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Decapod Crustacea from the International Indian Ocean Expedition (Larval and post-larval stages of **Parapenaeus** Smith (Penaeinae))

V. T. Paulinose^a

^a Regional Centre, National Institute of Oceanography, Cochin, India

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**Decapod Crustacea from the International
Indian Ocean Expedition
(Larval and post-larval stages of *Parapenaeus*
Smith (Penaeinae))**

V. T. PAULINOSE

Regional Centre, National Institute of Oceanography,
Cochin-682 018, India

Introduction

The present contribution is a part of a comprehensive programme of research on the larval histories of penaeid prawns, based on the material obtained from the zooplankton collections of the International Indian Ocean Expedition (1960-65). Out of 353 samples containing penaeid larvae from regions of different depths, ranging from 50 metres to 880 metres, only 51 samples contained larvae of the genus *Parapenaeus*. 69 specimens including second protozoa to late post-larvae were present.

There are few published descriptions of the larval stages of species of *Parapenaeus*. The larval and post-larval stages of *P. longirostris* (Lucas) were described by Heldt (1938) from the Mediterranean, by Pearson (1939) from the Gulf of Mexico and later by Cook (1966). Earlier Monticelli and Lo Bianco (1901) had described some larval stages of *P. longirostris* as *Penaeus membraneus*, and Stephenson (1923) described a larval stage of the same species as Penaeid larva No. 4 (*Funchalia woodwardii?*). Subramanyam (1971) gave generic larval characters of *Parapenaeus* based largely upon *P. longirostris*. Apart from the record of a mysis stage of *P. investigatoris* from the southwest coast of India by George and Paulinose (1973) no descriptions of any of the larval stages of *Parapenaeus* sp. are available from the Indian Ocean.

Complete certainty of identification of larvae can only be claimed when specimens have been hatched in the laboratory from an identified parent or live planktonic specimens reared to an identifiable juvenile. Neither of these methods was possible for the present material, but in each case a series of larvae and post-larvae have been obtained in which the oldest specimens show diagnostic adult characters. Of these the position or absence of the pterygostomian spine and the length of the 6th abdominal segment may be particularly mentioned. By using such characters of post-larvae and by comparing the larval distributions with known distributions of adults, near certainty of identification can be claimed.

Larval stages

***Parapenaeus investigatoris* Alcock and Anderson 1899**

George and Paulinose 1973 : 65 (*Parapenaeus investigatoris?*)

PROTOZOEAE II: Length 1.7 mm (fig. 1 (a)).

MATERIAL: One specimen.

LOCALITY: Stn. No. AB 77. Indian Ocean Biological Centre, 1969. North of Andaman Islands, Bay of Bengal.

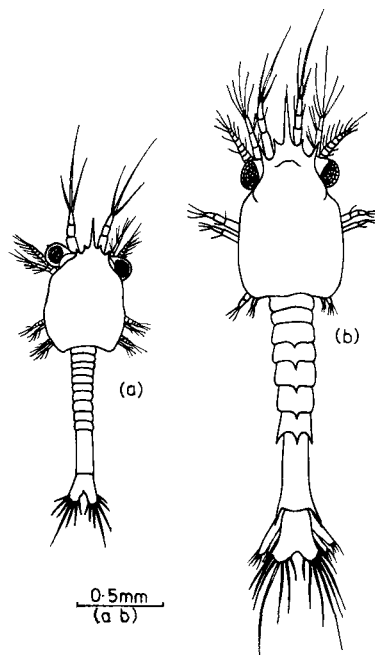


FIG. 1. *Parapenaeus investigatoris* Alcock and Anderson, Protozoaeae: (a) Protozoaea II; (b) Protozoaea III.

Rostrum extends beyond second segment of antennular peduncle, tip pointed and down-curved. Carapace without spines except two pairs of supraorbitals, inner being small. Eyes stalked but overhung to some extent by broad rostral extension of carapace.

Antennule uniramous, bearing 3 terminal setae. Antenna with segmented endopod and scale.

Telson with a notch and each ramus with seven setae.

PROTOZOEAE III: Length 2.4–3.5 mm (fig. 1 (b)).

MATERIAL: Nine specimens.

LOCALITY: Stn. Nos. AB 28, 77, 104, 337; Di 5535; Ki 689 and Pi 18 and 24 (IOBC 1969). Off Muscat and Somalia; east coast of India and Bay of Bengal.

Rostrum extends beyond antennular peduncle. Thoracic region shortened and more compact with carapace covering greater part of it. Rudiments of all pereopods present. Numbers of denticular setae on right and left mandibles are two and six respectively.

Each segment of abdomen except sixth bears a dorsomedian spine; that of fifth is longest. A pair of very conspicuous dorsolateral spines on fifth segment. Sixth segment more than twice length of fifth, with pair of long dorsolateral and ventrolateral spines. Uropods well developed. Cleft in telson shallow; spine formula 7 + 7.

Heldt (1938) and Pearson (1939) have shown 8 + 8 spines on the telson of their protozoaea III of *P. longirostris*, but Gurney (1924) and Subramanyam (1971) showed 7 + 7, and in the specimens to hand there are only 7 + 7 spines.

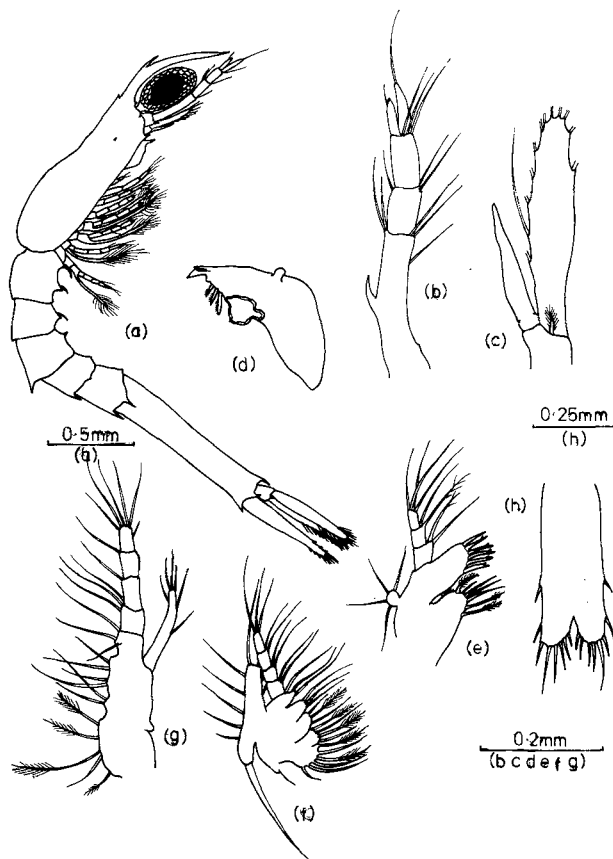


FIG. 2. *Parapenaeus investigatoris* Alcock and Anderson, mysis I. (a) Whole animal; (b) antennule; (c) antenna; (d) mandible; (e) maxillule; (f) maxilla; (g) maxilliped I; (h) telson.

MYSIS I: Length 3.7 mm (fig. 2 (a-h)).

MATERIAL: One specimen.

LOCALITY: Stn. No. AB 192 (IOBC 1969). Off Muscat, Gulf of Oman.

Rostrum with one dorsal tooth and a short epigastric tooth; extends beyond antennular peduncle. Tip of rostrum pointed and slightly curved down (fig. 2 (a)). A pair of supraorbitals present. Hepatic and pterygostomial spines present on carapace. Labral spine well developed.

Antennule with 2 unjointed flagella, inner shorter and outer with a terminal seta (fig. 2 (b)). Antenna with unsegmented endopod, scale without terminal spine. A short plumose seta at base of scale (fig. 2 (c)). Mandible with incisor and molar processes (fig. 2 (d)); 3 denticular setae between processes in right mandible, 7 in left; mandibular palp in form of small knob. Maxillule with basal part produced into two endites, each with a number of short setae; papilla-like exopod bearing 4 setae; endopod with 3-jointed palp, terminal segment of which bears 4 setae (fig. 2 (e)). Maxilla with protopod produced into 5 endites armed with setae; elongated exopod with a thick, long seta basally; endopod 4-segmented (fig. 2 (f)). Maxillipeds fully developed and biramous (fig. 2 (g)). All pereiopods with exopods.

Dorsomedian spines present on abdominal segments 3-6; segments 5 and 6 each with a pair of dorsolateral spines, segment 6 also with a pair of ventrolaterals. Ventromedian spines on last thoracic and first two abdominal segments. Sixth segment more than twice length of fifth and much longer than telson. Pleopods absent. Telson with a deep median cleft and 8+8 terminal spines (fig. 2 (h)).

MYSIS II: Length 4.7 mm (fig. 3 (a-h)).

MATERIAL: One specimen.

LOCALITY: Stn. No. AB 91 (IOBC 1969). Off Vizhak, Bay of Bengal.

Rostrum bears 2 dorsal + 1 epigastric teeth and 2 ventral setae (fig. 3 (a)). Supraorbital spines slightly reduced in size.

Antennular peduncle with more setae and outer flagellum 2-segmented (fig. 3 (b)). Antennal scale with a terminal spine and many marginal setae; endopod rod-like and unsegmented (fig. 3 (c)). Mandible with unsegmented palp; molar and incisor parts strengthened with an additional seta in both right and left mandibles, (4:8) (fig. 3 (d)). Maxillule without exopod (fig. 3 (e)). Maxilla with elongated exopod bearing more setae (fig. 3 (f)). Maxilliped I unchanged, exopod slender (Fig. 3 (g)).

Spines of abdomen as in previous stage but more developed. Pleopods absent. Telson longer than uropods; spine formula 8+8; median cleft slightly reduced (fig. 3 (h)).

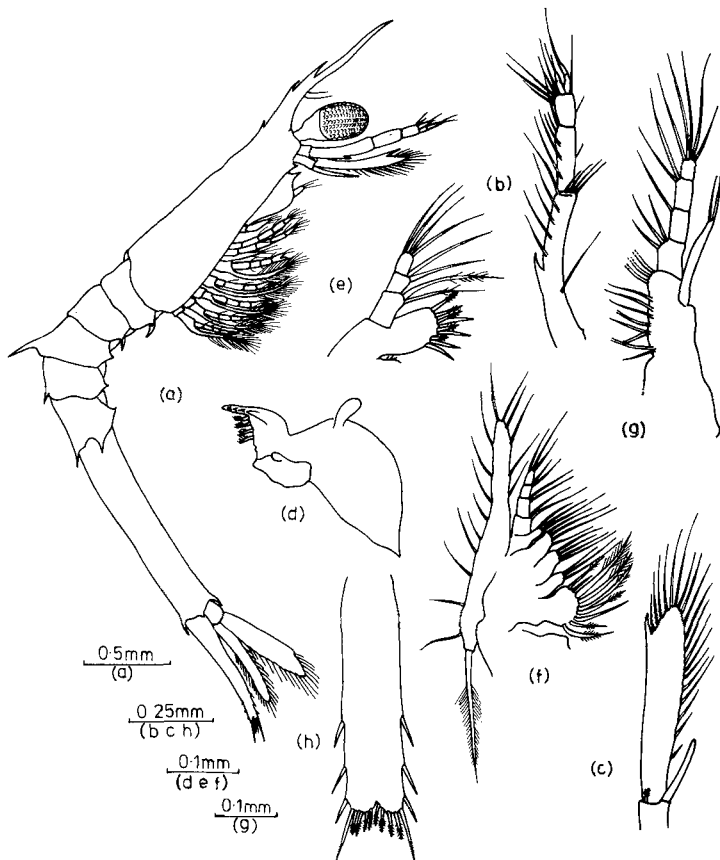


FIG. 3. *Parapenaeus investigatoris* Alcock and Anderson, mysis II. (a) Whole animal; (b) antennule; (c) antenna; (d) mandible; (e) maxillule; (f) maxilla; (g) maxilliped I; (h) telson.

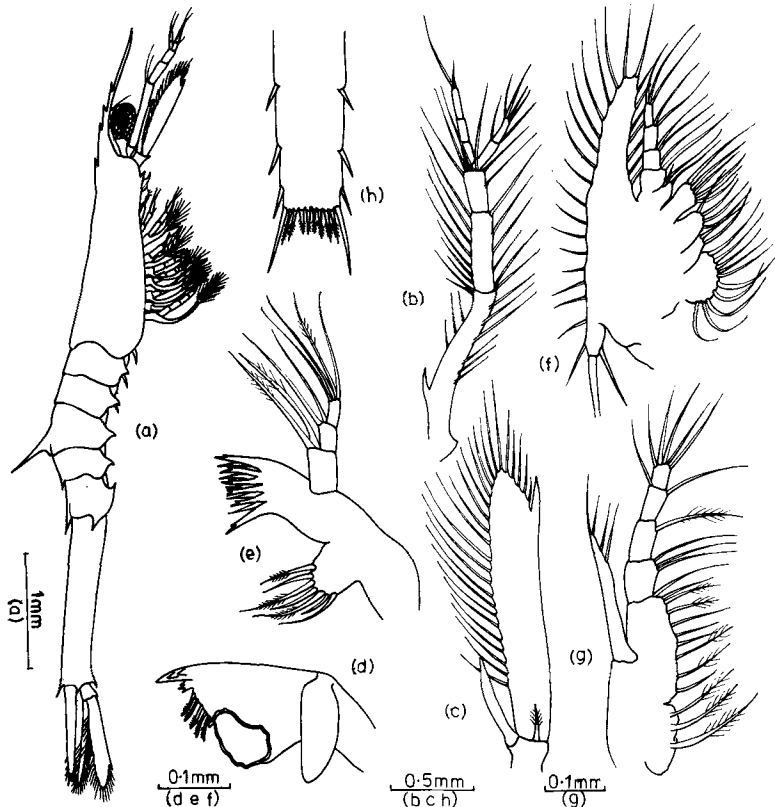


FIG. 4. *Parapenaeus investigatoris* Alcock and Anderson, mysis III, (a) Whole animal; (b) antennule; (c) antenna; (d) mandible; (e) maxillule; (f) maxilla; (g) maxilliped I; (h) telson.

MYSIS III: Length 6.0–6.5 mm (fig. 4 (a–h)).

MATERIAL: Six specimens.

LOCALITY: Stn. Nos. AB 33, 37; Ki 318, 377, 564 and Os 29 (IOBC 1969). East of Andaman Islands and east coast of India, Bay of Bengal.

Rostrum bears 3 dorsal + 1 epigastric teeth and 3 ventral setae (fig. 4 (a)), extends beyond antennular peduncle. Supraorbitals persist, hepatic and pterygostomian spines more developed, latter a little behind antero-inferior angle of carapace. Labral spine very prominent.

Antennule with segmented flagella (fig. 4 (b)). Antenna with long narrow scale bearing numerous setae and a terminal spine (fig. 4 (c)); endopod still unsegmented and without setae. Mandible with palp more developed but unsegmented; number of denticular setae in right and left mandibles increased to 5 : 9 (fig. 4 (d)). Pereiopods with exopods.

Number of abdominal spines unchanged, dorsomedian spine on segment 3 the longest. Ventrally each pleuron except fifth forms a spine. Pleopods present in form of small buds. Uropods well developed; exopod bears a spine at the externodistal margin. Telson with same spine formula (8+8) and median cleft completely vanished (fig. 4 (h)).

MYSIS IV: Length 7.0–8.7 mm (fig. 5 (a–h)).

MATERIAL: Six specimens.

LOCALITY: Stn. Nos. Ki 318, 408, 433, 559, 560 and 564. Northeast coast of India, Bay of Bengal.

This is the same stage as that described by George and Paulinose (1973) as stage III.

Tip of rostrum pointed and tilted upward; the ventral setae are more and found to be varying in different individuals. Supraorbitals reduced. Antennule (fig. 5 (b)) unchanged. Antenna with elongated scale bearing a long terminal spine; spine at base of scale has lost its plumose setae; endopod still unsegmented (fig. 5 (c)). Mandibular palp elongated with a constriction in middle, showing sign of segmentation (fig. 5 (d)); number of denticular setae on mandibles varies slightly in different individuals: 5 or 6 in right, 8 or 9 in left. Scale of maxilla narrow and bears a thick long seta at base (fig. 5 (f)). Maxilliped I with more setae on exopod (fig. 5 (g)).

Dorsomedian spine on third abdominal segment very long (fig. 5 (a)), other spines also more developed. Pleopods longer. Telson with small median spine, spine formula, 8 + 1 + 8 (fig. 5 (h)).

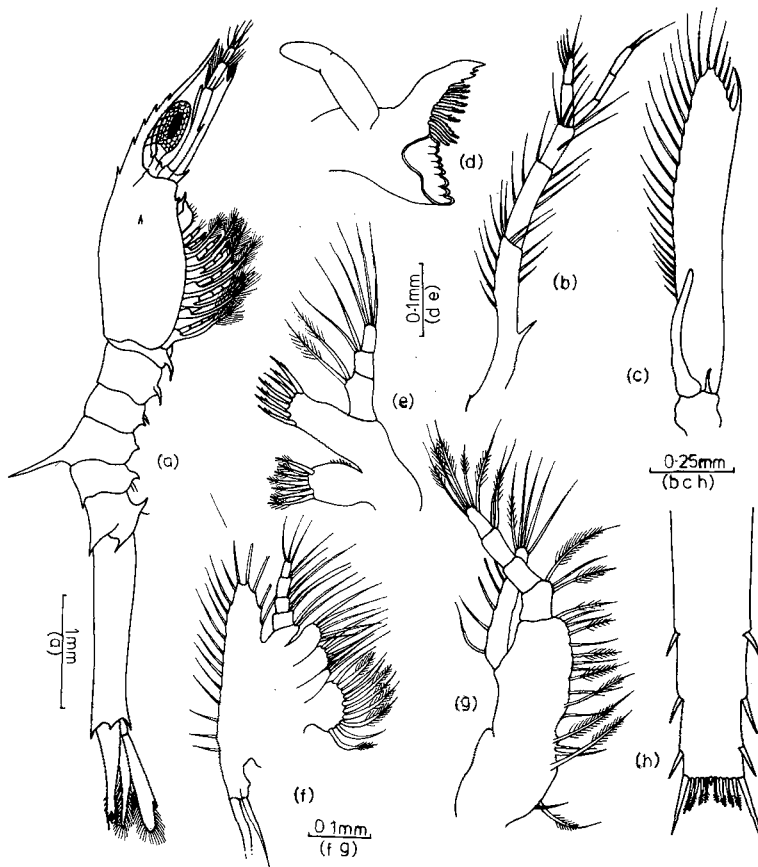


FIG. 5. *Parapenaeus investigatoris* Alcock and Anderson, mysis IV. (a) Whole animal; (b) antennule; (c) antenna; (d) mandible; (e) maxillule; (f) maxilla; (g) maxilliped I; (h) telson.

Post-larval stages

POST-LARVA I: Length 10.5–13.8 mm (fig. 6 (a–g)).

MATERIAL: 18 specimens.

LOCALITY: Stn. Nos. AB 36, 51, 60, 71, 96; Di 5381; Ki 308, 330, 337, 386, 405, 427, 543, 560 and 571 (IOBC 1969). Northeast coast of India and poorly represented in southwest coast of India.

Rostrum bears 5 dorsal + 1 epigastric teeth. Hepatic spine well developed, and labral very prominent. Pterygostomian far behind antero-inferior angle of carapace.

Antennal scale very narrow, endopod segmented (fig. 6 (b)). Mandibular palp of 2 segments and without setae (fig. 6 (c)); number of denticular setae 5–6 in right and 7–9 in left mandibles. Exopod of maxilla extremely elongated, bearing numerous setae (fig. 6 (e)). Pereiopods with exopods.

Dorsomedian spines of abdominal segments unchanged except that of the fourth slightly reduced. Ventral margin of each pleuron of abdominal segments 1 to 5 forms a spine, that of fifth pointed and bent forward. Pleopods with setose exopods and

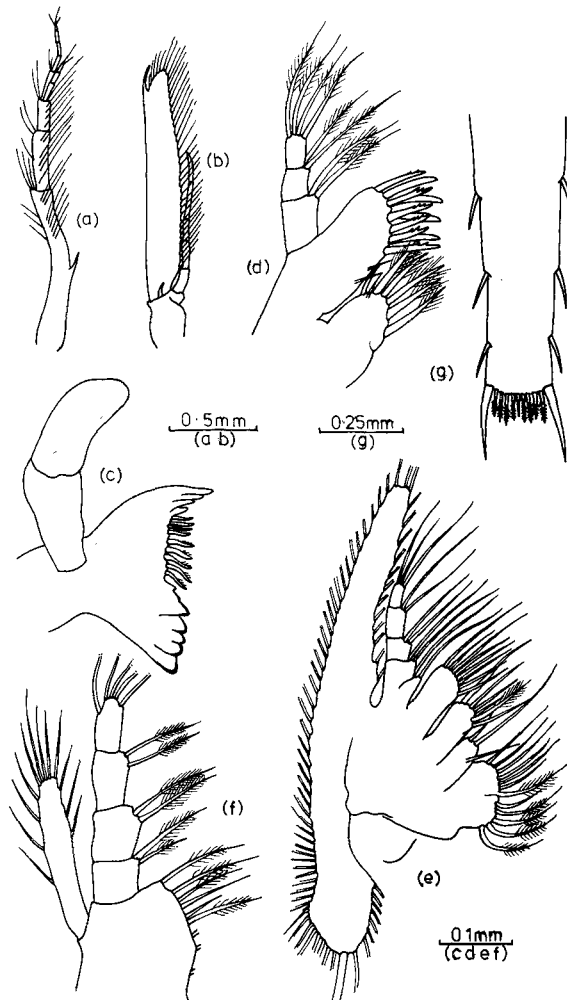


FIG. 6. *Parapenaeus investigatoris* Alcock and Anderson, post-larva I. (a) Antennule; (b) antenna; (c) mandible; (d) maxillule; (e) maxilla; (f) maxilliped I; (g) telson.

small endopods. Exopod of uropod bears more setae on outer margin, towards base. Telson tapers towards end; number of telsonic processes remains $8 + 1 + 8$ (fig. 6 (g)).

POST-LARVA: II: Length 12.6–14.5 mm.

MATERIAL: Seven specimens.

LOCALITY: Stn. Nos. AB 24, 67; Ar Ld 31 : Ki 433, 558 and 571 (IOBC 1969). Northeast coast of India and east of Andaman Islands.

Rostrum with $6 + 1$ dorsal teeth. Mandible with hard molar and incisor processes, palp of 2 segments; number of denticular setae 5 and 9 in the right and left mandible respectively; some reduction in size and number of setae.

Abdominal spines slightly reduced. Endopod of first pleopod absent, that of remaining ones more developed; exopods with setae. Telson narrower towards tip and median spine longer than apical ones.

REMARKS: Adults of *P. investigatoris* have been recorded from the Orissa coast, north and northeast coasts of India, Gulf of Mannar, Andaman Sea, southwest coast of India and Gulf of Aden. The majority of the larval forms recorded here were from the same areas, and the similarity of distribution tends to support the identification. As larvae of *Parapenaeus* were, in general, uncommon, the occurrence of all stages from mysis III to post-larva II in the same sample is regarded as strong evidence that these specimens belong to the same species. Earlier stages were taken nearby.

More direct support for the identification comes from the pterygostomian spine, which is present from mysis I and in the post-larval stage is situated well behind the antero-inferior angle of the carapace. This spine occupies the same position in adults of *P. investigatoris*, while in *P. fissurus* it is situated at the angle of the carapace and in *P. longipes* it is absent. *P. fissurus*, moreover, has not been recorded from the west coast of India.

Protozoal stages II and III closely resemble corresponding stages described by Gurney (1924) from the South Atlantic. Gurney's specimens may, however, have belonged to a closely related species. The later (mysis) stage which Gurney doubtfully assigned to *Parapenaeus* cannot be included in this genus as the spine on the third abdominal segment was too short and the telson had no median spine. It is more likely to have belonged to a species of *Penaeus*.

Four mysis stages are recognized in the present work, separable on size, the number of rostral teeth and the size of the pleopods. They correspond to the four stages described by Pearson (1939) for *P. longirostris*, although Heldt (1938) found that the same species in the laboratory passed through 14 mysis stages. This large number was probably the result of the laboratory conditions, but extra stages may also occur in nature.

Asymmetry of the mandibles was noted in all larval and post-larval stages of *P. investigatoris*. The occurrence of this phenomenon in larvae of the Penaeidae will be discussed in a later paper (in preparation).

Parapenaeus longipes Alcock 1905

Only 9 specimens were obtained from 7 samples. Two of them are in the third protozoal stage, one in the mysis and others in various post-larval stages. *P. longipes* is distinguished from *P. investigatoris* and *P. fissurus* in the adult chiefly by the absence of a pterygostomian spine. Since such a pterygostomian spine is not

present in the late post-larvae at hand, they are assigned to *P. longipes*. All the stages obtained are larger than the corresponding stages of *P. investigatoris*.

PROTOZOEAE III: Length 3.5 mm (fig. 7).

MATERIAL: Two specimens.

LOCALITY: Stn. Nos. Me 189 and 196 (IOBC 1969). Off Cochin and Mangalore, Arabian Sea.

The specimens differ obviously from protozoaea III of *P. investigatoris* in size and structure. Rostrum extends beyond antennular peduncle; carapace oval. Outer supraorbital spines longer and dorsomedian spines of abdomen more slender and longer than in *P. investigatoris*. Distal segment of maxillule bears 5 setae (see table).

The present larvae were collected from a region where adults of *P. longipes* are known to be common.

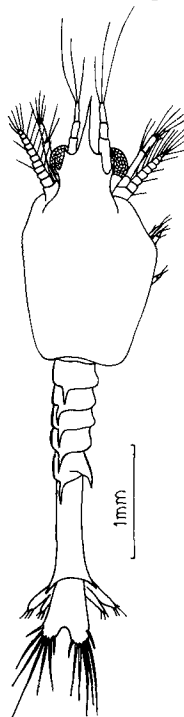


FIG. 7. *Parapenaeus longipes* Alcock, Protozoaea III.

MYSIS STAGE V?: Length 6.3 mm (fig. 8 (a-f)).

MATERIAL: One specimen.

LOCALITY: Stn. No. Ki 339 (IOBC 1969). South of Andaman Islands, Bay of Bengal.

The number of the rostral teeth (5) and the small bud-like pleopods suggest that the larva is in a late mysis stage but the exact stage cannot be determined. Epigastric spine lacking; rostrum extends far beyond antennular peduncle; small pterygostomian spine present (fig. 8 (a)).

Mandible simple, without palp. Eleven denticular setae in two groups on left mandible between incisor and molar processes; 6 smaller setae in upper region, 5 bigger setae in lower region (fig. 8 (b)); only 4 or 5 setae in right mandible. Maxillule without exopod; endopod bears 5 setae on terminal segment (fig. 8 (c)). Maxilla with

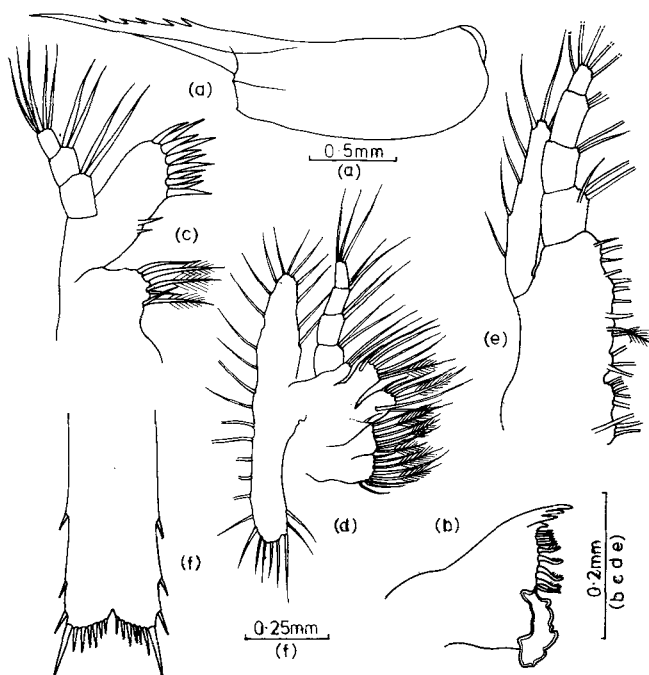


FIG. 8. *Parapenaeus longipes* Alcock, mysis V? (a) Carapace; (b) mandible; (c) maxillule; (d) maxilla; (e) maxilliped I; (f) telson.

very narrow elongated scale and 4-segmented endopod with 3 setae on terminal segment (fig. 8 (d)). Pereiopods with exopods.

Dorsomedian spines on abdominal segments 3–6, that of the third on a crest. Ventromedian spines on last thoracic and first two abdominal segments. No dorsolateral spines on fifth abdominal segment. Anal spine present. Pleopods as small buds. No spine on externodistal margin of uropodial exopod. Telson with median cleft and 6 terminal setae on each ramus; spine formula 10 + 10 (fig. 8 (f)).

POST-LARVA I: Length 12.0 mm (fig. 9 (a–f)).

MATERIAL: One specimen.

LOCALITY: Stn. No. Ki 719 (IOBC 1969). South of Ganjam, Bay of Bengal.

Rostrum bearing 6 dorsal teeth and small epigastric tooth; setae present ventrally. Pterygostomial spine reduced, hepatic short (fig. 9 (a)).

Mandible with unsegmented palp bearing a terminal seta (fig. 9 (b)); number of denticular setae increased to 13 on left and 6 on right mandibles. Maxillae and maxilliped I remain unchanged (fig. 9 (c), (d), (e)).

Dorsomedian spine on third abdominal segment more developed. Reduced ventromedian spine present only on last thoracic segment. Pleopods more developed, with terminal seta on exopod. Ventral part of pleura form curved spines, that on fifth segment curved forwards.

Telson with median spine, spine formula 10 + 1 + 10; median cleft completely vanished, tip of telson triangular (fig. 9 (f)).

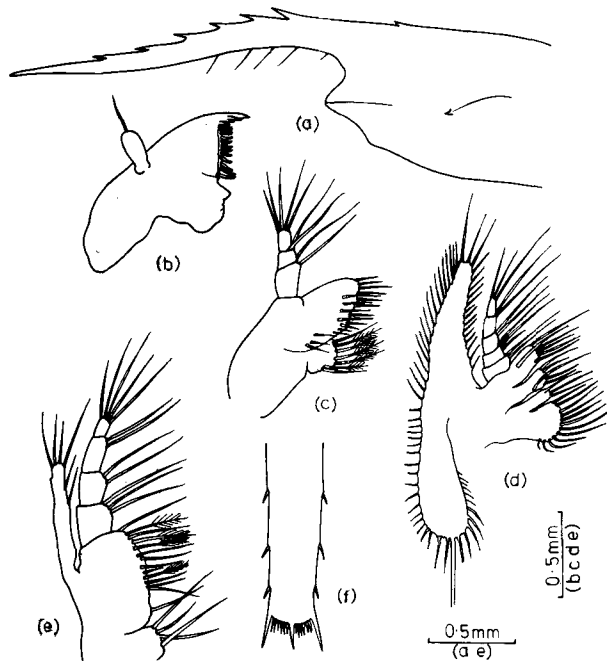


FIG. 9. *Parapenaeus longipes* Alcock, post-larva I. (a) Carapace; (b) mandible; (c) maxillule; (d) maxilla; (e) maxilliped I; (f) telson.

POST-LARVA III: Length 14.0–21.0 mm (fig. 10 (a–f)).

MATERIAL: Three specimens.

LOCALITY: Stn. Nos. AB 32; Ki 323 and 719 (IOBC 1969). Northeast off the Madras coast and east of Andaman Islands, Bay of Bengal.

Rostrum bears 8+1 dorsal teeth and row of ventral setae, extends beyond antennular peduncle. Only hepatic spine present on carapace (fig. 10 (a)).

Mandible with 2-segmented palp bearing a seta terminally; number of denticular setae increased to 19–20 on left mandible (fig. 10 (b)) and 8–9 on right. Maxillae with more setae (fig. 10 (c), (d)).

Pereiopods well developed with exopods. Crest on third abdominal segment prominent and spine on it shortened. Dorsomedian spines on fourth and fifth segments greatly reduced. Pleura form strong curved spines ventrally. Pleopods biramous, endopods bud-like. Telson with same spine formula (10+1+10) but median spine greatly elongated to nearly twice length of posterolateral fixed spines. Long setae on posterior margin of telson, in addition to lateral setae (fig. 10 (f)).

POST-LARVA IV: Length 26.3 mm.

MATERIAL: One specimen.

LOCALITY: Stn. No. AB 292 (IOBC 1969). Southeast of the Somali coast, Arabian Sea.

Rostrum with additional dorsal tooth (9+1). Hepatic more developed; antennal angle pointed. Pterygostomian absent.

Denticular setae of mandibles short and stout; many tooth-like processes on molar part. Ventromedian spine on last thoracic segment very strong; smaller ventral spine on fourth thoracic segment; those of the first 4 abdominal segments

short and blunt. Endopods of pleopods more developed. Telson unchanged (median spine broken).

JUVENILE STAGE: (Late post-larva): Length 22.2 mm (fig. 10 (g), (h)).

MATERIAL: One specimen.

LOCALITY: Stn. No. Di 5062 (IOBC 1969). Off Muscat, north-western Arabian Sea.

Though the specimen is smaller, characters like the presence of an antennal spine, shortened rostrum, setae on both the endopods and exopods of pleopods and the disappearance of all the terminal telsonic processes show a more advanced stage than the specimen previously described. Most of the mouth appendages are damaged or lost.

Rostrum with 9 + 1 dorsal teeth; a minute tooth at anterior-most part of rostrum which extends just beyond eyes. Antennal and hepatic spines well developed (fig. 10 (g)). No trace of pterygostomial spine. Median spine and on third abdominal segment short and on a small crest. Dorsomedian spines of fourth and fifth segments very much reduced, that of sixth short. Small ventromedian spines on last 2 thoracic segments; those on first 4 abdominal segments short and blunt.

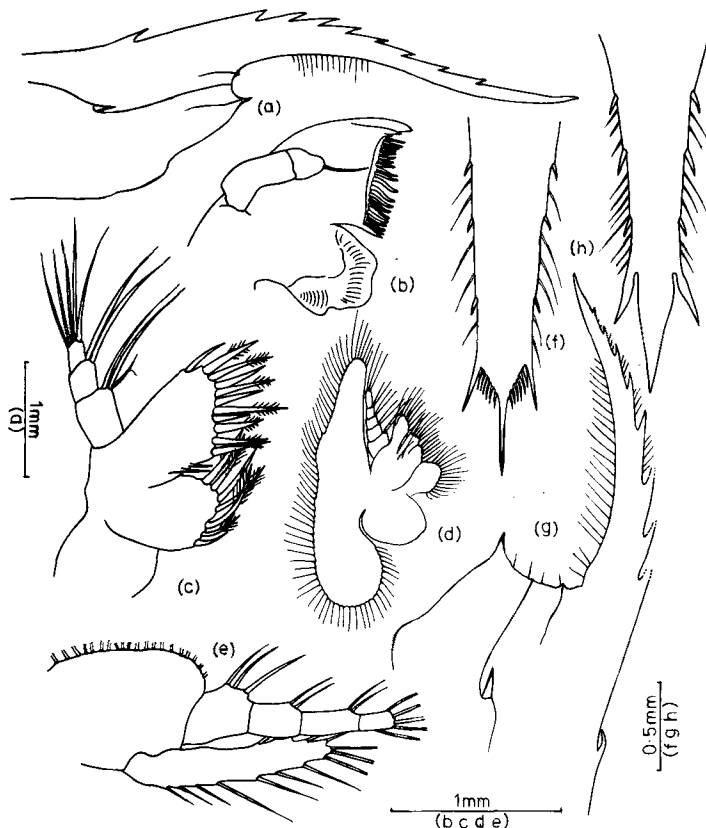


Fig. 10. *Parapenaeus longipes* Alcock, post-larva III. (a) Carapace; (b) mandible; (c) maxillule; (d) maxilla; (e) maxilliped I; (f) telson. Juvenile: (g) carapace; (h) telson.

Pereiopods without exopods. Basial and ischial spines present on first pereiopod. Pleopods well developed, exopods and endopods with setae; first pleopod without an endopod. Telson like that of adult, tridentate with median acicular spine, pair of fixed posterolateral spines and 3 pairs of lateral spines (fig. 10 (*h*)).

REMARKS: There are no previous records of *P. longipes* from the coasts of Somalia or Muscat, but the specimens here recorded from these areas appear to belong to the same species as the earlier stages taken in the Bay of Bengal. The range of the species therefore probably includes the western and northern Arabian Sea.

Parapenaeus fissurus (Bate 1888)

Eleven larval and post-larval specimens were obtained from the IIOE material, one of the specimens is in the third protozoal stage, three in mysis and the remaining seven in post-larval stages. An interesting character found in all these larvae is that the number of the rostral teeth remains the same. The mysis stage is differentiated from the post-larvae by the absence of setae on the pleopods. Since there was no addition of rostral teeth it was difficult to assign the post-larvae to stages; they are simply classified as early and late post-larvae.

PROTOZOA III: Length 3.0 mm (fig. 11).

MATERIAL: One specimen.

LOCALITY: Stn. No. Me 187 (IOBC 1969). Off Cochin, southwest coast of India.

Resembling protozoa of *P. longipes* in general body form, rostrum and nature of spines, except that inner pair of supraorbitals are much larger. Only 4 terminal setae on distal segment of endopod of maxillule (as in *P. investigatoris*).

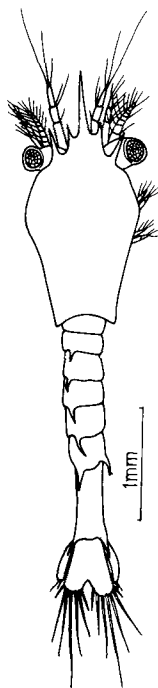


FIG. 11. *Parapenaeus fissurus* (Bate), protozoa III.

A comparison of post-larvae of *Parapenaeus investigatoris*, *P. longipes* and *P. fissurus*.

Feature	<i>P. investigatoris</i>	<i>P. longipes</i>	<i>P. fissurus</i>
Rostral spines	6 + epigastric	9 + epigastric	3 + epigastric
Hepatic spine	Strong and long	Weak	Small
Supraorbital spines	Absent	Absent	Prominent
Antennal spine	Absent	Present	Angle pointed
Pterygostomial spine	Present; placed a little behind antero-inferior angle	Absent	Present; placed at antero-inferior angle
Labral spine	Prominent	Absent	Small; less prominent
Denticular setae on mandibles (R:L)	6:9	9:19	5:9
Number of setae on distal segment of endopod of maxillule	4	5	4
Antennular flagella	Long	Short and equal	Not long
Ventromedian spines	Present on last thoracic and first 3 abdominal segments	Present on last 2 thoracic and first 4 abdominal segments	Present on last thoracic and first 2 abdominal segments
Dorsomedian spine on third abdominal segment	Long; without crest	Long; with crest	Long; without crest
Paired dorsolateral spines on fifth abdominal segment	Present	Absent	Absent (present in mysis)
Spine formula of telson	8+1+8	10+1+10	9+1+9

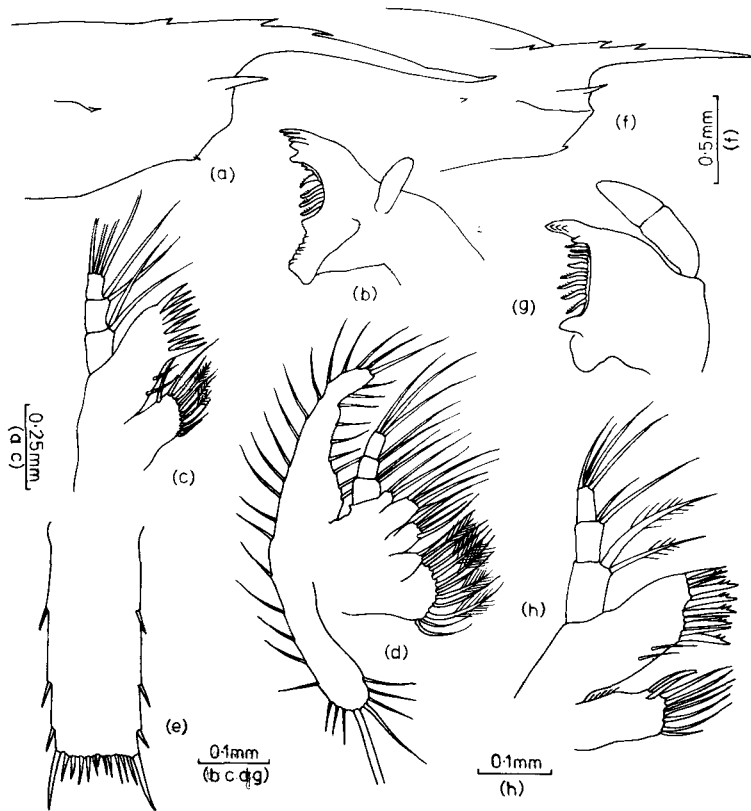


Fig. 12. *Parapenaeus fissurus* (Bate), mysis II. (a) Carapace; (b) mandible; (c) maxillule; (d) maxilla; (e) telson. Early post-larva: (f) carapace; (g) mandible; (h) maxillule.

MYSIS II: Length 4.9–6.5 mm (fig. 12 (a–e)).

MATERIAL: Three specimens.

LOCALITY: Stn. Nos. AB 192; Ki 318 and 633 (IOBC 1969). Off Muscat and Oman and Calicut, Arabian Sea; east of Andaman Islands, Bay of Bengal.

Rostrum with 2 + 1 dorsal teeth; extends beyond basal segment of antennular peduncle. Supraorbitals very strong and long; labral spine small; hepatic present. Pterygostomian situated at antero-inferior angle of carapace (fig. 12 (a)).

Mandible with unsegmented palp without setae (fig. 12 (b)); number of denticular setae in right and left mandibles is 4 and 9 respectively. Maxillule similar to that of *P. investigatoris* with 4 setae on distal segment of endopod (5 in *P. longipes*) (fig. 12 (c)). One of the basal setae of scale of maxilla very thick and long (fig. 12 (d)) as in other species of *Parapenaeus*; a widespread feature also found in many species of *Caridea*.

Pereiopods with exopods. Dorsomedian spines present on abdominal segments 3–6, no crest on third. A pair of dorsolateral spines present on fifth segment. Ventromedian spines on last thoracic and first four abdominal segments. Pleura serrated ventrally. Pleopods in form of buds. Telson parallel-sided and posterior end straight with a median spine and 10 apical spines; spine formula 9 + 1 + 9, the fourth the longest (fig. 12 (e)).

EARLY POST-LARVAE: Length 8.4–10.2 mm (fig. 12 (f–h)).

MATERIAL: Five specimens.

LOCALITY: Stn. Nos. Di 5002 and 5381; Dm 73 and Pi 10 (IOBC 1969). Central part of Red Sea, north-east of Muscat, off coasts of Calicut and Cochin and southwest of Java.

Rostrum bears 2 + 1 dorsal teeth and extends to tip of antennular peduncle. Supraorbitals, hepatic and pterygostomial spines persist (fig. 12 (f)).

Mandible with 2-segmented palp, setae present or absent (fig. 12 (g)). Number of denticular setae varies from 4 to 5 and 8 to 9 in right and left mandibles respectively. Dorsolateral spines of fifth segment reduced. Pleura of abdominal segments 4 and 5 serrated posteroventrally to form 3 or 4 spinules. Telson still parallel-sided, apical spines short and median spine shorter than others.

LATE POST-LARVAE: Length 13.3 and 16.0 mm (fig. 13 (a–f)).

MATERIAL: Two specimens.

LOCALITY: Stn. No. AB 33 (IOBC 1969). East of Andamans, Bay of Bengal.

Adult characters, like the presence of a supraorbital spine, hepatic slightly in front of epigastric spine and the presence of a pterygostomial spine in the antero-inferior angle of the carapace, along with the place of their occurrence confirm the identification of the species.

Rostrum bears 2 dorsal teeth and a small point (origin of third) + epigastric tooth. Tip of rostrum pointed, extends beyond antennular peduncle. Dorsal crest at

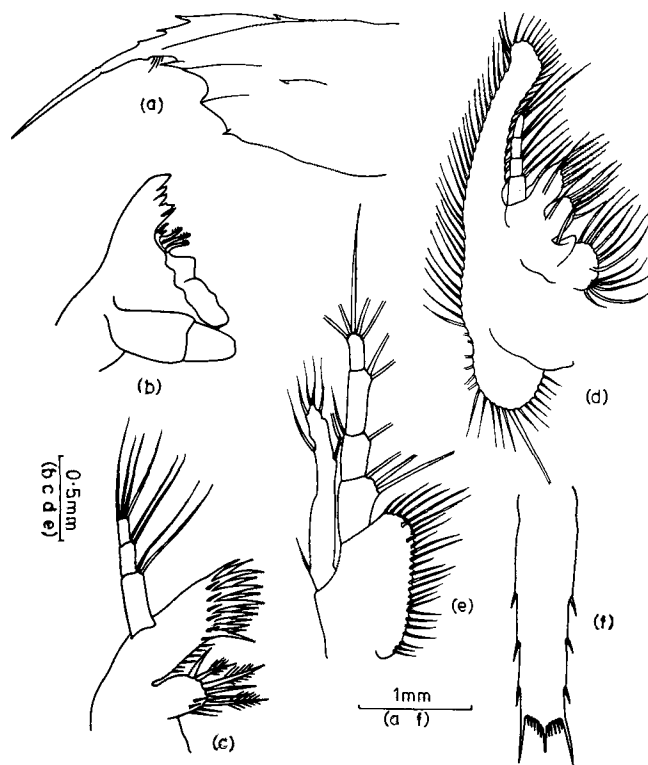


FIG. 13. *Parapenaeus fissurus* (Bate), late post-larva. (a) Carapace; (b) mandible; (c) maxillule; (d) maxilla; (e) maxilliped I; (f) telson.

base of rostrum and a few ventral setae towards base. Supraorbitals strong. Hepatic and pterygostomian spines small; latter at antero-inferior angle of carapace (fig. 13 (a)).

Mandible with 2-segmented palp (fig. 13 (b)); number of denticular setae reduced to 3 and 7 in right and left mandibles. Maxillae unchanged (fig. 13 (c), (d)). Maxilliped I of usual type (fig. 13 (e)). Pereiopods with exopods. Ventromedian spines restricted to last thoracic and first 2 abdominal segments. No paired dorsolateral spines on fifth segment in this stage (present in same stage of *P. investigatoris*).

Abdominal pleura each form a single spine ventrally. First pleopod without endopod; exopods and endopods of others bear setae. Telson narrow and tapers towards posterior end, retains same spine formula, 9 + 1 + 9 (fig. 13 (f)), with median spine the largest.

REMARKS: The inner pair of supraorbital spines is greatly developed in the protozoa and they persist not only in the mysis stages but also in post-larvae and adults, thus providing a very useful specific character. The occurrence of a protozoa, a mysis and a post-larva off southwest India tends to confirm the inclusion of these stages in the same species. All the specimens were taken in coastal regions.

Larval distribution

The larvae are widely distributed in the Bay of Bengal, Arabian Sea and central part of the Indian Ocean (fig. 14). Practically no larvae were obtained from the more southern latitudes. The pattern of distribution suggests that the species are not truly oceanic but can occur in comparatively deep water and are more abundant in the Bay of Bengal.

The larvae of *P. investigatoris* are distributed mainly around the Andaman Islands and in the northwestern part of the Bay of Bengal. They have also a patchy distribution off the south coast of Sri Lanka, off the southwest coast of India, off the coasts of Muscat and Somalia and to the northeast of the Seychelles. The larval records of *P. longipes* are from the Andaman Sea, off the east and west coasts of India, off Muscat and southeast of Somalia. *P. fissurus* has its larval distribution in the central Red Sea, the west coast of India off Calicut, Mangalore and Cochin, southwest of Java, and east of the Andamans. Larvae of the latter two species were rather scarce, and it is probable that none of the larval distributions gives a complete picture of the distribution of the species. It is noteworthy, however, that the larval records include regions where adults of the three species had been previously recorded, particularly the east coast of Muscat, east of the Andamans and the southwest coast of India.

Compared to the general distribution of penaeid larvae collected during the International Indian Ocean Expedition, the distribution of the larvae of *Parapenaeus* is very limited. Some regions were, however, sampled much less fully than others, and nearly all the sampling was limited to the upper 200 m. A few of the present records were from the open ocean, over deep water, and it is possible that more larvae would have been obtained if sampling had been extended to depths greater than 200 m. Only through further detailed investigations, including samples from greater depths, can we throw more light on these aspects.

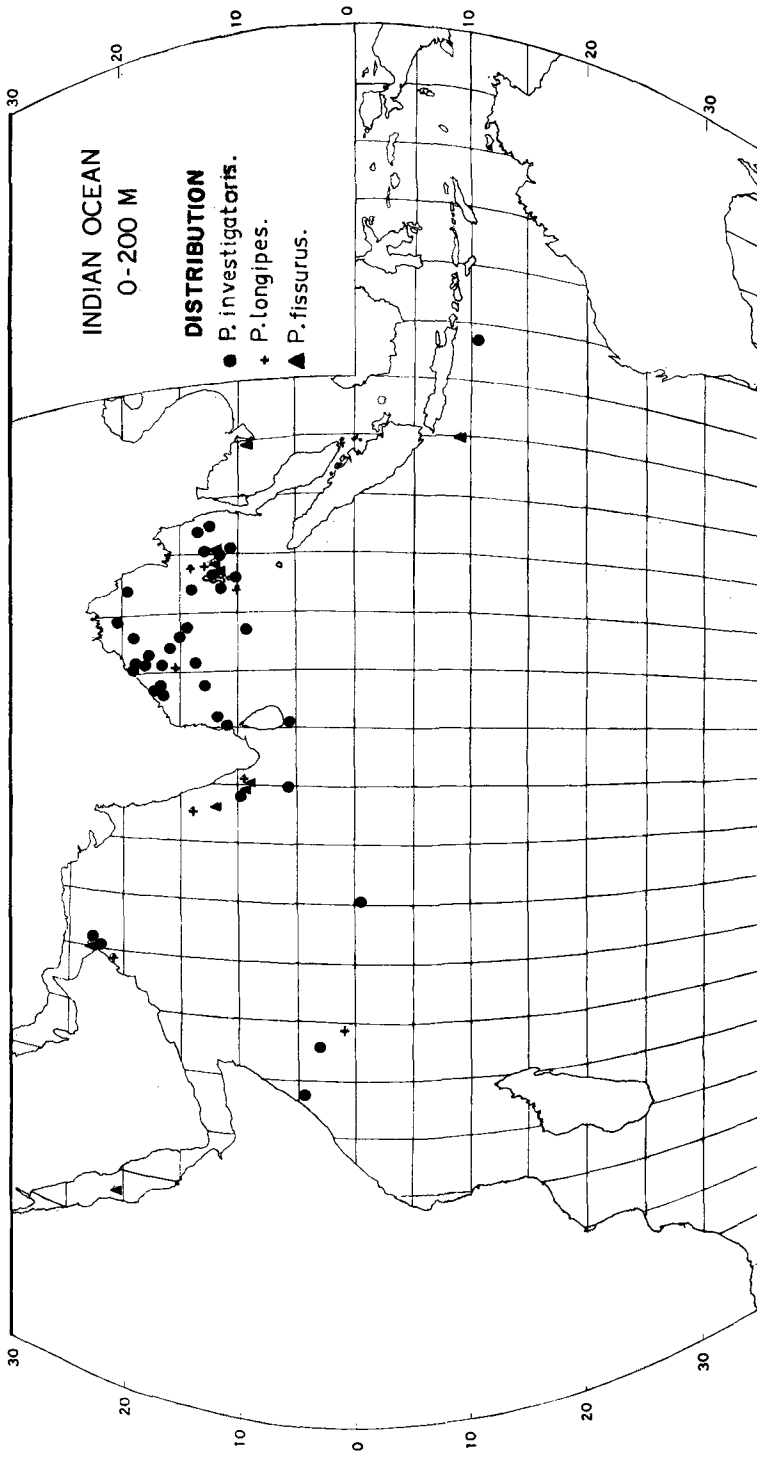


FIG. 14. Map showing the distribution of the larvae of *Parapenaeus* spp. taken by the IIOE.

Discussion

The diagnostic feature of the protozoae of *Parapenaeus* is the presence of two pairs of supraorbital spines, and the mysids and post-larvae bear a long postero-medial dorsal spine on the 3rd abdominal segment, ventromedial spines on the last thoracic and first few abdominal segments, a well-developed hepatic spine and a long median spine on the telson. The characteristic features of the post-larvae of *P. investigatoris*, *P. longipes* and *P. fissurus* are compared in the table. It is interesting to note that the number of the telsonic processes remained constant in each species throughout the mysis and post-larval stages. Thus there are 8+1+8 telsonic processes in the larvae of *P. investigatoris*, 10+1+10 in *P. longipes* and 9+1+9 in *P. fissurus*. It is also found that within a given developmental stage, e.g. mysis I, the size ranges of penaeid larvae as a whole, are extremely variable, but the larvae of *Parapenaeus* are generally larger than the same stage larvae of other genera. It is possible that different growth rates occur among the larvae and post-larvae of the same species at different times of the year, and since the size any stage can vary to consider it should be used with discretion for the purpose of identification.

Summary

Developmental stages of *Parapenaeus investigatoris* Alcock and Anderson from second protozoa to late post-larva and an incomplete series of *P. longipes* Alcock and *P. fissurus* (Bate) are described and figured. Important generic characters of the larvae of *Parapenaeus* are two pairs of supra-orbital spines in the protozoae, a strong hepatic spine, a long dorsomedian spine on the third abdominal segment, ventromedial spines on the anterior abdominal segments and sometimes on the last thoracic segment, a pair of dorsolateral spines on the fifth and sixth abdominal segments and a median spine on the telson.

The species recorded are widely distributed in the northern Indian Ocean, particularly in the Bay of Bengal, but only two specimens were taken south of the Equator and few in the more open parts of the ocean.

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