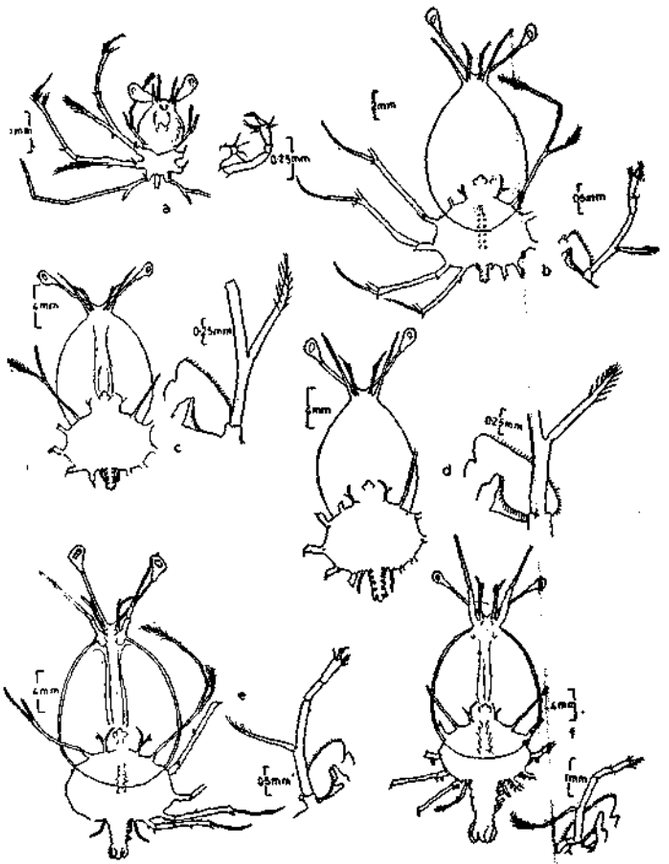

Fig. 2. Phyllosoma of *Panulirus versicolor* – a. Stage 2 (2.3 mm); b. Stage 7 (15.0 mm); c. Stage 8 (17.75 mm); d. Stage 9 (21.0 mm); e. Stage 10 (22.5 mm) and f. Stage 11 (27.0 mm).

2. **Panulirus versicolor** (Latreille, 1804) (Fig. 2 a-f)

Material

Stage I–1.8; II–2.7–3, 1.9, 2.0, 2.1, 2.2–5, 2.8, 2.4, 2.5, 2.25–2; III–3.1, 3.3–4, 3.4–4, 3.5–5, 3.6–2, 3.7–4, 3.9–3, 4.0–2, 3.75–2, 3.0; IV–4.25–4, 4.5–7, 5.5–5, 4.2, 4.1, 4.4–2, 4.6–3, 4.7–2 4.8–3, 4.9–3, 5.0–8, 5.1–2, 4.75, 5.25, 5.4; V–6.0–5, 6.5–9, 7.0–6, 5.6, 5.8–2, 5.7–5, 6.1–4, 6.2, 6.3–3, 6.4–5, 6.7, 6.8, 6.9, 6.25, 6.75; VI–7.5–10, 7.3, 7.7–2, 7.9–2, 8.0–4, 8.1, 8.5–9, 9.0–8; VII–11.34,

10.5–4, 9.3, 9.75–4, 11.82, 11.5–4, 12.0–3, 9.7–2, 10.0–4, 10.1–2, 9.25, 10.4, 10.6, 11.0–5, 11.5, 11.6, 11.75–2, 11.25–2, 10.25: VIII–12.25–3, 12.0–5, 15.0–5, 14.2, 13.25, 14.0–2, 14.5–2, 12.8, 13.4, 15.5, 13.5, 14.25, 12.5; IX–16.0–2, 16.25–2, 17.5–2, 17.25–2, 17.0–2, 18.0–4, 16.5–2, 17.75, 15.75; X–20.9, 22.25, 22.5, 18.5, 19.0–4, 20.0–3, 21.5, 22.0, 21.0, 18.25–3; XI–30.0. 3–damaged specimens.

3804 IV–1 (VI), 3814 III–2 (IX), 3814 IV–1 (VII), 3815 III–1 (IX), 3817 IV–1 (II), 3817 V–3 (VIII), 3824 VIII–2 (VII, IX), 3828 IV–6 (IV–3,V–2,VIII), 3843 IV–4 (VI, VII,VIII–2), 3844 VIII–1 (X), 3849 II–1 (XI),3850 II–1 (VII),3855 IV–1 (X),3860 XI & XV–2 (IX),3860 XXII–1 (VII), 3893 VIII–1 (IX), 3902 IV–1 (X), 3908 V–4 (IX–2, X–2), 3910 IV–3 (X), 3916 V–2 (VII, VIII), 3917 X–1 (VIII),3920, X–1 (V). 3924 V–1 (VIII), 3949 V–80 (II–10, III–13, IV–17, V–22, VI–10, VII–5, VIII–2, IX–1), 3951 V–1 (X), 3955 IV–12 (I, II–3, III–4, IV–2, VI, VII), 3955 V–39 (III–5, IV–11, V–10, VI–6, VII–3, VIII–3, X), 3956 IV–10 (III, IV, V, VI–4, VII, VIII–2), 3956 V–16– (V–3, VI–4, VII–3, VIII–5, IX), 3957 II–1 (damaged), 3957 IV–5 (IV, V, VII, 2 damaged), 3957 V–5 (VI,VII, VIII, IX–2), 3958 II–2 (IV, IX), 3958 III–1 (III), 3959 I–4 (III–3, IV), 3959 II–1 (V), 3959 III–1 (X), 3959 IV–1 (X), 3959–3 (VI, VI, IX), 3960 II–8 (VII–3, VIII–2, IX–3), 3961 II–10 (VI–2, VIII, IX–4, X–3), 3962 II–1 (V), 3962 III–1 (VII), 3962 IV–22 (V–4, VI–15, VII–2, VIII), 3962 V–9 (V–2, VI–4 VII–2, VIII), 3963 I–1 (IX), 3963 II–2 (VI, VII), 3964 V–1 (V), 3964 VII–1 (VIII), 3969 V–1 (IV), 3970 II–3 (IV), 3971 II–2 (II, IV), 3971 IV–1 (II) and 3972 I–1 (IX).

Description

The series of larvae represent all the stages of the species *P. versicolor*. The features are mostly in agreement with the description by Prasad and Tampi (1959) (as *P. penicillatus*) and others. The salient features are summarised in Table 2. The stages are also illustrated (Figs. 2 a -f). The cephalic shield is longer than wide from the first stage onwards. This length and width ratio increases in the succeeding stages and the width remains at 1/3 length from 3rd to 9th stages. In the last stages there is again a slight increase in maximum width.

The width of the thorax, considerably less than that of fore-body in the early stage, increases and remains equal to the width of the fore-body in stages 8 and 9. In the later stages there is a slight reduction in the width of the thorax.

The distance between the mouth parts and the level of the midpoint between the coxae of maxillpeds 2 is less than half the width between the bases of the coxae of these maxillipeds from stage 5 onwards and is much shortened in the last stages.

The sternal spines are noticed from only stage 9. The ventral coxal spines, subexopodal spines and dorsal coxal spines are more or less similar to those in corresponding stages of *P. ornatus*.

Remarks

As mentioned by Tampi and George (1975) this larval series, which is similar to the series described by Prasad and Tampi (1959) as that of *P. penicillatus*, is assigned to *P. versicolor* following the studies by Johnson (1958, 1971) and Michel (1969, 1971). Based on this identification the later stages described by Saisho (1966) as *P. penicillatus* and Form D of Murano (1971) may also belong to *P. versicolor*. Berry (1974) got two specimens of the larvae of this species from Natal waters.

Distribution

It is interesting to note that as in the International Indian Ocean Expedition collections (Tampi and George, 1975) the larvae of this species have the maximum representation in the DANA collection also, a total of 288 specimens being collected from the different areas. Although the larvae are represented in all the areas covered by the expedition, the species is most abundant in the western half of

TABLE 2. *Principal changes in successive phyllosoma stages 1 to 11 of* **Panulirus versicolor**

	length range (mm)										
	1.5–1.8	1.9–2.9	3.0-4.1	4.2-5.5	5.6-7.0	7.1-9.0	9.0-12.0	12.0-15.8	15.9-18.1	18.2-25.0	25.1-30.0
a-1	1 seg	..	..	..	4 seg. end	..	..	end long	..	end setose	..
a-2	1 seg < a-1	..	..	1 seg = a-1	2 seg. > a-1	4 seg	..	..	..	..	..
m-1	ant. br 2 sp	..	..	..	..	..	..	ant. br 3 sp	..	..	..
m-2	2 seg dist. 4 setae	..	..	5 setae	..	dist. seg flat 13 setae	21-25 setae	many setae	..	..	..
mpd-1	bud	..	..	..	..	..	..	..	bilobed	..	trilobed
mpd-2	no exo	..	..	..	..	exo bud	exo setose	..	..	..	..
mpd-3	exo setose vcs	..	..	..	..	..	..	..	..	..	..
p-1	exo setose vcs, ses	..	..	..	..	..	..	..	vcs, ses ss	..	..
p-2	exo setose vcs, ses	..	vcs, dcs ses	..	dcs ~~ses~~	..	..	..	dcs, ses ss	..	..
p-3	exo bud vcs, ses	..	exo setose vcs, dcs ses	..	dcs ses	..	..	..	dcs ses ss	..	..
p-4	0	0	bud	biramous	..	exo setose	..	ses, dcs	dcs, ses, ss	..	..
p-5	0	0	0	bud	..	..	..	long	3 seg	4 seg	5 seg
pleo	0	0	0	0	0	0	bud	..	birmous	—	..
uro	0	0	0	0	bud	..	..	biramous	..	..	end, exo lat. sp.

the Indian Ocean with nearly 250 specimens of which the majority are from stations off the west coast of Madagascar. Samples from station Nos. 3949 V and 3955 V off this coast contained 80 and 39 larval specimens respectively and most of them in the early stages. Other stations in this region also contained a good number of these larvae. This might indicate the concentration of the species in fishable quantities along the Madagascar Coast.

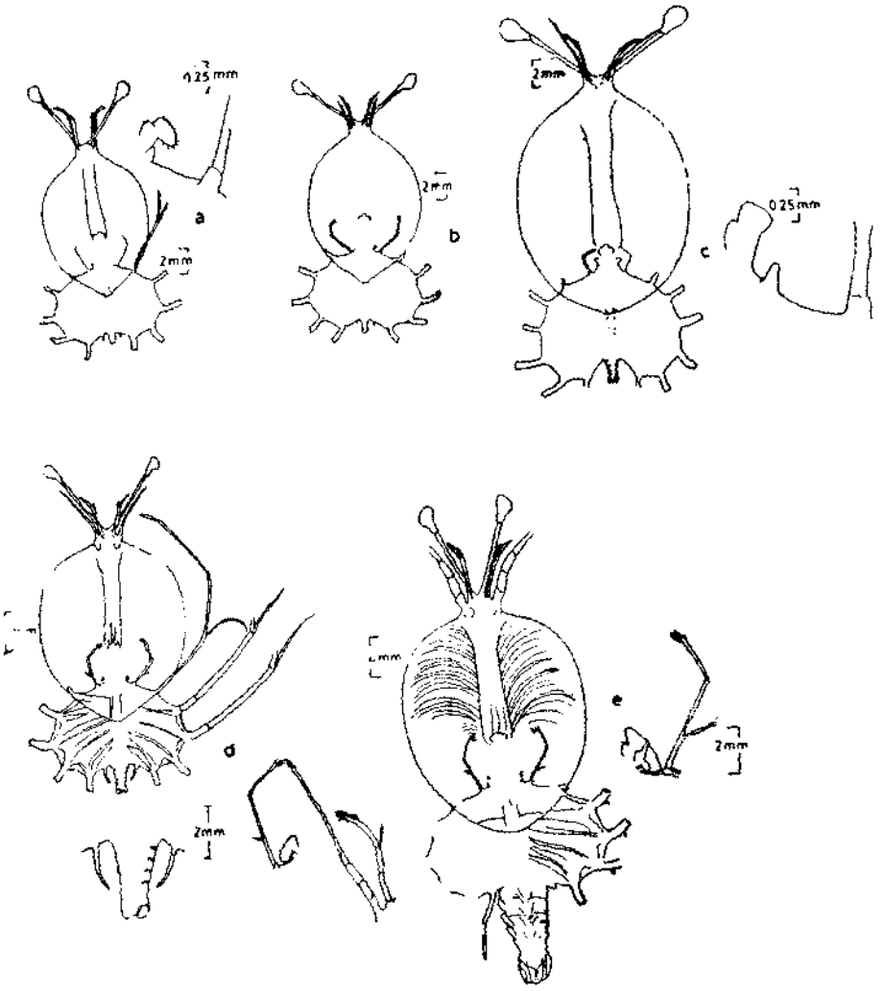

Fig. 3. Phyllosoma of *Panulirus penicillatus* – a. Stage 7 (15.0 mm); b. Stage 8 (16.0 mm); c. Stage 9 (23.0 mm); d. Stage 10 (26.0 mm) and e. Stage 12 (39.0 mm).

3. **Panulirus penicillatus** (Oliver, 1971) (Fig. 3 a-e)

Material

Stage VII–14.0–2, 15.0, 14.9, 15.1, 15.5–2; VIII–17.5, 16.0–3, 19.0, 18.0–2, 21.0–2, 19.5, 18.5, 20.0; IX–25.0–3, 26.0–2, 22.0, 23.0–2, 24.5, 25.5; X–30.0–4, 31.0–2, 30.5, 29.75, 28.0, 27.0–2; XI–37.0, 34.5–3, 37.5, 33.5–2, 34.0, 35.0, 35.5; XII–43.0, 41.0–2, 40.0–4, 39.0, 37.0, 39.5, 38.0 1–damaged specimen.

TABLE 3. *Principal changes in successive phyllosoma stages 1 to 12 of* **Panulirus penicillatus***

	Length range (mm)											
	1.5-1.8	2.2-2.6	3.1-3.5	4.2-5.5	6.5-8.0	10.0-12.0	13.0-15.8	16.0-21.5	22.0-26.5	28.0-33.0	33.5-38.0	38.0-43.0
a–1	1 seg	..	..	end bud	4 seg	..	end long	..	..	..	..	..
a–2	1 seg <a–1	..	..	..	..	..	..	4 seg > a–1	..	..	..	..
m–1	ant. br 2 sp	..	..	..	..	..	ant. br. 3 sp	..	..	..	..	..
m–2	2 seg. dist 4 setae	..	..	..	..	..	..	dist. seg. flat	dist. seg setose	..	..	..
mpd–1	bud	..	..	..	..	..	..	..	bilobed	trilobed	..	..
mpd–2	no exo	..	..	..	..	..	..	exo bud	..	exo setose	..	..
mpd–3	exo-setose vcs	..	..	..	no coxal sp	..	..	..	ss	..	..	..
p–1	exo setose vcs	..	..	..	no coxal sp	..	..	ss	..	..	..	..
p–2	exo setose vcs	..	..	..	no coxal sp	..	..	ss	..	..	..	..
p–3	exo bud vcs	exo long vcs	exo setose vcs	..	no coxal sp	..	..	ss	..	..	..	..
p–4	0	bud	long	biramous	exo setose	..	..	ss	..	..	..	..
p–5	0	0	0	bud	..	..	long	2 seg	..	3 seg.	4 seg.	5 seg.
pleo	0	0	0	0	0	0	0	bud	biramous	..	..	..
uro	0	0	0	0	0	bud	..	biramous	..	..	..	..

*Some of the stages from the description by Johnson (1968) have been incorporated to make the Table complete.

3814 IV–1 (VIII), 3815 VII–4 (VIII, X, XI, XII), 3824 V–1 (VIII), 3828 IV–6 (VIII, IX–2, X, XII, 1 damaged), 3928 IX–1 (XI), 3828 XIX–2 (IX), 3830 I–2 (X, XI), 3843 II–1 (IX), 3843 IV–7 (VIII–3, IX–3, XI), 3844 V–3 (VIII, X, XI), 3844 VI–1 (X), 3844 VIII–4 (VIII, X–2, XII), 3847 I–2 (IX, XII), 3847 III–1 (X), 3850 II–2 (XII), 3850 III–1 (XI), 3854 II–1 (X), 3855 IV–1 (X), 3856 II–1 (XII), 3860 VII–1 (XI), 3860 XI & XV–1 (XI), 3860 XXII–2 (XI), 3865–1 (X), 3902 IV–4 (VII–2, VIII, IX), 3908 IV–3 (IX, X–2), 3908 V–3 (XII), 3910 IV–1 (IX), 3944 V–1 VIII), 3949 V–3 (VII–2, VIII), 3951 V–1 (VIII), 3955 IV–1 (XII) and 3969 V–1 (VIII).

Description

P. penicillatus larvae are comparatively few in the collection and stage 7 onwards only are represented in the series. In summarising the salient features in Table 3, the descriptions of the earlier stages by Johnson (1968) are also used.

The species can be grouped along with *P. longipes* and *P. polyphagus* in the group without coxal spines on the pereopods in the later stages, coxal spines being absent from stage 5 onwards. Subexopodal spines also absent. Sternal spines are noticed from stage 8 onwards.

In comparison with the two other species of the group, namely *P. polyphagus* and *P. longipes*, the cephalic shield is broader, especially in the later stages and in these stages the ratio of cephalic shield width to thorax width remains at 1.0, unlike in the other two. The distance between the level of the mouth parts and the base of maxilliped 2 is long.

Remarks

Form C larvae described by Murano (1971) from Japanese waters, *Panulirus* 'a' phyllosoma recorded from Indian Ocean by Saisho (1966) and stages 9 and 10 from Natal waters by Berry (1974) have been considered in summarising the salient features of the larval series.

Distribution

The larvae of this species are common in the eastern half of the Indian Ocean as 58 numbers out of a total of 65 specimens are from this region. Only 7 specimens are from the African Coast. The maximum numbers of 6 and 7 are from station Nos. 3828 IV and 3843 IV respectively both off Sumatra Coast, indicating general abundance of the species in that locality.

4. **Panulirus polyphagus** (Herbst, 1793) (Fig. 4 a-h)

Material

Stage III–3.75; VI–5.5; V–7.25, 7.5–2, 6.8–2, 6.7, 7.4, 6.5, 7.3,; VI–7.8, 7.75, 10.0–3, 9.5–3, 8.0–2, 9.0, 8.25, 8.5–2; VII–11.5–4, 12.7, 10.72, 13.0–2, 11.0–4, 12.5–2, 12.0–4 12.25–3, 11.6, 10.3, 10.5, 11.75–2, 10.75; VIII–13.5–3, 13.75, 15.25, 17.5–2, 14.0–2; IX–18.0, 19.5, 20.0, 21.5–4 22.0–2, 25.0–3, 23.5, 26.25; X–27.5; XI–33. 75, 36.5.

3814 III–1 (VII), 3814 IV–1 (VII), 3817 V–1 (VII), 3824 VIII–4 (V, VII–3), 3828 IV–12 (IV, V, VI, IX–9), 3828 XIX–2 (VIII),3843 IV–1 (V), 3844 VII–1 (IX), 3849 III–2 (IX), 3850 IV–1(VII), 3854 II–1 (IX), 3855 IV–2 (IX) 3860 XXII–3 (VI–2, VIII), 3860–XXIII–1 (III), 3893 VIII–1 (X), 3924 V–1 (VIII), 3926 IV–3 (VII), 3928 III–1 (VII), 3932 V–1 (XI), 3934 1 & VI–1 (XI), 3944 V–3 (VI), 3949 V-2 (V), 3951 V-10 (VI-2), VII-5, VIII, IX–2), 3954 IV–3 (VI, VII–2), 3954 V–1 (IV), 3955 V–I (VI), 3956 IV–3 (V, VI–2), 3958 I–2 (VI, VII), 3958 II–2 (VII, VIII), 3958 III–1(VII), 3959 I–2 (VII), 3960 II–5 (VII–2, VIII–3), 3961 II–1 (VI) and 3962 IV–2 (VII).

TABLE 4. *Principal changes in successive phyllosoma stages 1 to 11 of* **Panulirus polyphagus***

	Length range (mm)										
	1.45	1.75	2.20	2.70-5.5	5.6-7.5	7.5-10.0	10.5-13.0	13.5 18.0	18.5-25.0	27.5-31.5	32.0-37.0
a-1	1 seg 3 setae	..	..	end bud	4 seg	..	end long	..	..	..	..
a-2	1 seg <a-1	..	..	..	..	..	4 seg =a-1	>a-1	..	..	..
m-1	ant. br. 2 sp	..	..	..	ant. br. 3 sp		..	..	..	..	..
m-2	2 seg. dist. 4 sp	..	..	..	..	6 setae	..	..	dist. seg. flat	many setae	..
mpd-1	bud	..	..	..	..	..	..	..	bilobed	..	trilobed
mpd-2	no exo	..	..	..	..	..	..	exo bud	exo long	exo setose	..
mpd-3	exo setose	..	..	vcs	..	no coxal sp	..	..	..	..	..
p-1	exo setose vcs	..	..	..	..	no coxal sp	..	..	ss	..	..
p-2	exo setose vcs	..	..	..	..	no coxal sp	..	..	ss	..	..
p-3	no exo, vcs	exo bud vcs	exo setose, vcs	..	..	no coxal sp	..	..	ss	..	..
p-4	0	0	bud	biramous	exo setose	..	1 seg	..	2 seg	3 seg	4 seg
p-5	0	0	0	bud	..	..	bud	..	biramous	..	..
pleo	0	0	0	0	0	0	..	biramous	..	..	..
uro	0	0	0	0	0	bud	..	biramous	..	..	..

* Stages 1-3 from Ong (1967).

Description

Stage 4 onwards of *P. polyphagus* are represented in this collection. The report of the early stages of the species by Ong (1967) is also used to summarise the salient features of the different stages in Table 4.

Except for the very early stages the hind body is conspicuously wider than the fore-body. The cephalic shield is also elongated. The distance between the mouth parts and the level of the mid point between the coxae of maxilliped 2 is large.

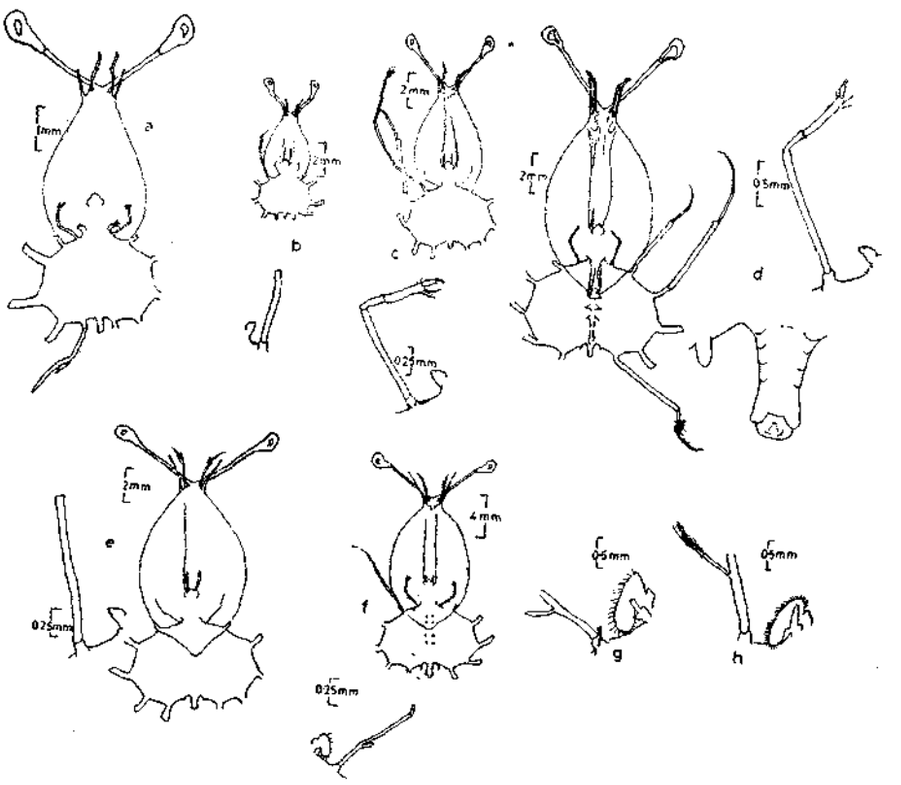

Fig. 4. Phyllosoma of *Panulirus polyphagus* – a. Stage 4 (5.5 mm); b. Stage 5 (6.5 mm); c. Stage 6 (9.5 mm); d. Stage 7 (12.7mm); e. Stage 8 (14.0 mm); f. appendages stage 9 (21.5 mm); g. appendages stage 10 (27.5 mm) and h. appendages stage 11 (33.75 mm).

Similar to *P. longipes* the subexopodal spines are absent. Ventral coxal spines are present in the earlier stages and coxal spines absent from stage 6 onwards. Sternal spines are present in the very late stages.

Remarks

P. polyphagus is closely allied to *P. penicillatus* and *P. longipes* in the matter of larval development as shown by the absence of coxal spines on the pereopods in the

TABLE 5. *Principal changes in successive phyllosoma stages 1 to 11 of* **Panulirus ornatus**

	Length range (mm)										
	1.4-1.9	2.0-3.2	3.3-4.5	4.6-7.0	7.1-8.9	9.0-12.0	12.1-14.5	14.6-16.5	16.7-20.0	20.1-25.0	25.1-32.0
a–1	1 seg	..	..	3 seg end bud	4 seg end bud	..	4 seg end long	..	4 seg end setose	..	..
a–2	1 seg <a–1	..	.. =a–1	.. > a–1	..	..	..	4 seg	..	..	..
m–1	ant. br 2 sp	..	..	..	..	ant. br 3 sp	..	..	..	..	..
m–2	2 seg dist. 4 setae	..	6 setae	10 setae	dist, seg. flat, 12–15 setae	14–17 setae	23–26 setae	many setae	..	..	..
mpd–1	bud	..	..	..	..	..	..	long, bud	bilobed	..	trilobed
mpd–2	no exo	..	..	..	exo bud	..	exo, setose	..	..	..	..
mpd–3	exo setose vcs	..	..	..	..	..	..	..	vcs, ss	..	..
p–1	exo setose vcs	vcs ses	..	..	..	..	vcs, ses ss	..	..	..	ses ss
p–2	exo setose vcs, ses	..	vcs, dcs ses	..	dcs ses	..	dcs, ses ss	..	..	..	ses ss
p–3	exo bud vcs, ses	..	exo setose vcs, dcs, ses	..	dcs ses exo	..	dcs, ses ss end 3 seg	..	..	..	..
p–4	0	0	bud	long biramous	setose	..	..	end 5 seg. ss 2 seg	dcs ss 4 seg	.. 5 seg	.. ..
p–5	0	0	0	bud	..	..	0	biramous bud	biramous	..	..
pleo	0	0	0	0	0	0	biramous	..	..	..	end, exo lat. sp.
uro	0	0	0	bud	..	..					

later stages. Tampi and George (1975) have discussed how they arrived at the parentage of these larvae and those observations are confirmed after an analysis of the larger series of larvae in the present collection.

Distribution

Out of a total of 79 specimens of various stages of the species, 34 were collected from the eastern half of the Indian Ocean covered by the expedition and 45 from the western part. The maximum numbers 12 and 10 were obtained from stations 3828 IV and 3951 V respectively, the former near Sumatra Coast and the latter off East African Coast. Generally the larvae are more abundant in the waters between East Africa and Madagascar.

5. **Panulirus ornatus** (Fabricius, 1798) (Fig. 5 a-h)

Material

Stage I–1.5–4, 1.75, 1.7, 1.9, 1.4, 1.6–3; II–2.24, 3.0–11, 2.8–2, 3.2–7, 3.1–2, 2.75–5, 2.4–2, 2.9, 2.0–2, 2.25–3, 2.5, 2.1, 2.2; III–3.5–3, 3.75–4, 3.3, 3.4, 4.0–2, 3.6, 4.5–2, 3.8–2, 4.25; IV–5.5, 4.6–2, 4.7, 4.75, 5.25, 5.4, 6.0, 6.25, 6.5–2, 6.2, 7.0–2; V–8.0–2, 8.2–2, 8.75–3, 8.5, 7.5; VI–9.25–2, 9.0–2, 9.75, 10.75, 9.5, 9.1, 11.25; VII–12.0, 13.0, 14.0; VIII–14.25, 16.25; IX–19.75; X–22.0; XI 31.0.

3804 IV–1 (II), 3814 III–1 (IV), 3817 III–1 (III), 3817 IV–2 (II, III), 3817 V–19 (II–8, III–6, IV–5), 3821 III–1 (IV), 3821 IV–1 (II), 3824 VII–1 (III), 3824 VIII–5 (III, IV, V–3), 3828 I–1 (III), 3828 IV–3 (I, II–2), 3843 IV–1 (IV), 3844 II–1 (I), 3847 IV–1 (I), 3850 IV–1 (VIII), 3858–1 (II), 3860 XI & XV–2 (III), 3860 XXII–15 (II–8, III–3, IV–3, VIII), 3860 XXIII–3 (II–2, III), 3902 IV–1 (III), 3903 II–2 (II), 3903 IV–7 (II–5, III, VI), 3913 II–1 (I), 3913 III–1 (II), 3913 V–4 (I). 3918 V–5 (VI–3, VII–2), 3918–1 (VIII), 3919 III–2 (V, VI), 3919 V–1 (VI), 3920 X–2 (VI), 3922 III–1 (I), 3926 IV–2 (VI, VII), 3942 IV–1 (IX), 3948 II–1 (XI), 3949 V–3 (II), 3953 II–1 (IV), 3958 I–1 (II), 3958 III 4 (II–3, VI), 3959 I–1 (III), 3961 I–1 (VI), and 3969 III–2 (I).

Description

Stages 1 to 11 of this species are represented in this collection.

The features of the 1st stage larva are quite in agreement with those described by Prasad and Tampi (1957) from a larva hatched out in the laboratory. The different stages are illustrated (Fig. 5 a-h) and salient features of each stages are summarised in Table 5.

In the first stage larva the cephalic shield is almost as wide as it is long and much wider than thorax. As growth progresses through the subsequent stages the body proportion changes considerably as can be seen from the figures. From the second stage onwards there is a regular increase in the length–breadth ratio of the cephalic disc so that it becomes oval in shape. The thoracic width also shows a regular increase from 1/3 length of the cephalic shield in the first stage to almost equal width in stages 5 to 8. In the last stages there is again a slight reduction in the width of the hind body in comparison to the fore-body.

The distance between the mouth parts and the level of the midpoint between the coxae of maxilliped 2 which is the same as the distance between the coxae of maxilliped 2 in the early stage gets regularly shortened and becomes less than half of it in the last stages.

The ventral coxal spines are very conspicuous up to stage 4. Thereafter these are found only on maxilliped 3 and pereopod 1. In the other pereopods the dorsal

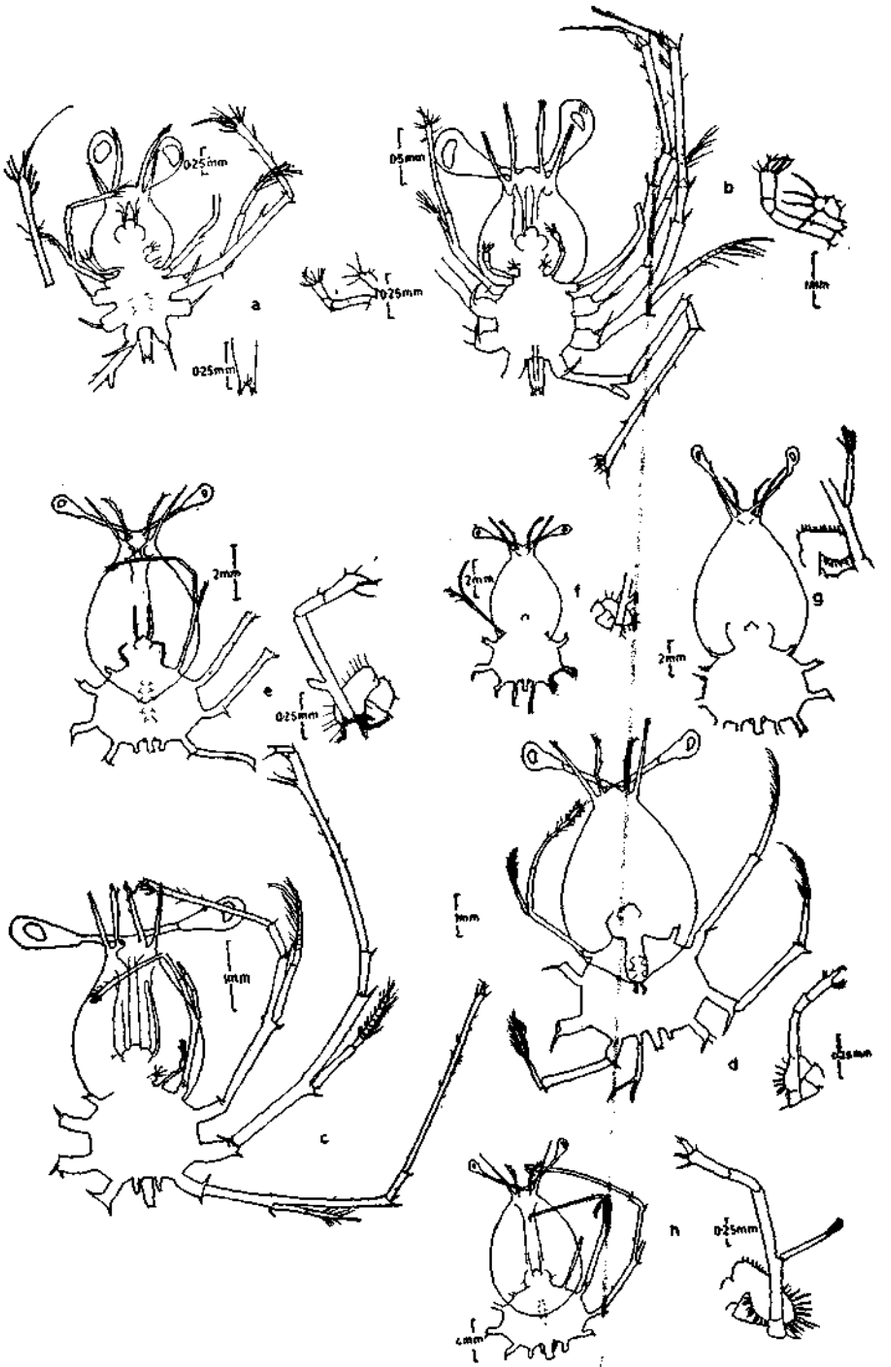

Fig. 5. Phyllosoma of *Panulirus ornatus* – a. Stage 1 (1.5 mm); b. Stage 2 (2.4 mm); c. Stage 3 (4.0 mm); d. Stage 4 (6.25 mm); e. Stage 5 (8.2 mm); f. Stage 6 (9.0 mm); g. Stage 7 (13.0 mm) and h. Stage 8 (16.25 mm).

coxal spines become prominent by this time. Subexopodal spines are present in legs 1 to 3 in almost all the stages. Sternal spines become evident from stage 7 onwards.

Remarks

The accounts of Prasad and Tampi (1957) on the 1st stage larva of *P. ornatus* and Johnson (1971) on stages 5, 9 and 11 of the species and Tampi and George (1975) on stages 4 and 8 have been taken into consideration in the identification and fixing up of the stages of the species in the collection. The availability of all the stages confirms the suggestion made by Tampi and George (1975) that the dorsal spines on the coxa develop in the later stages.

Distribution

There are 106 specimens of different stages of this species in this collection. The larval stages are present in varying numbers in all the areas in the Indian Ocean covered by the expedition. However, it may be said that the majority of the specimens of larvae of *P. ornatus* were collected from the eastern half of the Indian Ocean, more especially from off Sumatra Coast. Out of 106s pecimens, 71 were from the eastern part of the Indian Ocean. The maximum numbers of 19 and 15 larval specimens in a haul were from stations 3817 V and 3860 XXII respectively, both of which are off the middle of the Sumatra Coast. Although there are no reports of a fishery of this species from the Sumatra Coast, the availability of large number of larvae may indicate the presence of this species in large numbers in this area. The larvae are mostly found in the 100 and 50 m depth hauls.

6. Panulirus longipes (A. Milne Edwards, 1868) (Fig. 6 a-g)

Material

Stage V–6.0, 6.5, 7.0, 7.25, 7.5–2; VI–9.04, 11.64, 9.65, 11.61, 11.98, 8.0–3, 8.5, 8.75–2 9.5–2, 9.75–2, 10.0, 10.4, 10.45, 10.5, 10.75–3, 11.0–4, 11.5–2, 11.81, 11.82, 8.25–2, 10.25, 9.0–2, 9.25, 10.1; VII-12.5-9, 12.0-6, 13.2, 13.4, 13.45, 14.0,14.4-2 14.7, 13.5-2, 13.0-5, 13.25, 14.75, 12.75-3, 14.5, 14.25, 12.25,; VIII–15.36, 17.75, 18.25, 16.0–4, 18.0–3, 18.8, 16.5, 16.75, 17.5-3,17.25–2, 18.5–5, 18.75, 15.25, 15.5, 16.3, 15.75, 17.0, 15.0-2, 15.8; IX-20.0-4, 22.25–2, 22.0, 22.5-2, 19.0–3, 21.0, 22.75, 21.5, 19.5, 23.5; X–26.2, 24.0–5, 24.5, 26.0, 25.2, 27.5; XI–29.7, 31.5-2, 32.0, 33.0; 31.0; XII–33.0–3, 33.5, 34.0, 37.5.

3814 II–3 (VI–2, VIII), 3814 III–11 (VI–3, VII, VIII–2, IX–3, X, XI), 3814 IV– 29 (VI–17, VII–11, VIII), 3815 III–3 (VIII, IX–2), 3817 V–6 (VI, VII, VIII, XI, XII–2), 3824 VIII–32 (V–3, VI–3, VII–10, VIII–5, IX–4, X–5, XI–2), 3828 IV–2 (XI), 3828 XIX–4 (VI, VII, VIII–2), 3850 III–1 (X), 3850 IV–5 (IX), 3854 1–1 (X), 3854 II-4 (VII-2,VIII-2), 3855 IV–6 (VII, VIII–4,IX), 3856 IV-3 (VII, VIII–2), 3860 XI & XV-1 (X), 3860 XXII-3 (VII, VIII, IX), 3904 II-1 (X), 3905 V–1 (XII), 3907 V-1 (VIII), 3910 V-3 (VIII), 3944 V-1 (IX). 3949 V-1 (VIII), 3951 V-3 (VI),3954 IV-2 (VII, IX), 3954 V–1 (XI), 3955 I–1 (IX), 3955 V–1 (VI), 3958 III–1 (VIII), 3959 II–3 (VII–2, VIII), 3959 IV–2 (VII), 3960 II–1 (VII), 3961 I–1 (VII), 3961 II–2 (VII, X), 3964 V–10 (VI–8, VII, XII), 3965 II–1 (XII) and 3970 II–2 (VI, VIII).

Description

Except for the very early stages, all these from stage 5 onwards of *P. longipes* are represented in the collection. The salient features of the different stages are summarised in Table 6 using the accounts of Saisho and Nakahara (1960) and Michel (1969) for the earlier stages.

The cephalic shield is more elongated and in contrast to species like *P. versicolor, P. ornatus* and *P. homarus*, the hind body is conspicuously wider than the

cephalic disc from stage 4 onwards. The distance between the mouth-parts and the level of the midpoint between the coxae of maxilliped 2 remain constantly high throughout the stages.

The ventral coxal spines on the legs are present in the earlier stages and no coxal spines, either ventral or dorsal, occur in the later stages. Subexopodal spines are lacking throughout in all the stages.

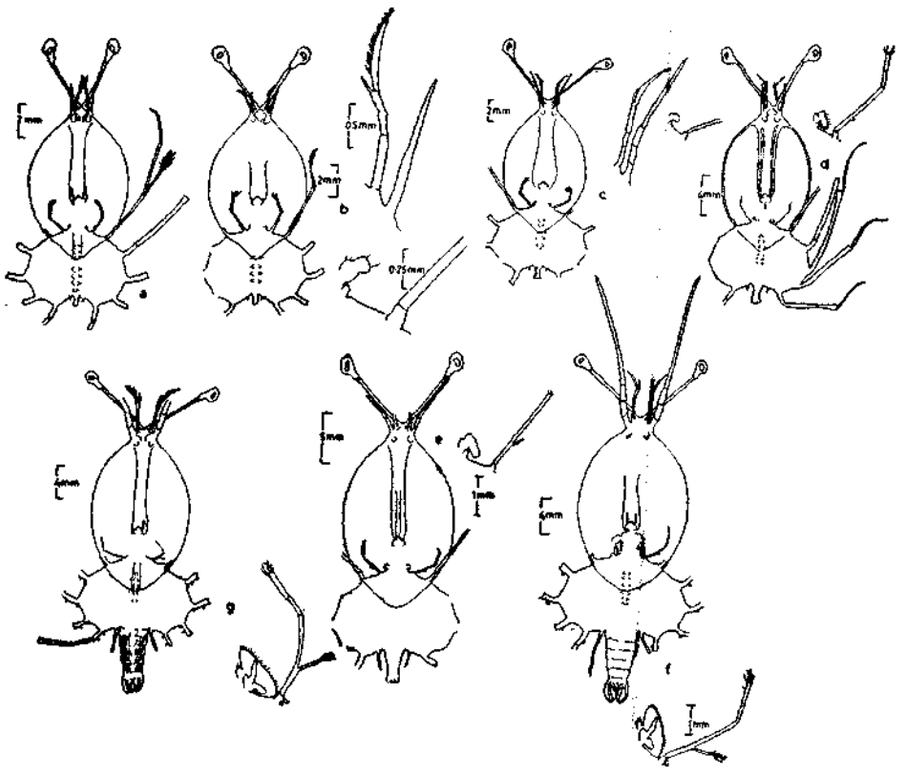

Fig. 6. Phyllosoma of *Panulirus longipes* – a. Stage 6 (11.5 mm); b. Stage 7 (13.0 mm); c. Stage 8 (17.5 mm); d. Stage 9 (20.0mm); e. Stage 10 (25.2 mm); f. Stage 11 (32.0 mm) and g. Stage 12 (33.5 mm).

Remarks

According to George and Holthuis (1965) there are two subspecies for *P. longipes*, namely *P. longipes longipes* and *P. longipes femoristriga*. Berry (1974) described a few stages from Natal waters as belonging to the subspecies, *P. longipes longipes*. He presumed that Michel's (1969) description of different stages pertained to the subspecies *P. longipes femoristriga*. The present collection, coming from the areas near the Pacific region as well as the western part of the Indian Ocean, may have a combination of larvae of both subspecies. As Chittleborough (1969) puts, it is possible that the two subspecies may not be existent.

TABLE 6. *Principal changes in successive phyllosoma stages 1 to 12 of* **Panulirus longipes***

	Lengh range (mm)											
	1.17-1.23	2.01-2.10	2.5-2.6	3.0-4.5	5.5-7.0	7.5-12.0	12.0-15.0	15.1-18.9	19.0-24.0	24.5-29.5	29.0-33.5	33.5-37.5
a–1	1 seg	..	..	..	end bud	4 seg	..	end long	..	exo, end	..	..
a–2	1 seg <a–1	..	..	..	..	..	..	4 seg > a-1	..	..	..	..
m–1	ant. br 2 sp.	..	..	..	ant. br 3 sp.	..	..	..	..	..	..	..
m–2	2 seg. dist. 4 setae	..	..	..	..	5 setae	6 setae	dist, seg flat 18 setae	many setae	..	..	..
mpd–1	bud	..	..	..	..	..	..	long	..	bilobed	..	trilobed
mpd–2	no exo	..	..	..	..	..	..	exo bud	..	exo long	..	exo setose
mpd–3	exo setose vcs	..	..	..	..	..	no coxal sp	..	..	..	..	..
p–1	exo setose vcs	..	..	..	..	..	no coxal sp	ss	..	..	..	..
p–2	exo setose vcs	..	..	..	..	..	no coxal sp	ss	..	..	..	..
p–3	exo bud vcs	..	exo few setae, vcs	exo setose vcs	..	vcs	no coxal sp	ss	..	..	..	..
p–4	0	0	bud	biramous	exo setose	..	..	..	ss	..	..	..
p–5	0	0	0	bud	..	1 seg	..	..	2 seg	3 seg	4 seg	5 seg
pleo	0	0	0	0	0	0	bud	..	biramous	..	..	
uro	0	0	0	0	0	bud	..	biramous	..	..	..	lat. sp.

* Stages 1–4 from the descriptions of Saisho andNakahara (1960) and Michel (1969).

Distribution

The larvae of this species are represented more in the eastern part of the Indian Ocean than in the western part, out of total of 153 specimens, nearly 120 coming from the eastern region, especially from the region off Sumatra Coast. Maximum number of 29 and 32 per haul were collected from station numbers 3814 IV and 3824 VIII respectively, both of them off Sumatra Coast. Like *P. ornatus* this species also seems to be abundant in that region.

7. **Panulirus** sp. 1 (Fig. 7 g)

Material

Stage IV–9.0, 7.25, 7.75–2, 6.6, 7.2, 7.3–3, 8.3, 8.75, 8.5–2, 8.0; VI–11.25, 11.5, 10.5, 10.75–3, 11.2.

3814 III–1 (IV), 3817 V–1 (IV), 3860 XI & XV–1 (IV), 3949 V–6 (IV), 3958 II–1 (IV), 3960 II–3 (IV), 3963 III–2 (VI), 3964 V–4 (VI), 3971 V–1 (IV), and 3972 I–1 (VI).

Description

Stage 4: 7.25 mm (Fig. 7g). This appears to be an earlier stage of the species, stage 7 of which has been described as that of *Panulirus* sp. II by Tampi and George (1975) from IIOE material. Cephalic shield is elongated, ratio of length to breadth being 1.4. Thorax is almost of the same width as cephalic shield, if not slightly wider. 2nd antenna stouter than 1st. Distal segment of 1st maxilla small and carrying 4 setae. Coxal spine characteristically present only on 1st leg. 5th leg rudimentary. The ratio of distance between mouth parts and mid-line between the coxae of maxilliped 2 and distance between the coxae is 1.4. A few specimens of stage 5 are also present in this collection, but none of the specimens are complete.

Distribution

Out of 21 specimens of these larvae, 18 were obtained from the western part of the Indian Ocean near the African Coast. The other 3 specimens were from the eastern half near the Java, Sumatra Coast.

8. **Palinustus mossambicus** Barnard, 1926 (Fig. 7 a-e)

Materia

Stage II–3.5; IV–4.9, 7.5, 8.0, 8.8, 7.0; V–11.0–6, 10.5–3, 10.75–2, 10.25, 10.9, 11.3; VI–13.0–4, 13.25, 14.75, 12.5, 13.5–2, 14.0–2, 14.3, 15.0; VII–17.0, 15.6.

3817 V–1 (II), 3824 VIII–1 (IV), 3918 V–12 (V–5, VI–6, VII),3919 IV–1 (VII), 3919 V–3 (IV, V, VI), 3920 X–14 (IV–2, V–6, VI–6) and 3951 V–1 (IV).

Description

Stage 2: 3.5 mm (Fig. 7a). Ratio of cephalic shield length to breadth is 1.5 and that of cephalic shield width to thoracic width 1.3. 2nd antenna half the length of the 1st and bearing a spine at one third length from the base. Mouth parts very closely spaced. 2nd maxilla 2-segmented, with 7 setae on the distal segment. 2nd maxilliped without exopod; coxal spines present; subexopodal spines present. In addition, 2 more spines present near the subexopodal spines on legs 1 to 3. 4th leg rudimentary.

Stage 4: 7.5 mm (Fig. 7b) Carapace shield is wider, the ratio of shield length to breadth being 1.4 and that of shield width to thoracic width 1.1. 1st antenna segmented. 2nd antenna extending to three fourth length of 1st and with spine. Distal segment of 2nd maxilla flattened and with 11 setae. 2nd maxilliped with finger-shaped exopod. Coxal spines ventral. 4th leg with setose exopod, 5th leg rudimentary.

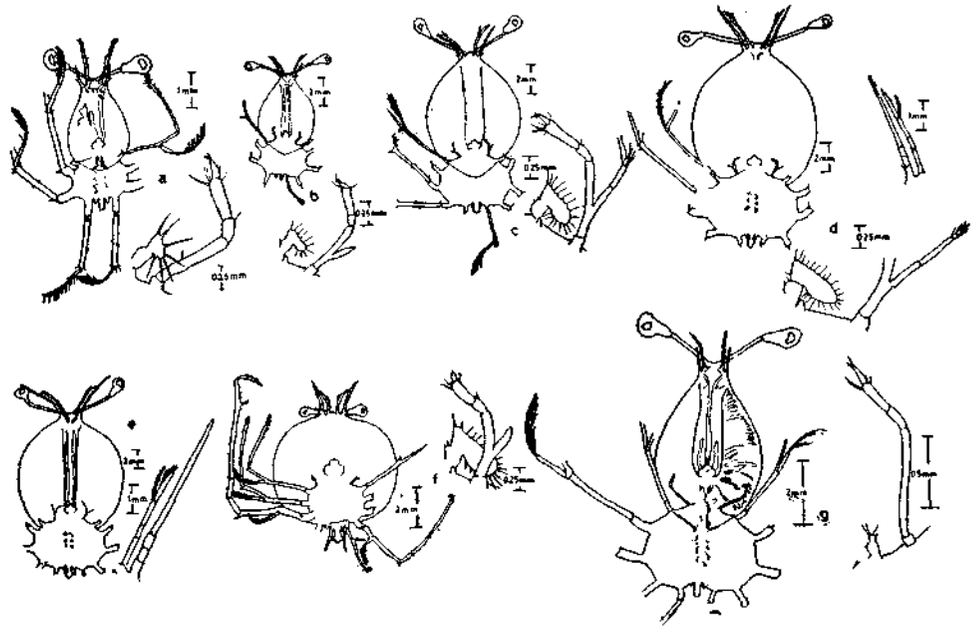

Fig. 7. Phyllosoma of *Palinustus mossambicus* – a. Stage 2 (3.5 mm); b. Stage 4 (7.5 mm); c. Stage 5 (11.0 mm); d. Stage 6 (13.25 mm); e. Stage 7 (17.0 mm); f. Stage 5 of *Puerulus angulatus* (6.8 mm) and g. Stage 4 of *Panulirus* sp. I (7.25 mm).

Stage 5: 11.0 mm (Fig.7c) The fore-body becomes more sub-circular and the ratio of length to breadth is 1.3 and cephalic shield width to thoracic width ratio is 1.25. 1st and 2nd antenna equal in length. Latter also faintly segmented. Distal segment of 2nd maxilla has 17 setae. Exopod of 2nd maxilliped segmented and setose. Coxal spines present. 5th leg extending to middle of the abdomen.

Stage 6: 13.25 mm (Fig. 7d). The cephalic shield typically sub-circular. Ratio of cephalic shield length and breadth 1.25 and that of shield breadth and thoracic width 1.3. 2nd antenna segmented and longer than 1st. The characteristic spine at the extremity of the 3rd peduncular segment of 2nd antenna is clearly noticed at this stage. Spine on the 1st segment small. Distal segment of 2nd maxilla with 22 setae. Coxal spines present. 5th leg 2-segmented.

Stage 7: 17.0 mm (Fig. 7e). This is the same stage as described by Tampi and George (1975). All the details agree with their description. The ratio of length to breadth of cephalic shield is 1.3 and that of cephalic shield width to thoracic width 1.25.

Remarks

The earlier stages of this species have never been recorded, although Johnson (1971) recorded a later stage from South China Sea (as *Panulirus* sp.) and Berry (1974) from Natal Coast. Tampi and George (1975) got one specimen of stage 7 from the IIOE material. The spine on the extremity of the 3rd peduncular segment of 2nd antenna and the anterior branch of the 1st maxilla with two masticatory processes only are diagnostic characters of the species in later stages.

Distribution

All the 33 specimens of this series of larvae have been obtained from the western half of the Indian Ocean. In fact, 32 specimens came from the central part of this region, the maximum number from a single station being 14, from 3920X. Only a solitary specimen was obtained from near the east coast of Africa. The distribution of these larvae might indicate the possibility of the occurrence of their adults in the deeper waters of that region. The occurrence of large quantities of this species in the deeper waters off south-west coast of Kerala, India has been recently reported in the exploratory fishing conducted by the Integrated Fisheries Project. The occurrence of these in still deeper region is indicated only by the presence of their larvae in that region.

9. **Puerulus angulatus** (Bate, 1888) (Fig. 7f)

Material

3828 IV – 1 (III) 4.0 and 3903 III – I (V) 6.8.

Description

Stage 3: 4.0 mm. The larva is quite similar to stage 2 larva (4.3 mm) described by Johnson (1971) from South China Sea and almost all the characters like the segmentation of the 2nd antenna agree with his description.

Stage 5: 6.8 mm (Fig. 7f). This resembles well the 7.3 mm larva figured by Johnson (1971). The overlapping of the thorax by the cephalic shield includes the coxae of the 2nd pair of pereopods and the third legs are biramous.

Remarks

Johnson (1971) had tentatively put the 4.3 mm larva as stage 2 and 7.3 mm larva as stage 7. Taking into account the size of the larva and development of the appendages in the two larvae almost near these lengths it is more probable that they belong to stages 3 and 5 respectively.

Distribution

The two specimens present in the collection have both been obtained from the eastern part of the Indian Ocean, off Java Coast.

10. **Palinurellus wieneckii** (de Man, 1881) (Fig. 8a-j)

Material

Stage II–2.1, 2.9, 2.7–5, 2.6–4, 2.75–3, 2.5, 2.8; III–3.5–3, 3.75–3, 3.6–2, 4.0–3, 4.1, 3.7; IV–4.7, 4.75, 4.9–4, 4.8–4, 5.0–7, 5.2, 5.1, 4.6; V–6.0, 6.3, 6.8, 6.5–5, 5.75, 6.25–4, 6.75–2; VI–7.0, 8.0, 8.25, 8.5; VII–8.6, 9.0–2, 8.5, 9.75–2; VIII–12.5, 13.0; IX–11.5, 14.0–2, 14.75; X–15.0, 15.5; XI–16.0–2, 23.0–4, 18.0, 17.0; XII–27.0, 23.75, 24.0.

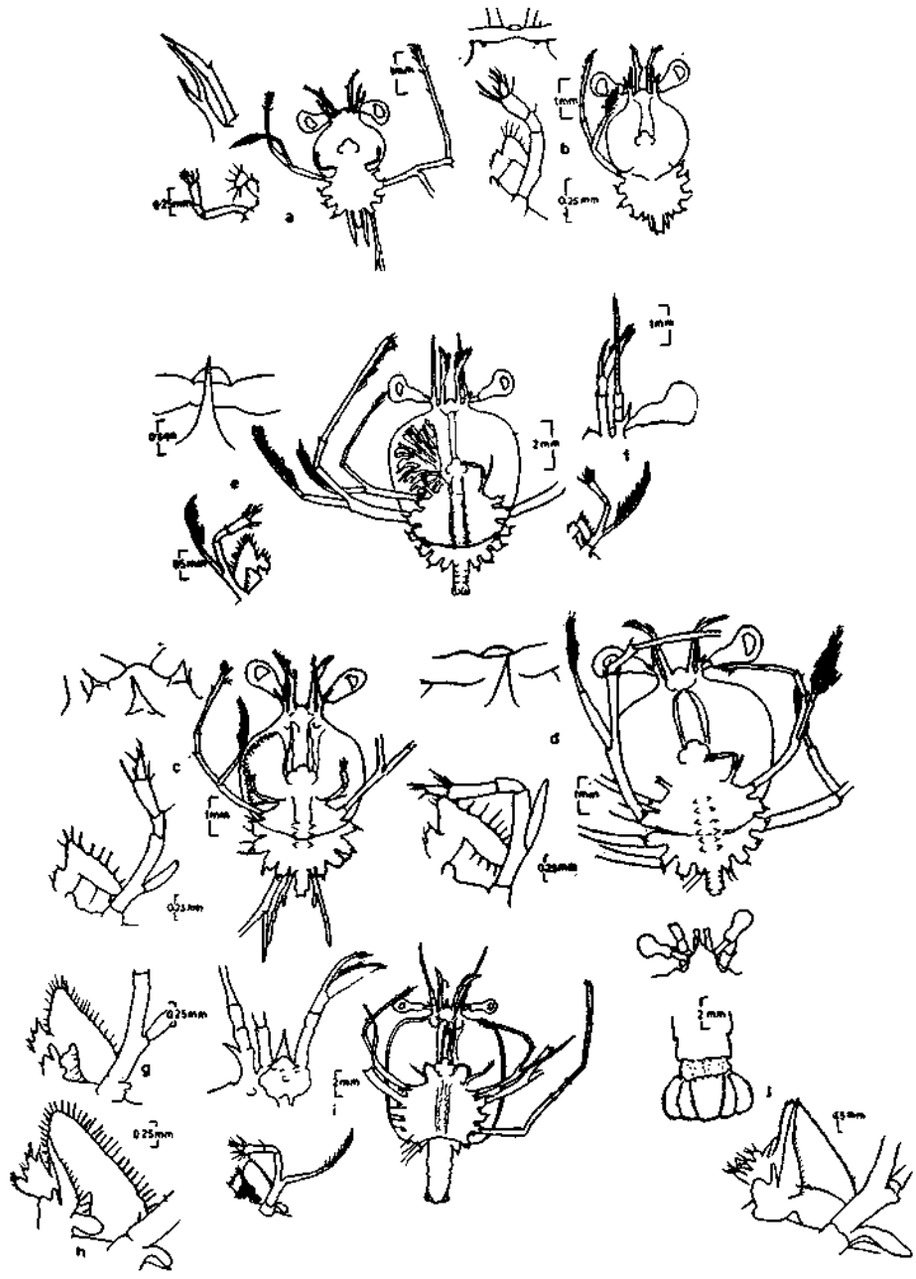

Fig. 8. Phyllosoma of *Palinurellus wieneckii* – a. Stage 2 (2.9 mm); b. Stage 3 (3.5 mm); c. Stage 4 (4.9 mm); d. Stage 5 (6.0 mm); e. Stage 6 (8.0 mm); f. appendages of stage 7 (8.6 mm); g. appendages of stage 8 (9.0 mm); h. appendages of stage 9 (13.5 mm); i. Stage 10 (16.0 mm) and j. rostrum, telson and appendages of stage 12 (27.0 mm).

TABLE 7. *Principal changes in successive phyllosoma stages 2 to 12 of* **Palinurellus weineckii***

	Length range (mm)										
	2.1-2.9	3.0-4.1	4.5-5.2	5.5-6.9	7.0-8.5	8.6-9.9	10.0-13.0	13.2-14.9	15.0-18.0	18.5-23.8	24.0-27.0
a–1	1 seg. 3 setae	end bud	..	end long	exo end	..	..	..	..	..	..
a–2	bifid <a–1	..	..	..	seg > a–1	basal sp.	..	..	..	..	..
m–1	ant. br 2 sp	..	palp, with 2 setae	..	ant. br 3 sp	..	..	..	..	..	..
m–2	2 seg. 6 setae	flat 9 setae	12 setae	22 setae	many setae	.. ..	prox. seg. 3 lobed	4 lobed	5 lobed	..	..
mpd–1	bud	..	..	..	bilobed	..	..	trilobed	4 lobed	..	..
mpd–2	no exo	exo bud	exo long	..	exo setose	..	..	..	..	..	..
mpd–3	exo setose, vcs	..	..	..	..	..	..	..	..	..	..
p–1	exo setose vcs	..	..	..	..	..	..	..	..	..	..
p–2	exo setose vcs	..	..	..	..	..	..	..	..	..	..
p–3	exo small vcs	exo setose, vcs	..	..	..	..	..	..	..	..	..
p–4	0	long	exo setose vcs	..	..	..	..	..	..	..	..
p–5	0	bud	long, exo bud	exo setose, vcs	..	..	..	..	..	..	..
pleo	0	0	0	bud	biramous	..	..	..	..	..	..
uro	0	0	bud	biramous	..	..	..	..	..	..	..

* First stage is not represented in this Table.

3817 IV–1 (XII), 3817 V–5 (III, IV–3,V), 3824 VIII–1 (VII). 3860 VII–1 (IV), 3960 XI & XV –2 (III), 3860 XXII–6 (II, III–5), 3860 XXIII–1 (III),3903 IV–1 (II), 3908 V–1 (XII),3918 V–1 (II), 3931 IV–1 (II), 3936 V–2(II, III), 3949 III–1 (XII), 3949 V–24 (II–4, III–3, IV–8, V–3, VIII, X, XI –2, XII–2), 3950 I–1 (IV), 3951 V–9 (IV–2, V–4, VIII, IX, XI), 3954 I–1 (II), 3954 V–3 (II–2, XI), 3955 II–1 (III), 3955 III–1 (IV), 3955 IV–12 (III–2, IV–3, V–6, IX), 3955 V–4 (II–2, III, IV), 3957 V–1 (VIII), 3958 I–2 (II, XI), 3959 III–2 (III, XI),3959 IV–1 (V), 3960 II–2 (XII), 3962 V–1 (XII), 3964 IV–2 (VII), 3964 V–6 (VII, VIII, XII–4) and 3967–2 (II).

Description

A complete series of the larvae of *P. wieneckii* except the 1st stage is available in the collections and the characters agree with those given by Michel (1969, 1971). In summarising the salient features in Table 7 Michel's description of some of the stages are also made use of.

The presence of a rostrum on the cephalic shield is one of the characteristic features of the species and the rostrum is quite prominent in the later stages. The cephalic shield which is of the usual shape in the very early stages becomes rectangular and completely encloses the thorax in the later stages. The presence of palp with two setae on the 1st maxilla and 5 well defined endites on the endopod of 2nd maxilla are also diagnostic features. The distance between the mouth parts and the bases of 2nd maxillipeds decreases with the development of stages.

Remarks

Johnson (1968 a) recorded 2 large sized phyllosoma of the species as *phyllamphion* from Hawaii, while Sims (1966) concluded that a series of larvae with rectangular shield from Caribbean area was of the genus *Palinurellus*. Later, Michel (1969) described similar larvae from New Caledonia with rectangular cephalic shield possessing rostrum as that of *Palinurellus wieneckii*. Possession of a rostrum and rectangular shape of the cephalic shield are given as identifying characters of the species by Michel (1971). The present series of larvae definitely belong to *P. wieneckii* based on all the characters.

Distribution

100 larvae were obtained from different parts of the Indian Ocean. However, most of the specimens came from the western half of the Ocean, 80 specimens being obtained from that region. Maximum number of 24 specimens from a single station was obtained from station 3949 V off East African Coast. In fact most of the specimens in the collection were from that region only, indicating thereby that the adults of the species are most abundant in the area. A few specimens were present in the collection of eastern part of the South African Coast, although Berry (1974) failed to get a single specimen of the species off Natal Coast.

Family: SCYLLARIDAE

11. **Scyllarus cultrifer** (Ortmann, 1897) (Fig. 9 a-i)

Material

Stage II–2.3, 2.2, 2.5–3, 2.75–2, 28–3, 26, 225; III–3.0–3, 3.3, 3.75–3, 3.5–3; IV–5.0, 4.5–2, 4.0–2, 4.25–4, 4.75, 4.6; V–5.2–2, 5.5–3, 6.5–2, 5.25, 6.25, 6.4; VI–8.5–6, 8.0–2, 8.75–2, 6.75, 6.8, 7.0–2, 7.2, 7.5–2, 7.25, 8.6, 8.9–2, 8.8; VII–9.5, 10.2, 9.25, 9.75–2, 10.1, 10.5–2, 10.6, 9.4, 9.6–2, 10.0–2, 10.9; VIII– 11.8–2, 12.0–6, 12.6, 12.8, 13.0–2, 13.2–2, 12.5–3, 11.2, 12.2, 13.75–2, 11.0, 12.25, 12.75, 12.9, 13.25, 13.4, 13.5, 14.0; IX–14.5, 14.1; X–17.0; XI–25.0,

TABLE 8. *Principal changes in successive phyllosoma stages 2 to 12 of* **Scyllarus cultrifer**

	Length range (mm)										
	2.0–2.8	2.9–3.8	3.9–5.0	5.1–6.5	6.7–8.8	9.0–10.8	11.0–14.0	14.1–16.5	16.6–19.0	19.5–25.0	25.5–33.0
a–1	end bud	end long	end, exo	..	..	..	..	..	..	..	..
a–2	1 seg <a–1	with process	..	..	..	.. ≈a–1	..	..	..	..	..
m–1	ant. br. 2 sp.	..	..	..	ant. br 3 sp.	..	..	..	..	..	..
m–2	dist. 4 setae	..	..	..	1 seg. no setae	blunt	tip flat	..	..	..	..
mpd–1	0	0	0	bud	..	..	..	..	..	triangular	bilobed
mpd–2	no exo	..	..	..	..	..	..	..	..	..	..
mpd–3	no exo, vcs	..	..	..	..	..	..	..	..	..	..
p–1	exo setose vcs	..	..	..	..	..	..	..	..	..	..
p–2	exo setose vcs	..	..	..	..	..	..	..	..	..	..
p–3	exo setose vcs	..	..	..	..	..	..	..	..	..	..
p–4	exo bud vcs	..	exo long vcs	exo setose, vcs	..	..	..	..	..	..	..
p–5	bud	bud	..	finger shaped	long	..	3 seg	4 seg vcs	..	..	5 seg. vcs
pleo	0	0	bud	..	..	..	biramous	..	..	..	..
uro	0	bud	biramous	..	..	..	..	..	..	..	..

First stage not represented. Final stage from Berry (1974).

3809 I-4 (II, VI-2, VIII), 3809 IV-13 (II-4, III, VI-2, VII-3, VIII-3), 3817 V-7 (II, III-2, V-3, VII), 3821 V-5 (II, III-3 VIII), 3828 IV-1 (VIII), 3843 IV-1 (VIII), 3860 XI & XV-5 (II-2, IV, VIII-2), 3860 XXII-2 (IV, V), 3900 I-23 (V-3, VI-7, VII-5, VIII-6, IX), 3900 III-22 (VI-8, VII-4, VIII-9, IX), 3903 V-9 (III, VI, VII-4, VIII-3), 3949 V-1 (III), 3951 IV-1 (XI), 3951 V-1 (VI), (II), 3954 III-I (III), 3954 IV-1 (V), 3954 V-2 (II) 3955 IV-1 (VI), 3956 IV-1 (III), 3962 IV-1 (X), 3954 II-1 3967-II (IV-9, V-2) and 3969 II-1 (IV).

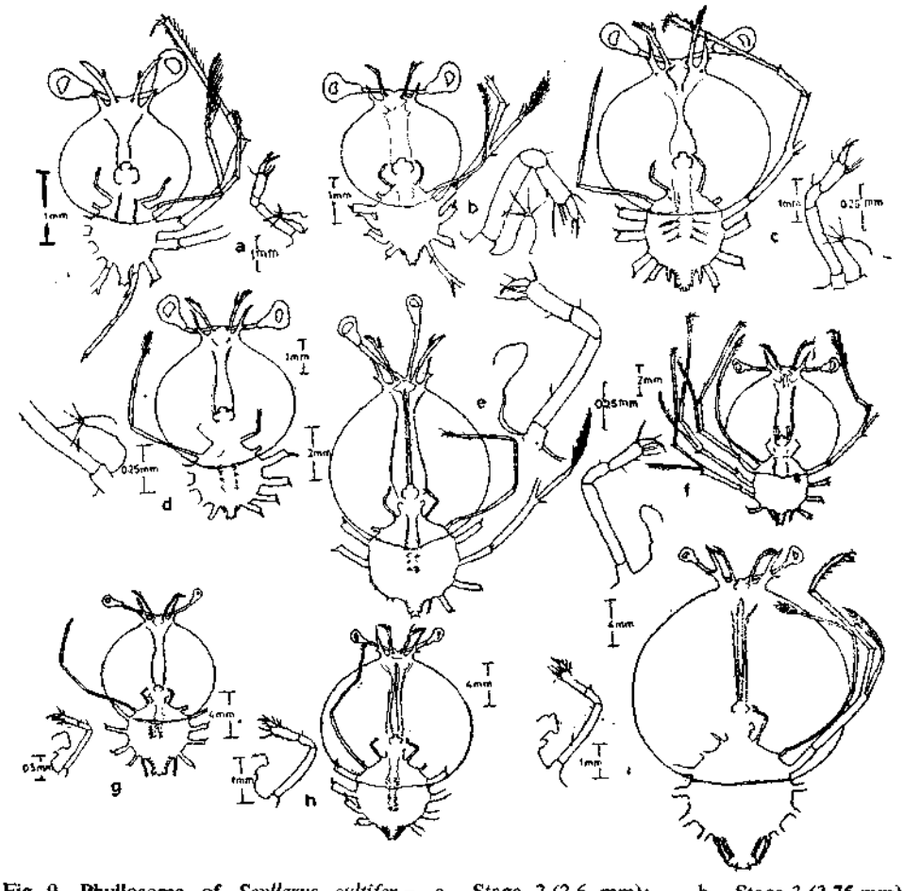

Fig. 9. Phyllosoma of *Scyllarus cultifer* – a. Stage 2 (2.6 mm); b. Stage 3 (3.75 mm); c. Stage 4 (5.2 mm); d. Stage 5 (5.5 m) e. Stage 6 (8.5 mm); f. Stage 7 (10.2 mm); g. Stage 8 (14.0 mm); h. Stage 10 (17.0 mm) and i. Stage 11 (25.0 mm).

Description

In this series of larvae, identified as belonging to *S. cultrifer*, the 1st, 9th and the final gilled stages are lacking in the collections. The important features of the different stages are summarised in Table 8.

In all the stages the cephalic shield is almost twice the width of the thorax and the shield is nearly as wide as long except in the later stages where the width is

increasing compared to the length. The distance between the anterior mouth parts and the level of midpoint between the coxae of maxilliped 2 increases towards the later stages.

The lateral process on the 2nd antenna appears in stage 3. The 2nd antenna in earlier stages is smaller than 1st and in the later stages the two are almost equal in length. Fringing setae are wanting on the 2nd maxilla after stage 5. Ventral coxal spines present on all legs and the third maxillipeds.

Remarks

Tampi and George (1975) recorded stages 2 to 7 of this species from the IIOE collections from Indian Ocean and mentioned that the gilled stage obtained from Natal waters by Berry (1974) seemed to be a continuation of the series. All the intermediate stages except stage 9 are present in this collection.

Distribution

The larvae are distributed both in western and eastern halves of the Indian Ocean covered by the cruise. However, their occurrence is more in the eastern part. Out of a total of 115 specimens, 92 were collected from the eastern part of the Ocean mostly near Java, Sumatra Coast. Maximum number of 45 larvae were collected from station 3900 I, 23 larvae from a depth of 100 m and 22 from 50 m, on the eastern coast of northern half of Sumatra. The occurrence of the adults of *S. cultrifer* in this area in large quantities may be indicated by the concentration of these larvae in this region.

12. Scyllarus rugosus (H. Milne Edwards, 1837) (Fig. 10 a-j)

Material

Stage I–1.7, 1.28; II–2.2, 2.25–2, 2.48, 2.5–5, 2.0; III–3.0, 3.25–3, 3.75–2, 2.8–2, 2.9, 3.0, 4.3, 4.25, 4.2, 3.9–5, 4.0–2; IV–4.7, 5.1, 5.25–3, 5.5–6, 5.0–4, 4.5, 5.4–2; V–5.75–8, 6.5–3, 6.0–3,6.25; VI–7.5–4, 6.75–2, 7.25–4, 7.3, 7.0; VII–8.0–4, 8.25, 7.75–5, 8.6, 8.5–2; VIII–9.0–2; IX–10.25, 11.25–4, 10.75–2, 11.0; X–11.5–5, 12.0–3, 12.75–3, 12.5–4, 12.8; XI–14.75–2, 14.0, 13.12, 13.25, 14.25, 13.0; XII–18.0–2, 16.75, 17.8, 17.5–3, 18.25, 18.5–3, 17.0, 17.75.

3804 III–2 (VI, XII), 3809 II–20 (II–3, III–5, IV–5, V, VI, VII, IX, X–2, XI), 3809 III–2 (II, V), 3809 IV–16 (I, II–4, III–4, IV–2, V, VIII, XI, XII–2), 3814 III–1 (IX), 3817 V–2 (IV, IX), 3820 II–1 (IV), 3821 III–4 (III, VIII, X–2), 3821 V–3 (V, VII, X),3824 V–1 (IV), 3824 VIII-1 (IV),3828 IV–1 (VII), 3844 III–1 (XI), 3960 XI & XV–1 (X), 3893 III-1 (V), 3893 IX–1 (X),3900 I–6 (XII), 3900 III–4 (X, XII–3), 3903 V–2 (X, XII), 3916 II–1 (IX), 3916 III–8 (III, IV–1, V, VI, VII, IX), 3919 IV–1 (X), 3922 III–1 (VII), 3922 IV–8 (II–2, IV,V, VI, VII–3), 3922 V–4 (IV, V–3), 3924 II–1 (IX), 3924 III–1 (X), 3924 IV–1 (X), 3926 IV–1 (VII), 3931 II–1 (XI), 3931 III–1 (I), 3937 II–1 (IV), 3937 III–1 (X), 3937 IV–1 (X), 3937 V–1 (VII), 3942 IV–1 (VII), 3951 V–2 (IX, XI), 3953 IV–1 (XI), 3954 V–1 (IV), 3955 1–2 (V, X), 3955 IV–15 (III, IV–2 VI–8, VII–2, IX, X), 3956 IV–1 (V), 3961 1–1 (XI), 3967–13 (III–8, IV–2, V–3), 3970 II–1 (VI) and 3971 V–1 (IV).

Description

A complete series of larval stages of *S. rugosus* is present in the collection. However, the descriptions of Berry (1974) and Tampi and George (1975) are also taken into consideration in summarising the salient features of the species given in Table 9.

As in *S. cultrifer* the cephalic shield length and width are almost the same, with slight differences only in a few stages. The thorax is slightly wider than half the

width of the shield especially the later stages. The distance between the mouth parts and the coxal level of maxilliped 2 decreases towards the later stages unlike in *S. cultrifer*. In general, the size of the larvae is much smaller when compared to *S. cultrifer*.

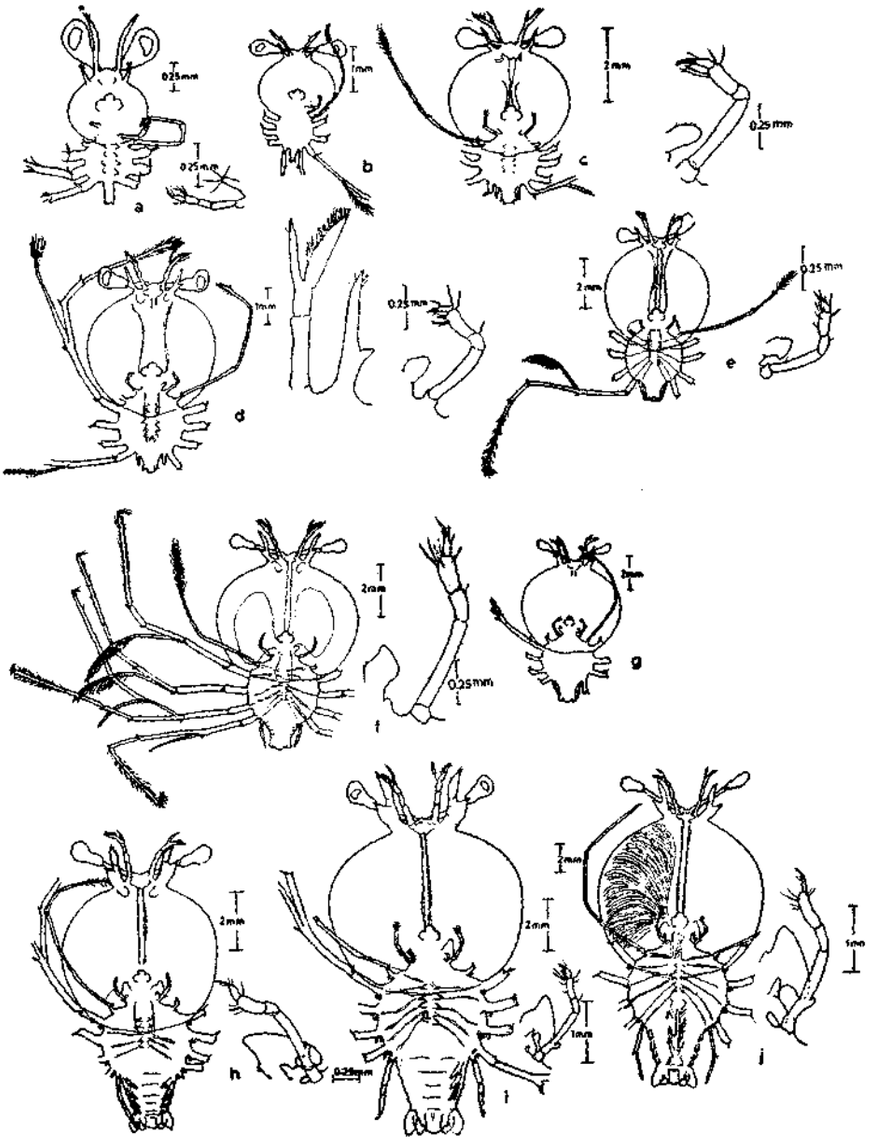

Fig. 10. Phyllosoma of *Scyllarus rugosus* – a. Stage 1 (1.2 mm); b. Stage 2 (2.5 mm); c. Stage 3 (4.3 mm); d. Stage 4 (5.0 mm); e. Stage 5 (6.5 mm); f. Stage 6 (7.5 mm); g. Stage 7 (8.5 mm); h. Stage 8 (9.0 mm); i. Stage 10 (12.75 mm) and j. Stage 12 (18.0 mm).

TABLE 9. *Principal changes in successive phyllosoma stages 1 to 12 of* **Scyllarus rugosus**

	Length range (mm)											
	1.1-1.8	1.9-2.8	3.0-4.3	4.4-5.6	5.7-6.8	6.9-7.6	7.7-8.6	8.7-9.8	9.9-11.3	11.4-12.9	13.0-15.0	15.1-18.5
a–1	1 seg	end bud	end long	end, exo	..	..	..	..	..	..	..	..
a–2	1 seg 2 setae <a–1	no setae	with process	..	..	..	..	broad	.. =a–1	..	..	.. <a–1
m–1	ant. br. 2 sp.	..	..	..	ant. br. 3 sp	..	..	..	..	..	..	..
m–2	dist. seg 4 setae	..	1 seg 3 setae	1 seta	blunt	..	..	flat	..	..	..	..
mpd–1	0	0	bud	..	..	..	..	bilobed	..	..	..	..
mpd–2	no exo	..	..	..	..	..	..	exo rudiment	..	..	..	..
mpd–3	no exo, vcs	..	..	..	..	..	..	..	..	..	..	..
p–1	exo setose vcs	..	..	..	..	..	..	..	..	..	..	..
p–2	exo setose vcs	..	..	..	..	..	..	..	..	..	..	..
p–3	exo setose vcs	..	..	..	..	..	..	..	..	..	..	..
p–4	bud	exo bud vcs	exo setose, vcs	..	..	..	..	..	..	..	..	..
p–5	0	0	long	..	vcs	..	..	..	4 seg. vcs	..	..	..
pleo	0	0	bud	..	biramous	..	..	..	..	..	..	..
uro	0	0	biramous	..	..	..	..	..	..	..	..	..

The second antenna is never more than the length of the first antenna and becomes broader from stage 8 onwards. The gills also start appearing in the 8th stage at 8.5 mm size.

Remarks

Based on circumstantial evidence of distribution of adult, Tampi and George (1975) assigned certain larvae collected during IIOE to *S. rugosus*. Similar larvae present in the collections from Natal waters were tentatively suggested to belong to the same species by Berry (1974). Therefore, there is no hesitation in considering the present series of larvae as belonging to *S. rugosus*.

Distribution

The species is almost equally distributed in the two halves of the Indian Ocean covered by the expedition. Among a total of 142 specimens, 70 larvae were from the eastern half and the rest from the western half. The maximum number of 20 and 16 were collected from the stations 3809 II and 3809 IV at depths of 300 m and 50 m respectively. The station is located off the western tip of Java. Station 3955 IV off mid-western coast of Madagascar also yielded 15 larvae. These localities may be areas where adults of *S. rugosus* are concentrated.

13. **Scyllarus martensii** Pfeffer, 1881 (Fig. 11 a-i)

Material

Stage I–1.8 1.9–6, 1.6–4; II–2.4–5, 2.25, 2.0–2, 2.1, 2.15, 2.75–7, 2.8–6, 2.9–5, 2.2, 2.3, 2.5–6, 2.87, 2.6–3, 2.7; III–3.0–9, 3.1–2, 3.5–6, 3.7, 3.75–12, 3.25–5, 3.8–5, 3.4, 3.3–3, 3.6–2, 3.85, 3.9; IV–4.66, 4.5–10, 4.18, 4.0–25, 4.1–8, 4.3–6, 4.4–2, 4.75–3, 5.0–5, 5.1–3, 4.25–10, 4.2–4, 4.6; V–5.2–2, 5,75–6, 5.9–2, 5.25–3, 5.5–3, 5.8–2, 5.24, 5.7; VI–6.0–21, 6.2–2, 6.5–7, 6.1, 6.25–10, 6.3–2, 7.0–2, 6.9; VII–7.4–2, 7.8, 8.0–3, 7.25, 7.5–2, 7.6; VIII–8.25–4, 8.1,8.2, 8.6–3, 9.0–15, 9.5–4, 9.1–2,–9.25–8, 8.75–3, 8.8, 9.2–4, 8.5, 9.4; IX–10.1, 10.0–3, 11.0–7, 10.25–2, 9.75–3, 10.5–6, 10.6, 9.7; X–12.0–2, 12.75, 14.25, 14.0–2, 11.5, 14.5, 13.0, 13.75, 13.25–5, 12.5–3, 13.5–2.

3804 III–1 (II), 3804 IV–1 (II), 3809 I–2 (III, IV), 3809 II–2 (IV, VIII), 3809 III–1 (IV), 3809 IV–66 (1–2, II–9, III–10, IV–17, V–4, VI–4, VII–3, VIII–8, IX, X, 7 damaged), 3814 III–1 (VIII), 3817 V–1 (II), 3821 II–2 (II, VI), 3821 III–3 (II, IV, IX), 3821 V–12 (II–3, III–6, IV–3), 3824 VIII–3 (V, VI. VII), 3828 I–1 (V), 3828 IV–1 (V), 3843 IV–1 (VIII), 3844 II–1 (IX), 3844 VIII–1 (X), 3850 II–1 (IX), 3850 III–1 (X), 3860 VII–1 (I), 3860 XI & XV–3 (I, IV, V), 3860 XXI–1 (III), 3860 XXII –3 (III, IV, VI), 3893 IX–7 (IV, VII, VIII–3, IX–2), 3900 I–4 (VIII–3, IX), 3900 III–1 (VIII), 3901–1 (III), 3903 V–4 (IV–2, IX–2), 3910 IV–1 (I) 3913 V–1 (VII), 3915 II–1 (III), 3916 III–3 (III, VI,VII), 3922 II–1 (II), 3922 III–38 (1–3, II, III–2,IV–7, V–2, VI–10, VIII–11, IX–2), 3922 IV–10 (IV–5, VI –3, VIII–2), 3922 V–68 (1–2, II–10, III–16, IV–18,V–6, VI–12, VIII–4), 3924 III–1 (VIII), 3925 V–1 (V), 3931 I–1 (I), 3931 III–1 (II), 3931 IV–1 (II) 3942 IV–1 (VI), 3944 I–1 (VII), 3944 II–2 (VI), 3944 IV–1 (VIII), 3944 V–1 (VI), 3948 II–1 (IX), 3948 III–2 (IX, X), 3949 I–1 (X), 3949 II–1 (III), 3949 IV–1 (IX), 3949 V–2 (IV, IX), 3950 I–2(VI, (III), 3951 V–3 (III–2, V), 3953 II–1 (X), 3953 IV –1 (X). 3954 IV–2 (II, X), 3954 V–1 (IV), 3955 I–4 (III–2, X–2), 3955 III–1 (IV), 3955 IV–30 (II–1, III–3, IV–11, V–2, VI–3, VIII–5, IX–2, X–2, 1 damaged), 3955 V–1 (IV), 3956 III–1 (X), 3959 I–1 (IV), 3961 I–1 (VII), 3962 V–4 (VI, X–3), 3963 III–1 (X), 3964 IV–3 (VI, X–2), 3965 I–1 (X), 3965 II–11 (X), 3967–5 (I, II–7, III–2, IV–3,VI, X), 3969 III–3 (VIII, X–2), 3969 IV–7 (IV, VI, VII, VIII, X–3), 3969 V–1 (X), 3971 III–1 (X), 3971 IV–2 (VI, X) and 3971 V–2 (II, IV).

Description

Several stages of *S. martensii* have been described in earlier works (Johnson 1971; Berry, 1974 and Tampi and George, 1975) and these have been considered in summarising the salient features of this series of larvae in Table 10.

TABLE 10. *Principal changes in successive phyllosoma stages 1 to 10 of* **Scyllarus martensii**

	length range (mm)									
	1.1–1.9	2.0–2.9	3.0–3.9	4.0–5.1	5.2–5.9	6.0–7.0	7.1–8.0	8.1–9.5	9.6–11.0	11.1–14.5
a-1	1 seg. 2 setae	end bud	end long	end exo	..	..	..	..	..	..
a-2	1 seg. <a-1	..	with process	..	..	.. =a-1	..	..	..	..
m-1	ant. br. 2 sp.	..	..	..	ant. br. 3 sp.	..	..	..	..	..
m-2	dist. 4 setae	..	..	blunt	flat	..	..	..	..	..
mpd-1	0	0	bud	..	bilobed	..	..	..	..	..
mpd-2	no exo	..	..	..	..	exo bud	..	..	..	..
mpd-3	no exo vcs	..	..	..	..	exo bud vcs	..	..	..	..
p-1	exo setose vcs, ses	..	..	..	..	..	..	..	..	..
p-2	exo setose vcs, ses	..	..	..	..	..	..	..	..	..
p-3	exo short vcs, ses	exo setose vcs ses	..	..	..	..	..	..	..	..
p-4	1 seg	exo bud vcs	exo long vcs	exo set-ose, vcs	..	..	..	..	..	..
p-5	0	bud	vcs	2 seg. vcs	exo bud, vcs	3 seg vcs	..	..	..	..
pleo	0	0	0	bud	biramous	..	..	..	..	..
uro	0	0	bud	biramous	..	..	..	..	..	..

The cephalic shield length and width ratio is almost constant in all the stages and width of fore-body is almost double the width of the thorax throughout the stages. The distance of the mouth parts from mid level of the coxae of maxilliped 2 shows a decrease towards the later stages, as in most other species.

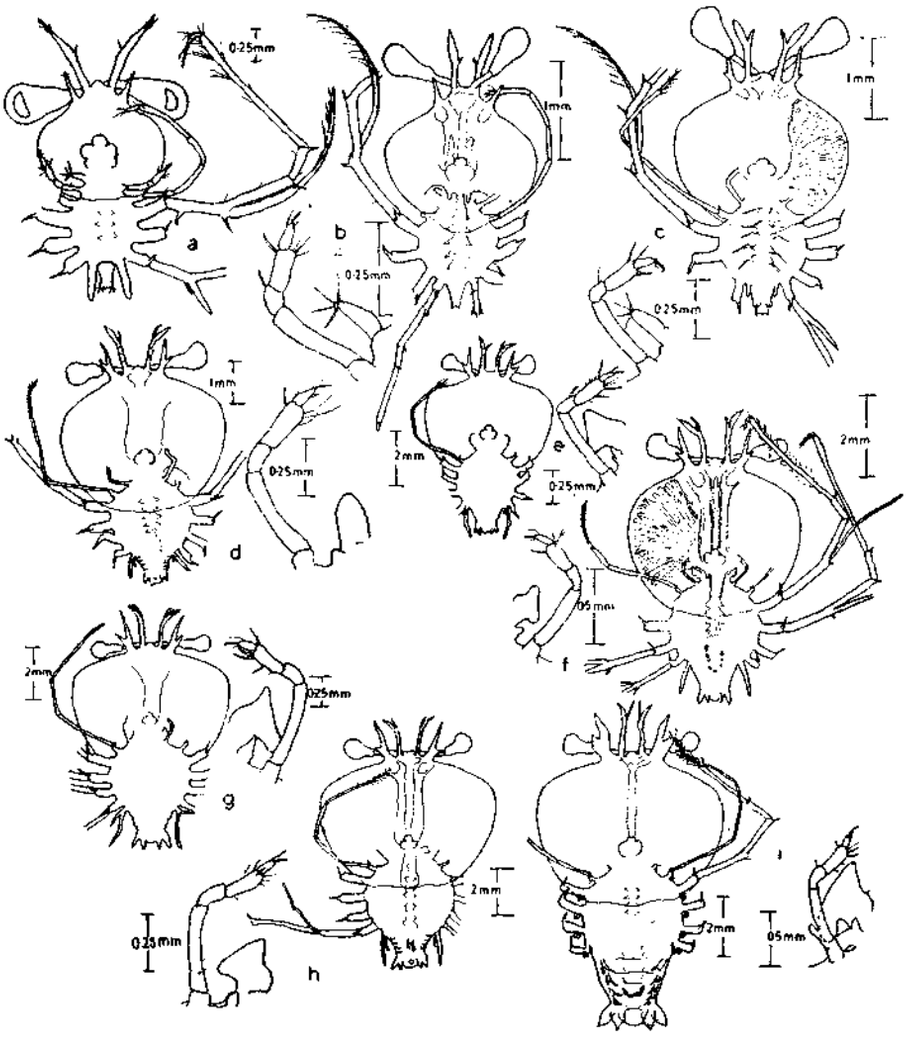

Fig. 11. Phyllosoma of *Scyllarus martensii* – a. Stage 1 (1.6 mm); b. Stage 2(2.2 mm); c. Stage 3 (3.0 mm); d. Stage 4 (5.0 mm); e. Stage 5 (5.7 mm); f. Stage 6 (6.0 mm); g. Stage 7 (7.5 mm); h. Stage 8 (9.1 mm) and i. gilled stage (9.25 mm).

The tips of the uropods ending in sharp points is a diagnostic feature of this species. The sizes of the different stages of larvae are comparatively small. The gilled stage is reached at a length of 8 to 9 mm size. The second antenna becomes equal in length with the first antenna in the later stages and never exceeds its length.

Remarks

The larvae with trapizoidal cephalic shield which were originally thought to be belonging to *Scyllarides* sp. have later on been proved to belong to *Scyllarus* sp. only (Robertson, 1969). Johnson (1970), Berry (1974) and Tampi and George (1975) have identified these larvae as that of *S. martensii* and this identification is followed in assigning the largest series of larvae in the present collection to a species.

Distribution

The larvae of this species are the most abundant among the scyllarids, a total of 360 specimens being collected from the different areas. However, the larvae are more common in the western half of the Indian Ocean than in the eastern half, only 129 larval specimens coming from the latter region and the rest 231 from the former region. The maximum number of 68 larvae from a single station was collected from station 3922 V near the Seychelles Islands. Station 3809 IV near Java Coast yielded 66 larvae. From the number of larvae present in the collections this seems to be the commonest species of scyllarid in the Indian Ocean region.

14. Scyllarus batei Holthuis, 1946 (Fig. 12 a-j)

Material

Stage I–1.88, 1.8–2; II–2.24, 2.64, 2.6, 2.78, 2.9, 3.15, 3.2, 3.25, 2.1, 2.5, 2.75-2, 3.0, 2.7; III–3.8–2, 4.25, 4.5, 4.2, 3.9; IV–4.97, 5.9, 4.8, 5.0, 5.5, 6.25–2, 6.5, 6.0–2, 6.3, 7.0–2; V-9.02, 7.3, 9.25–2, 7.5; VI–11.5, 10.6, 11.0, 10.5, 10.0–2, 11.2; VII–12.2, 12.0, 12.5–3, 13.0–2, 12.1, 13.2, 13.5–2, 14.0, 12.75; VIII–15.0, 14.5; IX–18.0–2, 17.0, 17.5–2, 16.75; X–25.0.

3804 III-1 (VIII), 3804 IV-6 (II-2, IV-2, VI, IX), 3809 I-1 (VII), 3809 II-3 (III, VI, XI), 3809 III-8 (I, II-4, III-2, IV), 3809 IV–3 (IV), 3817 IV–1 (IV), 3817 V–2 (II), 3821 II–1 (III), 3821 V–2 (II, VI), 3824 VII–1 (VI), 3824 VIII–3 (IV–2, V), 3828 IV–2 (IV, V), 3844 VIII–1 (IX), 3860 VII–1 (II), 3860 XI & XV–1 (V), 3860 XXII–2 (IV), 3903 IV–2 (V, VII), 3916 III–1 (II), 3922 V–2 (I), 3937 II-2 (II, III), 3954 IV–1 (II), 3958 I–1 (II), 3958 III–1 (IX), 3959 III–1 (IX), 3961 I–6 (VII–3, VIII, IX-2), 3961 II–7 (VI–2 VII–5), 3962 IV–3 (V–2, VII), 3962 V–1 (VII), 3964 VIII–1 (VII) and 3967–2 (II, III).

Description

A complete series of larvae of this species of *Scyllarus* is represented in these collections. Tampi and George (1975) described a few stages of the species. Their account as well as that of species A described by Johnson (1971) have been made use of in summarising the salient features of the species in Table 11.

Compared to *S. cultrifer* the cephalic shield width increases in proportion to length towards the later stages. The thorax is only half the width of the fore-body in most of the later stages from stage 6 onwards earlier to which it is slightly wider. The distance between anterior mouth parts and the coxal level of maxilliped 2 decreases in later stages.

The gills appear from stage 9 onwards from a size of 16 mm and above. The long telsonic spine from the early stages onwards is a noteworthy feature of these larvae. The presence of dorsal spines along the margin of the thorax at the base of the pereopods from stage 8 is also characteristic of the species.

TABLE 11. *Principal changes in successive phyllosoma stages 1 to 12 of* **Scyllarus batei**

	Length range (mm)											
	1.1-1.9	2.0-3.3	3.4-4.5	4.6-6.8	7.1-9.2	9.3-11.5	11.6-14.0	14.1-16.5	16.6-19.5	20.0-23.0	23.1 25.5	26.0-29.0
a–1	1 seg. end bud	..	end long	end exo	..	..	..	..	..	..	..	..
a–2	1 seg. 2 setae <a–1	1 seta	with process	...	..	.. =a–1	..	..	..	..	..	..
m–1	ant. br. 2 sp.	..	..	ant. br. 3 sp.	..	..	..	..	..	..	..	..
m–2	dist. 4 setae	..	..	blunt 2 setae	..	..	..	..	..	flat	..	..
mpd–1	0	0	0	0	0	bud	..	..	..	bilobed	..	..
mpd–2	no exo	..	..	..	..	..	..	..	..	..	..	..
mpd–3	no exo vcs	..	..	..	..	..	..	..	..	..	..	..
p–1	exo setose vcs	..	..	..	..	..	..	exo setose vcs, dts	..	..	..	..
p–2	exo setose vcs	..	..	..	..	..	..	exo, setose vcs, dts	..	..	..	..
p–3	exo setose vcs	..	..	..	..	..	..	exo setose vcs, dts	..	..	..	..
p–4	no exo	exo bud	exo long	exo set-ose, vcs	..	vcs dts	..	..	..	..	..	..
p–5	0	0	bud	..	..	long, vcs	..	seg. vcs	..	..	..	..
pleo	0	0	0	0	0	bud	..	biramous	..	..	..	..
uro	0	0	0	bud	..	biramous	..	..	..	..	..	..

Remarks

Based on the circumstantial evidence of the distribution and the prominent telson spines in the first larva hatched out by Prasad and Tampi (1960) and the later stages obtained by them, Tampi and George (1975) tentatively assigned similar larvae as that of *S. sordidus*. Recently, Sankolli and Shenoy (1973) described the

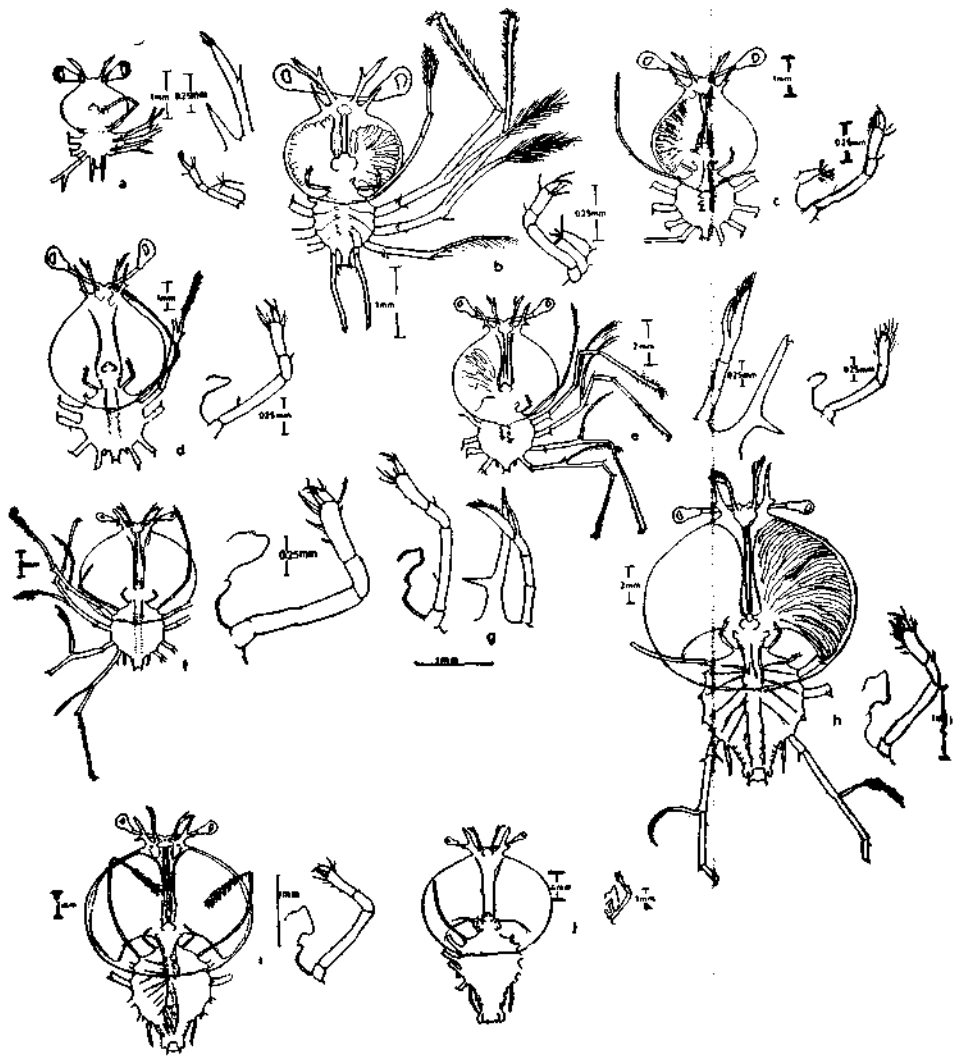

Fig. 12. Phyllosoma of *Scyllarus batei* – a. Stage 1 (1.8 mm); b. Stage 2 (2.4 mm); c. Stage 3 (4.2 mm); d. Stage 4 (6.0 mm); e. Stage 5 7.0 mm); f. Stage 6 (11.5 mm); g. appendages of stage 7 (12.2 mm); h. Stage 8 (15.0 mm) i. Stage 9 (18,0 mm) and j. gilled stage (25.0 mm).

larvae of *S. sordidus* reared in the laboratory up to the 6th stage. None of these stages possessed, according to them, the prolonged telson spines. So, the present larvae as well as those described by Tampi and George (1975) can only belong to

TABLE 12. *Principal changes in successive phyllosoma stages 2 to 8 of* **Scyllarus amabilis**

	Length range (mm)						
	2.5-3.5	3.6-4.9	5.0-7.0	7.1-8.9	9.0-10.8	10.9-12.8	13.0
a–1	1 seg. end bud	end long	..	..	..	..	..
a–2	1 seg. <a–1	with process	..	..	..	..	..
m–1	ant. br. 2 sp.	..	ant. br. 3sp	..	..	..	..
m–2	dist. 4 setae	..	no setae	..	..	..	tip, flat
mpd–1	0	0	0	bud	..	..	triangular
mpd–2	no exo	..	..	..	..	..	..
mpd–3	no exo, vcs	..	..	..	..	..	..
p–1	exo setose, vcs	..	vcs ses	..	..	..	..
p–2	exo setose vcs	..	vcs ses	..	..	..	..
p–3	exo setose vcs	..	vcs ses	..	..	..	..
p–4	exo ,vcs	..	exo setose vcs	..	..	..	..
p–5	bud	..	long	..	..	vcs	3 seg. vcs
pleo	0	0	bud	..	..	..	biramous
uro	0	0	bud	biramous	..	..	..

Stage 1 not represented.

some other species. As the early stages of Johnson's (1971) species A agree with these larvae, they may belong to a species prevalent in both South China Sea as well as the Indian Ocean. *S. batei* has been recorded from the Arabian Sea and Bay of Bengal (Alcock, 1901), Zanzibar area (Ramadan, 1938) and from the Philippines (Holthuis, 1960). Recently, George (1967) recorded one of the subspecies of *S. batei* from south-west coast of India. Thus, it is seen that this species has a distribution in the whole of the Indian Ocean region as well as in the Western Pacific. So, the larvae are tentatively assigned to *S. batei.*

Distribution

The species is slightly more abundant in the eastern half of the Indian Ocean. Among 70 specimens, 40 were collected from the eastern region of the Indian Ocean and 30 from the other half. The maximum number of 8 larvae were collected from station 3809 III off western tip of Java. 7 and 6 larvae were collected from stations 3961 III and 3961 I respectively in the western part also. So, the adults seem to be present in both areas.

15. **Scyllarus amabilis** Holthuis, 1963 (Fig. 13a-e)

Material

Stage II–3.0–4, 2.9, 3.25–3, 3.4–2, 3.5–4, 3.1–2, 2.8, 3.3, 3.6; III–4.0–5, 3.75–3, 4.1–4, 4.4, 4.5–3, 4.25, 4.9–2, 3.7, 3.8–2, 3.9, 4.7, 4.75; IV–5.5–4, 5.0–2, 6.5–4, 7.0–4, 5.75–4, 6.9, 5.1, 5.25, 5.6, 5.7, 6.0–2, 6.1–2, 6.2, 6.3, 6.6, 6.7–2, 6.75, 6.8, 6.25; V–7.3, 8.0–3, 7.25-2, 7.1, 7.2, 7.9, 8.3, 8.5–2, 8.75–3; VI–9.0–3, 9.5–4, 9.75, 10.0, 10.22–2, 10.5, 10.6–2, 10.75; VII–12.5.

3809 I-1 (III) 3809 II–3 (II, IV–2), 3809 IV–19 (II–9, III–9, IV), 3814 IV–1 (V), 3815 III-1 (IV), 3817 V–1(IV), 3820 II–1 (II), 3821 V–3 (III, IV, V), 3824 VII–1 (IV), 3828 IV–1 (III), 3843 IV–3 (III, IV, V), 3854 II–1 (VII), 3860 XI & XV–1 (IV), 3860 XXII–2 (II, IV), 3893 VII–2 (III, V) 3900 I–1 (II), 3900–III–65 (II–5, III–12, IV–22, V–11, VI–15), 3902 III–1 (II), 3902 V-2 (IV).

Description

Stages 2 to 7 of a species of *Scyllarus* were present in the collection in fairly good numbers. The salient features of the larvae are summarised in Table 12 including those of stage 8 given by Tampi and George (1975).

The length to breadth ratio of the cephalic shield is very constant at 1:1 in all the stages available. Thoracic width in proportion to cephalic shield width is also almost constant.

The pereopods possess subexopodal spines from stage 4 onwards. Ventral coxal spines are present on pereopods from early stage. Telson possesses prominent postero-lateral spines in stage 8.

Remarks

Stage 8 of a similar species was described in the collection of IIOE by Tampi and George (1975), as *Scyllarus* sp. III. From the distribution, it is quite evident that these larvae belong to a species which is perhaps restricted to east of 90°E longitude in the eastern half of the Indian Ocean. The only species of scyllarid recorded from this region is *S. amabilis.* This was recorded from north-west coast of Australia only by Holthuis (1963). The specimen of the IIOE collection (Tampi and George, 1975) has actually been collected at a station latitude 10°41′S

and longitude 112°12′ E off north-west coast of Australia. The distribution of the present larvae in the localities above this area might indicate that they belong to this species and therefore, these larvae are tentatively assigned to *S. amabilis*.

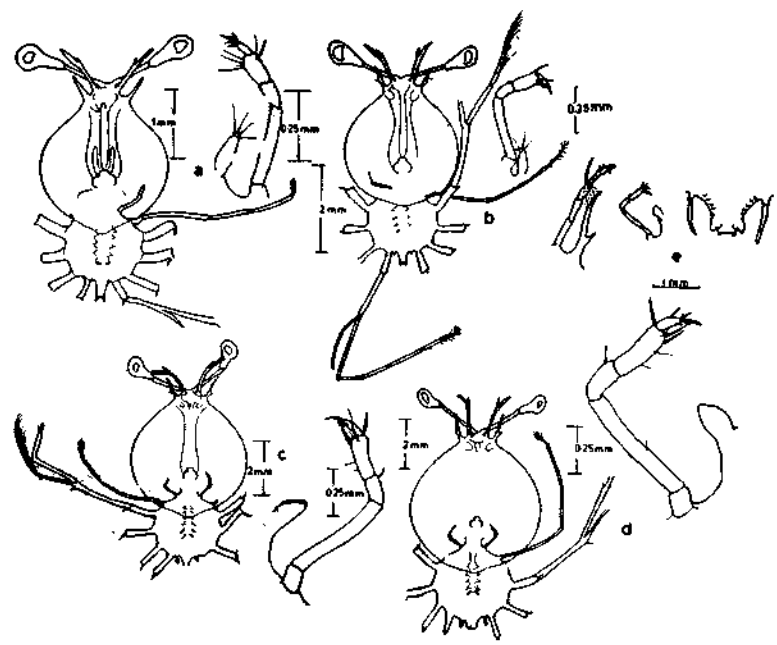

Fig. 13. Phyllosoma of *Scyllarus amabilis* – a. Stage 2 (3.1 mm); b. Stage 3 (4.0 mm); c. Stage 4 (6.5 mm); d. Stage 5 (8.0 mm) and e. appendages and abdomen of stage 6 (10.0 mm).

Distribution

The distribution of this series of larvae is quite peculiar in that they are found only in the eastern half of the Indian Ocean covered by the expedition and that too east of 90°E longitude. Station 3900 III yielded the maximum number of larvae out of a total of 110 specimens. This station is located near the north-east coast of Sumatra. Apart from one other station *i.e.* 3809 IV yielding 19 larvae most of the other stations had only 1 or 2 larvae each.

16. **Scyllarus** sp. I (Fig. 14 a, b)

Material

20.6, 31.0 (gilled), 14.0, 19.5, 22.0, 28.0, 16.0, 29.25, (gilled), 30.0 (gilled), 16.0, 11.75, 13.0, 11.5, 11.75, 12.75, 13.0, 24.5, 19.0, 26.0.

3804 IV–1, 3814 III–1, 3815 VII–1, 3844 III–2, 3844 VIII–1, 3847 IV–1, 3893 IX–2, 3916 III–1, 3919 IV–2, 3919 V–1, 3926 III–3, 3928 III–1, 3937 IV–1, 3941 IV–1.

Description

This series of scyllarid larvae is quite peculiar in having a thick cephalic shield. Excepting for the thick shield with a distinctly concave posterior margin

all the characters are those of the scyllarid. Smaller sizes of larvae were not encountered, all the specimens being above 11.5 mm in total length, most of them above 20.00 mm length.

Larva–11.5 mm (Fig. 14 a): Cephalic shield is 7.9 mm in length and 10.2 mm in width. The thorax is 4 mm wide. 1st antenna segmented and with elongated endopod. 2nd antenna almost the same length as the 1st and with strong lateral process. 2nd maxilla single segmented ending in a blunt point and without setae. 1st maxilliped rudimentary. Exopods absent on 2nd and 3rd maxillipeds. Coxal spines present on all legs and 3rd maxillipeds. Leg 5 small and uniramous. Biramous buds of uropod and pleopods present. Telson bears two strong terminal spines.

Larva–31 mm (Fig. 14 b): Posterior margin of cephalic shield concave. Cephalic shield thick and 21 mm long 28.5 mm wide. The thorax is 51 mm wide. 2nd antenna broad. 2nd maxilla flattened but fringing setae wanting. 1st maxilliped bilobed. Exopods on 2nd and 3rd maxillipeds present as rudimentary buds. Coxal spines and subexopodal spine present on legs. Leg 5 with 3 segments and coxal spines present. Biramous pleopods and uropods present. Telson spines relatively shorter. Gills present.

Remarks

The gilled stage especially resembles species A described by Johnson (1971) excepting for the thick cephalic shield which is not mentioned by him. But the shape of the shield and other characters of the gilled stage are quite in agreement.

Distribution

Out of 19 specimens of these larvae, 9 were from the western part of the Indian Ocean and the others from the eastern part, near the Java, Sumatra Coast.

17. **Scyllarus** sp. II (Fig. 14 c)

Material

3809 II–2 and 3955 IV–2; 5.5, 8.9, 5.8, 11.0.

Description

All the four larvae resembled *Scyllarus* sp. II described by Prasad and Tampi (1960). Most of the characters agree with their description. The anterior part of the cephalic shield is the broadest and it is almost twice as broad as the thorax. In the 11.0 mm specimen the gills are quite well developed and the 2nd maxilla is the flattened to usual shape, without setae. The 3-segmented 5th pereopod is almost as long as the abdomen. Coxal spines present on all the pereopods. Both maxillipeds 2 and 3 possess rudimentary exopods. The 11.0 mm specimen appears to be last gilled stage.

Two of the specimens were collected from near Java Coast and the two others came from off Madagascar Coast.

18. Scyllarus sp. III (Fig. 14 d)

Material

3971 III-1, 37.0

Description

This is the only larva of the type in the collection. 37.0 mm total length. As in scyllarids the maxilliped 3 is without exopod. But all the other features are those of a palinurid larva. The third peduncular segment of antenna 2 carrying 2 spines ventrally and 1 dorsally at the distal end. Maxilliped 2 with rudimentary exopod. Coxal spines prominent in maxilliped 3 and all legs. Gills present in all the legs. Pleopods and uropods biramous. On the lateral margin of exopod of uropod there are two prominent spines midlaterally in addition to small serrations.

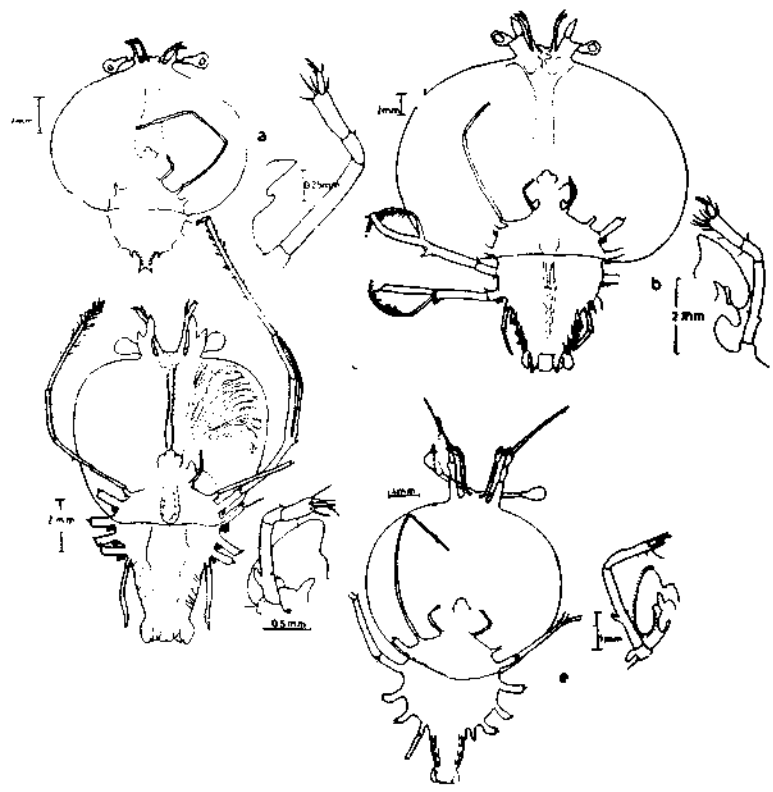

Fig. 14 a and b: Phyllosoma of *Scyllarus* sp. I – a. 11.5 mm; b. 31.0 mm; c. Phyllosoma of *Scyllarus* sp. II–11.0 mm and d. Phyllosoma of *Scyllarus* sp. III–37.0 mm.

19. Evibacus sp.

Material

3903 IV – 1, 43.0.

Description

A single specimen 43 mm in total length with all legs broken was obtained from station 3903 IV. From the description of the larvae of *Evibacus princeps* given by Johnson (1968 b) from the Gulf of California the present specimen seems to belong to that genus. The cephalic shield and the thorax are slightly broken. Tips of the pereopods are available. Although there are some differences in the number of spines, there is no doubt that these belong to a larva of the same genus. The antennule is comparatively stouter than the antenna. On the dorsal aspect of the carapace there is a median raised plate. Maxilliped 3 has a short rudimentary single segmented exopodite as in the case of several of the scyllarids of this group.

20. **Thenus orientalis** (Lund, 1793) (Fig. 15 a-d)

Material

Stage II–2.5, 3.1, 3.5–6; III–4.3; VI–10.0, 10.2, 11.0, 11.4; VII–19.0; VIII–26.75; IX–41.0, 45.0.

3809 II–4 (II, VII, IX–2), 3809 III–5 (III, V, VI–3), 3809 IV–1 (VII), 3900 III–1 (II), and 3922 V–6 (II).

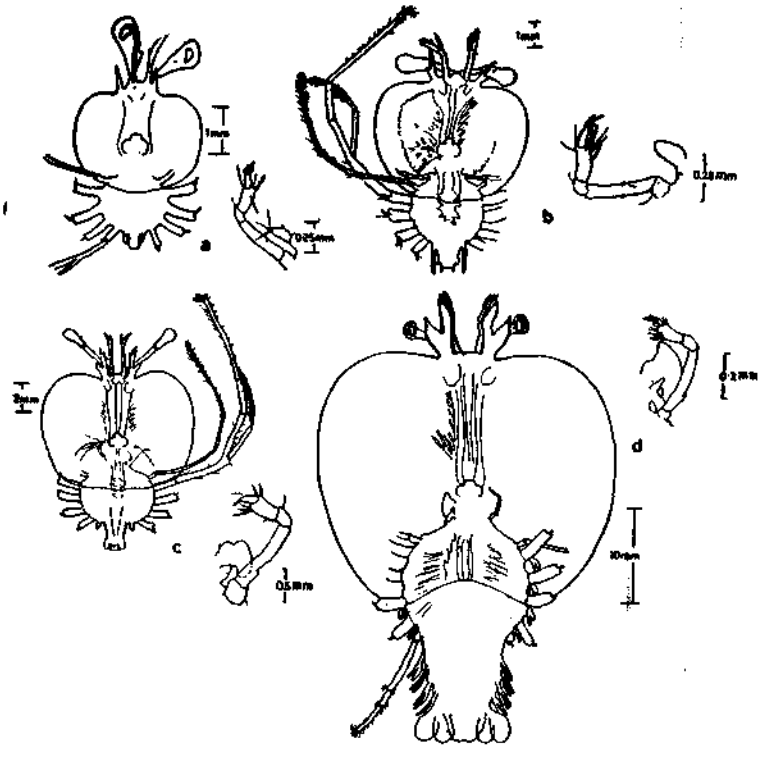

Fig. 15. Phyllosoma of *Thenus orientalis* – a. Stage 2 (3.5 mm); b. Stage 3 (4.3 mm); c. Stage 4 (11.4 mm) and d. gilled stage (41.5 mm).

TABLE 13. *Principal changes in successive phyllosoma stages 1 to 4 and 6, 7 and 9 of* Thenus orientalis

	Length range (mm)						
	2.5-3.0	3.1-3.9	4.0-5.1	5.2-7.0	10.1-13.0	15.0-20.0	41.0-45.0
a–1	1 seg. 3 setae	end bud	end long	..	..	..	..
a–2	1 seg. 1 seta <a–1	..	with process	..	flat	..	..
m–1	ant. br. 2 sp.	..	ant. br. 3 sp.	..	..	..	..
m–2	dist. 3 setae	..	blunt	..	flat no setae	..	..
mpd–1	0	0	bud	..	bud	bilobed	..
mpd–2	no exo	..	..	..	..	exo bud	..
mpd–3	no exo vcs	..	..	..	..	exo bud vcs	..
p–1	exo setose vcs, ses	..	..	..	..	..	..
p–2	exo setose vcs, ses	..	..	..	..	..	..
p–3	exo setose vcs, ses	..	..	..	..	..	..
p–4	no exo 5 seg.	exo bud vcs	exo long vcs	exo setose vcs	..	..	..
p–5	bud	..	long	2 seg.	5 seg. vcs	..	..
pleo	0	0	0	bud	..	..	..
uro	0	bud	..	biramous	..	..	..

Stages 5 and 8 not represented.

Description

The first stage hatched out in the laboratory and a few later stages of *T. orientalis* have been described by Prasad and Tampi (1957). The same stages available in the present collection agree well with their description and the salient features of the series including the stages given by them are summarised in Table 13.

The cephalic shield is broader than long in all stages and the ratio of length to width remains constant between 0.8 and 0.9 through the stages. The width of the thorax is almost half the width of the shield except in the last gilled stage where it is only one-third.

The 4th pereopod is quite well developed even in the first stage although without the exopod. Subexopodal spines are present on the pereopods. Unlike in other scyllarids even in the first gilled stage the pleopods are only buds.

Remarks

Prasad and Tampi (1957) found that the characters of the larvae of *T. orientalis* described by them differed considerably from those described by Stephenson (1923) as the same species and the phyllosoma of *Thenus* described by Gurney (1936). As the 1st stage was hatched out from a known parent in the laboratory, there is no doubt as to the identity of the larvae described by Prasad and Tampi (1957) and this identification is followed here.

Distribution

Only 17 specimens were present in the whole collections. Out of these, 11 larvae were from near Java, Sumatra Coast, 10 of them being collected from stations 3809 II, III and IV and the other from 3900 III. The rest of the specimens were from off Seychelles Islands. The poor representation of the larvae of this species in the collection appears strange in view of the fairly wide distribution of this lobster in Indian seas.

21. **Parribacus antarcticus** (Lund, 1793) (Fig. 16 a-e)

Material

Stage II–2.75, 2.5–3, III–4.0, 3.5–3, 3.75–2; IV–5.5–3, 5.2, 5.4; V–6.75, 8.0–2, 6.9, 7.0, 7.75, 8.25; VI–9.0–2, 9.4; 10.25, 10.5, 9.25, 9.5; VII–13.5, 13.0; XI–76.0, 67.0; XII–77.0, 80.0.

3814 IV–4 (VI–3, VII), 3815 VII–1 (XII–Giant), 3824 VIII–1 (IV), 3860 XI & XV–1 (IV), 3860 XXII–1 (VI), 3860 XXIII–3 (II), 3916 I–1 (XI Giant) 3916 V–1 (XII Giant), 3951 V–3 (IV, V, VI,) 3952 II–1 (XI Giant), 3952–1 (VII), 3954 IV–2 (IV, VI), 3955 V–6 (IV–2, V–3, VI), 3959 I–1 (V), 3959 II–1 (VI).

Description

Some of the larval stages including the giant larvae of *P. antarcticus* are present in the collections. The salient features of the series of larvae are summarised in the Table 14, using the descriptions of some stage of Johnson (1971 a,b).

The cephalic shield length and width ratio increases gradually from the first stage onwards to stage 6 and then gradually decreases. The cephalic shield width

and thoracic width ratio, on the other hand decreases gradually from stage I onwards to stage 6 and thereafter gradually increases. The distance of the mouth parts to the coxal level does not show much change in the various stages.

The nature of the 2nd antenna is quite characteristic, being biramous with the inner ramus articulated up to the 4th stage. In stages 5 and 6 there is only a short process and in the stages 7 to 9 the process is absent. From stage 10 onwards the process appears and becomes much broader in the last stages. The coxal spines on the pereopods disappear from stage 7 The pleopods and uropods develop comparatively later, although all pereopods are developed and with setose exopods by the 7th stage.

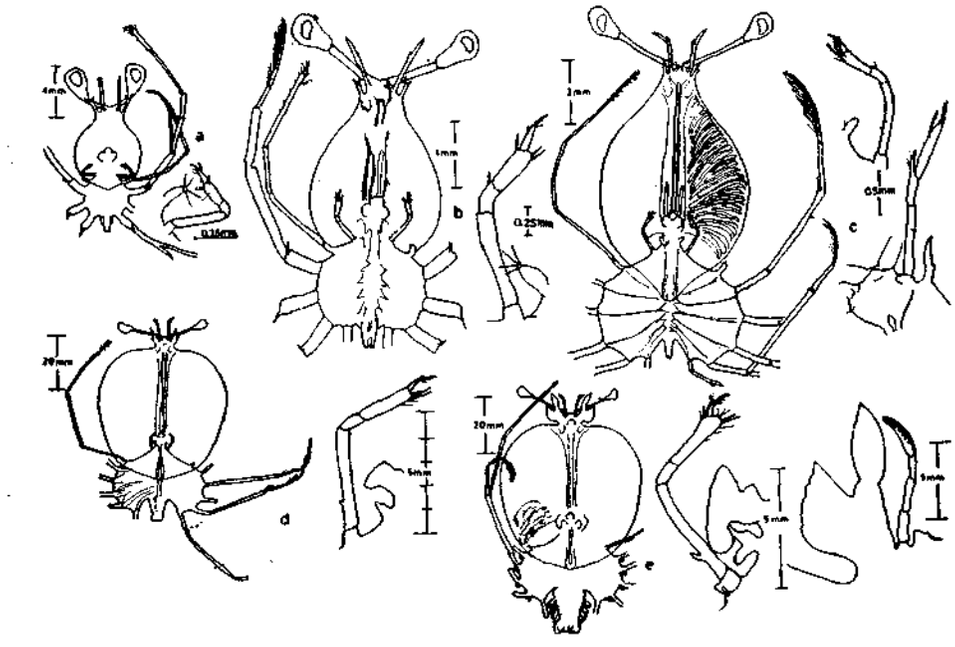

Fig. 16. Phyllosoma of *Parribacus antarcticus* – a. Stage 2 (2.5 mm); b. Stage 3 (4.0 mm); c. Stage 6 (9.0 mm); d. giant phyllosoma (67.0 mm) and e. giant phyllosoma (80.0 mm).

Remarks

Johnson (1968 b, 1971 a, b) described several stages of *P. antarcticus*, from California Coast, Hawaiian Islands and South China Sea respectively. The characters given by him are quite diagnostic that there is no hesitation in assigning the present series of larvae to that species. According to him, Robertson's (1968) Caribbean giant phyllosoma may be of the same species and also Saisho's (1962, 1966) specimens. Berry (1974) also identified the larvae from Natal waters as belonging to this species. From the Laccadive Seas Prasad and Tampi (1959) described a stage I larva possessing biramous 2nd antenna as that of *Jasus lalandii*. However, the articulated nature of the inner ramus of the 2nd antenna would indicate that this may be the 1st stage larva of *Parribacus antarcticus*.

TABLE 14. *Principal changes in successive phyllosoma stages 1 to 12 of* Parribacus antarcticus

	Length range (mm)											
	1.2-1.9	2.0-3.1	3.2-4.3	4.5-5.5	5.6-8.3	8.5-12.0	12.5-17.0	17.5-25.0	31.5	41.8	50.0 67.0 76.0	77.0 80.0
a-1	uniramous	..	end bud	..	..	end long	..	..	..	..	..	..
a-2	biramous	..	..	..	with process	..	no process	..	..	with small process	base broad	.. = a-1
m-1	ant. br. 2 sp.	..	..	..	..	..	ant. br. 3 sp.	..	..	..	..	..
m-2	dist. 4 setae	..	..	..	..	blunt 1-2 setae	..	..	..	..	..	flat, no setae
mpd-1	0	0	bud	..	..	..	..	..	..	..	..	bilobed
mpd-2	no exo	..	..	..	..	..	..	..	..	..	..	exo bud
mpd-3	no exo	..	..	..	..	no exo vcs	no exo vcs	..	..	..	..	exo bud
p-1	exo setose vcs	..	..	..	..	..	no vcs	..	..	..	..	..
p-2	exo setose vcs	..	..	..	..	..	no vcs	..	..	..	..	..
p-3	exo bud vcs	exo long vcs	exo set-ose, vcs	..	..	..	no vcs	..	..	..	..	..
p-4	bud	..	exo bud long	exo setose, vcs	..	..	no vcs	..	..	..	..	..
p-5	0	0	bud	..	exo bud	..	exo setose, no vcs	..	..	..	..	..
pleo	0	0	0	0	0	0	bud	..	..	biramous	..	..
uro	0	0	0	0	0	0	bud	..	biramous	..	..	..

Some of the stages from the description by Johnson (1971 a, b).

Distribution

Altogether 28 specimens were collected including 4 giant phyllosoma specimens measuring 67.0 mm, 76.0 mm, 77.0 mm and 80 mm. Among the total larvae of the species, 17 have been collected from the western half of the Indian Ocean and the rest 11 only from the eastern part near the Java, Sumatra Coast. Out of the 17 collected from the western half, most of them came from nearer the east and South African Coast excepting 2 giant specimens collected from station 3916 near the equatorial region due south of India. Of the other two giant larvae, one was obtained from near Java Coast and the other, off Madagascar Coast. The limited number of larvae might indicate that the species is not very common in the Indian Ocean. The equatorial region due south of India seems to be an area where the species is more abundant as Saisho (1966) and Tampi and George (1975) also got larvae of this species from that area.

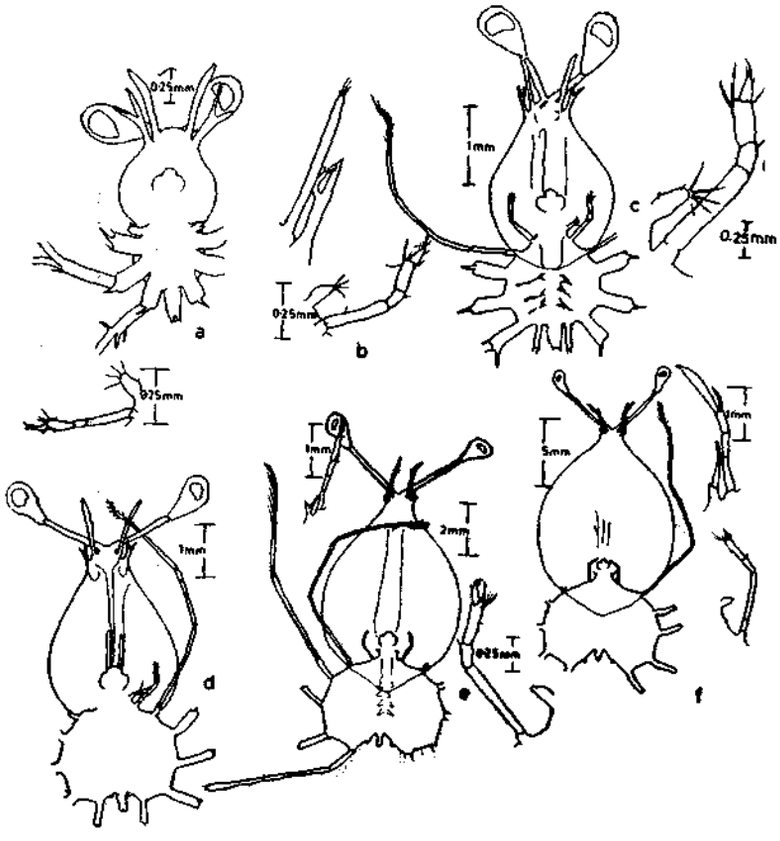

Fig. 17. Phyllosoma of *Scyllarides* sp. – a. Stage 1 (1.4 mm); b. appendages of stage 2 (2.25 mm); c. Stage 3 (3.09 mm); d. Stage 4 (4.9 mm); e. Stage 7 (9.5 mm) and f. Stage 8 (16.5 mm).

22. **Scyllarides** sp. (Fig. 17 a-f)

Material

Stage I–1.4; II–2.0–2, 2.3–2, 2.25–2; III–3.09, 3.15, 3.3, 3.8, 3.9; IV–4.2, 4.5, 4.7 4.9–2; VII–9.5, 11.0; VIII–16.5, 15.0; IX–18.25.

3817 V-1 (III), 3860 XXII-4 (II-3, III), 3903 IV-1 (II), 3931-1 (II), 3931 III-1 (I), 3936 III-1 (II), 3944 III-1 (VII), 3949 V-9 (III-3, IV-5, VII), 3961 II-1 (VIII), 3963 I-1 (VIII), 3964 IV-1 (IX).

Description

In the absence of several stages it will suffice here to provide detailed figures of those stages present in this collection and to point out the significant similarities and differences from similar stages of allied genus *Parribacus*. The 1.4 mm specimen shown in Fig. 17 a is probably comparable to the ist stage of *Parribacus antarcticus*. The most important difference is that the inner ramus of 2nd antenna is not articulated. The specimens measuring 2.0 to 2.3 mm (Fig. 17b) are comparable to stage 2. of *P. antarcticus* and those 3.09 mm and 3.15 mm to stage 3. In these stages as well as in 4.2 mm specimens referable to stage 4 also the inner ramus of 2nd antenna is not articulated unlike in the other species. Stage 5 and 6 are not present in the collection. The most striking difference in the seventh and eighth stages (Fig. 17 e, f) from those of *P. antarcticus* is in the degree of development of the fifth pair of legs. As in *Scyllarides squammosus* described by Johnson (1971 a) the fifth pair of legs are only rudimentary buds in these stages, while in *P. antarcticus* they are quite well developed with exopodite. Another difference in these stages is the presence of lateral processes in the 2nd antenna as in *S. squammosus*. The present larvae as well as those of *S. squammosus* and *P. antarcticus* agree in the deep concavity of the posterior margin of the thorax and the shape of the cephalic shield.

Remarks

Robertson (1969) described the larval characteristics of *Scyllarides* and both Johnson (1971 a) and Berry (1974) reviewed the literature on *Parribacus*, *Scyllarides* and *Arctides*. Based on their discussions the present larvae may be assigned to *Scyllarides* sp. Coming from the different parts of the Indian Ocean, one or more species may be involved.

Distribution

Out of a total of 22 larvae belonging to stages 1 to 8, 16 specimens were collected from near the African Coast and only 6 larvae from eastern part of the Indian Ocean. Station 3949 yielded 9 larvae.

GENERAL REMARKS

The specific identification of phyllosoma larvae has been a major problem. In recent years there has been an increasing volume of literature appearing on this subject but in most cases the assignment of the particular larva to a species has been based on circumstantial evidence. That being so, the problem becomes more difficult with collections made from tropical regions where there is multiplicity of species. The authors, therefore, have depended very much on the published data for identification of the wide variety of larvae constituting the collection.

The collection, on detailed study has revealed 1983 larvae consisting of 1087 palinurids and 896 scyllarids. Ten species belonging to 4 genera of palinurids viz., *Panulirus versicolor*, *P. homarus*, *P. longipes*, *P. ornatus*, *Palinurellus wieneckii*, *Panulirus polyphagus*, *Palinustus mossambicus*, *Panulirus* sp. I, and *Puerulus angulatus* were recorded in the order of abundance. There is a greater variety in

respect of scyllarids of which there are 5 genera and 12 species. In the order of abundance they are, *Scyllarus martensii, S. rugosus, S. cultrifer, S. amabilis, S. batei, Parribacus antarcticus, Scyllarides* sp., *Scyllarus* sp. I, *Thenus orientalis, Scyllarus* sp. II, *Scyllarus* sp. III and *Eribacus* sp.

Prasad and Tampi (1965) had observed that the numerical dominance of palinurid phyllosomas could be possibly attributed to their larger population and/or higher fecundity compared to scyllarids. A greter concentration of phyllosoma larvae was observed in the western half of the Indian Ocean. This may probably be due to the larger number of samples collected from this half. Likewise, the total number of palinurid larvae in the western half of the Indian Ocean was higher, whereas the scyllarids were in greater abundance in the eastern half. It may also be mentioned that phyllosomas of *Palinustus mossambicus* were found exclusively in the western half while those of *Scyllarus amabilis* were confined to the eastern half. Berry (1974) reported that in the collections made during 1970–73 off Richards Bay and Durban, 84% of the larvae were scyllarids. No attempt has been made to examine the possible reasons for the observed difference in the concentration of the larvae.

All studies have clearly indicated a greater concentration of phyllosoma larvae near land masses. This is to be expected considering the fact that the adult lobsters inhabit the coastal regions. Berry (1974) has reported that in the case of the distribution of phyllosoma of *P. homarus* no correlation was evident between the stage of development and distance offshore. In spite of prolonged planktonic life, water movements, etc. it is interesting that the larvae are concentrated in restricted areas thereby facilitating restocking the areas. It is well known that several types of invertebrate larvae manage their movements in such a way as to remain in a particular area despite seemingly unfavourable currents. As Johnson and Brinton (1963) have remarked: 'This could be accomplished mainly by swimming from one depth level to another during vertical migrations, or through seasonal migrations of this type. During these shifts of level, which occur under the directive stimulus of light, even weakly swimming animals may conceivably spend a good deal of time alternately in currents flowing in different directions, or at different speeds. In this way a retardation or prevention of the wholesale outwash is effected'.

The vertical distribution pattern shows some interesting aspects. The maximum number of larvae was found at about 50 m. There were very few near the surface but were abundant at 100 m. Their number decreased at 150 m and 250 m, but fairly large numbers were obtained at 200 m and 300 m. At 500 m and 600 m the larvae appeared to be more abundant than at depths other than 50 m or 100 m. The numerical abundance and the pattern of vertical distribution mentioned above could partly be attributed to the difference in the size of the nets used for sampling as well as the duration of hauls at different depths. Nevertheless, it is clear that the number of larvae decreased with increasing depth. The occurrence of larvae at depths as great as 3500 m is another interesting feature. Most of the phyllosomas obtained beyond 1000 m are of palinurids and no scyllarid phyllosoma was caught below 2000 m.

The majority of the larvae obtained from the deeper waters were in fairly advanced stages of development. A few, however, were found to belong to the early stages. One such larva collected from 2000 m appears to be the first phyllosoma stage of *Panulirus ornatus* as it is only 1.7 mm in length. Since most of the lobsters inhabit shallow coastal regions and are not known to migrate to deeper waters for spawning, the presence of such early stages in deep waters is difficult to explain.

Only a very general examination of the relationship between oceanographical factors and larval distribution pattern has been attempted. 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 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.

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