Part II

LARVAL DEVELOPMENT
Genus - Paguristes
The hermit crab genus *Paguristes*, which is supposed to be the largest speciose genus of the family Diogenidae, with more than 100 species, is distributed throughout tropical and subtropical marine waters from the intertidal zone to moderate depths (Hice and Provenzano, 1965; Provenzano, 1978). Though larvae of six species are known from other regions, so far no account is available on the larval development of any of the species of the genus in question from the Indian waters. The species for which larvae are known are: *P. turridus* (Stimpson) from the north-western Pacific ocean (Hart, 1937); *P. oculatus* (Fabricius) from the Mediterranean sea (Pike and Williamson, 1960); *P. abbreviatus* DeChance from France (DeChance, 1963); *P. sericeus* A. Milne Edwards from the Florida coast (Rice and Provenzano, 1965); *P. digitalis* (Stimpson) from Arasaki, Japan (Kurata, 1968) and *P. spinipes* Milne Edwards from the West Indian waters (Provenzano, 1978).

In the hermit crabs usually there is a series of zoeal or larval stages, followed by a glaucothoe and then a series of crab instars to attain definite adult form. The features of the early juvenile stages are so different from those of the adults that even specialists find difficulty in identifying young individuals of variable species. Hence, early taxonomists misplaced glaucothoe in a separate genus, *Glaucothoe* (Milne Edwards, Bouvier, Stebbing, etc.). Also, such repeated instances of misidentifications lead to confusion in literature and lengthy synonymy.
During the development, series of specific characters undergo changes, also, some generic features of importance show modification. Presence of absence of abdominal appendages is one such important characters in classification. In several genera pleopods are found on only one side in adults, in some paired abdominal appendages present on first and second segments of one or both sexes, some modified for sexual function; in some neither sex have such appendages. The study of juvenile morphology is significant in order to know some things about the development of adult characters of taxonomic importance.

In decapods as a whole and Anomura in particular, practically no work has been done except for Provenzano and Rice (1966), Shenoy and Sankolli (1971), Sankolli and Shenoy (1975) and Paul (1977) on the juvenile morphology.

Provenzano and Rice (1966) described the juvenile morphology and development of taxonomic characters in Paguristes sericeus from Florida. Shenoy and Sankolli (1971) described the first crab instar of a porcellanid crab, Petrolisthes limonkeeli from Bombay waters and later Sankolli and Shenoy (1975) gave an account of the first crab instar of Diogenes avarus from Karwar. Paul (1977, unpublished) in his Ph.D. thesis described juvenile morphology of two porcellanid crabs, Petrolisthes rufescens and Pisidia gordonii from Karwar region wherein he described three crab instars of the former
and four of the latter. Except for Sankolli and Shenoy (1975) no information on juveniles of hermit crabs is available from Indian waters.

The present account describes the laboratory reared life history and juvenile morphology of Paguristes neomictatus Alcock, the only intertidal species of the genus from Karwar region. This is the first account of the Paguristes larvae from the Indian waters. The larvae passed through 2 zoeal stages before a glaucothoe which readily entered the tiny, empty gastropod shells provided in the rearing containers and moulted to the next stage. Small stones encrusted with green algae were provided as substratum. The juveniles were observed to scrape these algae for food. No specific food was provided for the crabs. The molts obtained during the experiment were preserved and used to study the taxonomic characters. In this way five crab instars were obtained. However, rarely some larvae hatched out as prezoae which immediately moulted to first zoae.

Berried females for the present work were collected from rocky shore of Shankarbag (map. 4) and were kept alive in aquaria with filtered sea water until the zoeae hatched. During the course of the experiment, temperature was between 26 and 28°C and the salinity 34 ppt, of the sea water.

Eggs oval, light orange red immediately after oviposition, turning semitransparent and pale when about to hatch; diameter of eggs being 0.74 x 0.78 mm.
**Description of larval stages**

**First zoea (fig. 35)**

Carapace length : 0.9 mm; Abdomen length : 1.9 mm;
Duration of the stage, about 20 hours.

Larvae fairly big. Eyes stalked but only partially free from carapace (fig. 35, a & b). Postero-lateral margin of carapace rounded but anteriorly a prominent pterygostomial spine present. Rostrum smooth, acutely pointed, reaching to the distal end of antennule. Porciopod buds well developed.

Telson process formula, 7 + 7.

**Antennule (fig. 35, c) biramous, outer ramus very faintly segmented, with 5 aesthetases and 2 subequal apical setae.**

Inner ramus separated as a bud with a single large apical, plumose setae. **Antenna (fig. 35, d):** Scale about twice as long as broad, with outer margin slightly incurved and terminating into a sharp, long spine; 12 plumose setae present along the median margin, first and last being considerably shorter than others. Endopod unsegmented, shorter than scale, bearing 3 long unequal, plumose setae terminally. Peduncle with a long, sharp spine serrated on either margins and reaching up to the basalmost seta of scale. **Mandible (fig. 35, e):** Slightly asymmetrical and unlike the usual appendage of the stage, with a rudimentary palp. Incisor and molar parts indistinctly separated and cup-shaped with 1 or 2 very blunt tooth-like
projections. **First maxilla** (fig. 35, f): Almost like that of adult except for setation - coxal endite with 4 short, stumpy setae and basal with 2 stout bristles. Endopod unsegmented, terminating in a short seta. **Second maxilla** (fig. 35, g): Posterior lobe of scaphognathite not yet developed, anterior lobe however, fringed with 6 plumose setae; unsegmented endopod with 2 groups of setae, 2 terminal and 2 subterminal. Both coxal and basal endites bilobed, distal lobe of basal endite with 3 and proximal with single setae. Coxal endite without any setae. **First maxilliped** (fig. 35, h): Exopod 2-segmented with 4 natatory setae. Endopod short, only 4 segments could be clearly made out, 1 seta each on first and second, 2 inner and 1 outer on third and 4 apical and 1 outer on last segments. Endopod segmentation of all three maxillipeds is not as clearly visible as in other hermit crab larvae. Basis elongated and without setae. **Second maxilliped** (fig. 35, i): Exopod and basis as in first maxilliped. Endopod with 4 segments, only last segment bearing 4 apical and 1 outer setae; segmentation of remaining segments not clear. **Third maxilliped** (fig. 35, j): Biramous, but non-functional. **Pereiopods** (fig. 35, k): All five pairs as well developed buds, first showing chelate nature, fifth subchelate. **Abdomen** (fig. 35, a & b) 5-segmented, first to third segments broader than long, fourth and fifth, longer than broad; sixth fused to telson. Second to fifth segments with distinct dorsomedian spines on each, fifth with a pair of large posterolateral, articulated spines in addition to
the dorsomedian spine. Telson (fig. 35, 1) broadly triangular, process formula, 7 + 7, posterior margin almost straight or slightly convex with a broad, shallow median notch; first process a sharp, smooth, articulated spine reaching to about middle of third process; second process, an 'anomuran' hair; third to seventh, rather short, blunt, plumose setae. Posterior margin, inclusive of median notch, armed with fine spinules in between the processes. A fringe of hairs are also present on median notch. A small anal spine present. Uropod buds seen through cuticle in some late first zoae.

**Chromatophores**: The chromatophore pattern in the larvae are as shown in fig. 35, a and b, orange red and brownish red chromatophores being the main components.

**Second zoae (fig. 36)**

Carapace length : 1.0 mm; Abdomen length : 2.1 mm;
Duration of the stage : 25 to 30 hours.

Larvae (fig. 36, a & b) fairly advanced. Eyes stalked. Rostrum longer than in previous stage, reaching beyond antennule and antenna, tip of the terminal spine of antenna falling little short of rostrum. Pleopod buds present. Telson process formula, 8 + 1 + 8; uropods present.

**Antennule (fig. 36, c)**: Inner ramus three-fourths the outer, with a single terminal seta. Outer ramus with 4.
aesthetasc and 2 setae terminally, 2 aesthetasc subterminally and 1 little below the subterminal one. Peduncle basally notched and with 2 long, plumose setae on distal margin as in figure. Antenna (fig. 36, d): Scale as in previous stage. Endopod divided into 4 unequal segments as in figure with 1 terminal seta much reduced. Peduncle with one more spine (much shorter than the other) at outer angle of the base of the scale. Mandible and first maxilla (fig. 36, e & f): Not much changed over previous stage. Second maxilla (fig. 36, g): Posterior lobe of scaphognathite well developed, but without setae, anterior lobe with setation increased to 13 - 14. Maxillipeds (fig. 36, h, i & j): Exopod now with 7, 7 and 6 natatory setae respectively on first, second and third maxillipeds. Endopod segmentation now fainter than in previous stage in first maxilliped and no change in second and third maxillipeds. Pereiopods (fig. 36, k & l): Buds more elongated, showing segmentation, the first shows chelate nature and the fifth subchelate. Abdomen (fig. 36, a & b), 6-segmented, sixth segment without any spine and separated from telson; 4 pairs of biramous pleopod buds (fig. 36, m) on second to fifth segments. Mid-dorsal spines on second to fifth segments gradually increasing in size posteriorly. Telson (fig. 36, n): Process formula; 8 + 1 + 8. Addition of a pair of median processes and a single short median process over previous stage. Anal spine continues to be present. Pleopods (fig. 36, n): Broad, oval exopod and a small rounded endopod bud. Exopod with small terminal spine
and 3 to 4 setae represented as small stumps in some larvae.

Glaucothoe (figs 37 & 38)

Carapace length: 0.75 mm; Abdomen length: 1.4 mm;
Duration of the stage, 6 days.

Carapace about one-half as long as abdomen, armed with
groups of 3 - 4 finely plumose setae, on anterior margin and
6 - 8 setae posteriorly as in fig. 37, a & b. Anterior shield
clearly demarcated. No ocular scicles could be observed.
Rostrum broadly triangular with an almost acute tip, shorter
than first segment of antennular peduncle and about one-half
of antennal scale. Tip of eyes reaching the base of antennal
flagellum. Chelipeds almost subequal or slightly unequal.

Antennulo (fig. 37, c): Peduncle 3-segmented, few setae
on each segment as shown in figure. Inner flagellum 2-segmented,
proximal segment bearing a single seta and distal with 6 - 7
setae. Outer flagellum broad, longer than inner and 3-segmented.
Basal segment without setae, second with 2 tiers of aesthetascs,
2 each on inner margin, last with 3 subterminal aesthetascs,
and 4 terminal setae of which one very long, and one outer
proximal seta. Antenna (fig. 37, d): Peduncle slightly shorter
than occular peduncles, consisting of 5 segments. Scale reduced
to a blunt, non-setose process. Flagellum of 4 segments of
unequal length and not reaching the tip of chelipeds, section
of flagellum being, 0, 5 - 6, 6 and 8 long and 2 short, from
first to last segments distallywards, setae being smooth.

Mandible (fig. 37, e): Cutting edges as in adult, cup-shaped, almost smooth except for 1 or 2 blunt projections. Pulp 3-segmented, distal segment armed with about 6 bristle-like teeth. First maxilla (fig. 37, f): Resembles that of adults. Coxal endite with 6 setae and basal with 6 - 8 short, conical teeth and about 4 long setae. Pulp unsegmented, tip bilobed as in figure, with a single minute seta on outer lobe. Second maxilla (fig. 37, g) almost as in adult. Scaphognathite fringed with about 20 setae; endopod without any setae but with a pointed tip in some; basal and coxal endites bilobed with 6 + 4 and 3 + 4 setae respectively. First maxilliped (fig. 37, h), like that of adult, exopod flageller but without setae. Endopod much reduced and palp-like, smooth. Protepod bilobed, lined with small setae. Second maxilliped (fig. 37, i): Exopod long, incurved, with 5 - 6 apical, long, plumose setae. Endopod much reduced and with 4 distinct segments with few setae as in figure. Third maxilliped (fig. 37, j): Endopod now well developed with setae as in figure, densely arranged on last two segments. Exopod as in second maxilliped. Spines etc of adult, however, not yet developed. Pereiopods: First pereiopod (fig. 38, a), chelate, subequal, armed with a number of spines as shown in figure. Fingers almost as long as the palm or slightly longer. Setae scattered all over. Second and third pereiopods (fig. 38, b & c), similar and armed with spines as illustrated. Setae sparsely scattered all over. Merus, prepedus
and doctylus subequal, dactylus being longest; carpus and ischium one-half as long as morus. Fourth pereiopod (fig. 38,d) with spines distributed as in figure. Propodus with 5 - 6 broad, spine-like corneous teeth along its posterior margin. Dactylus broad, ending in a claw and placed slightly at an angle with propodus forming a subehels-like structure. Fifth pereiopod (fig. 38, e), without spines on ischium, merus and carpus. Propodus distally prolonged to form a short, fixed finger and armed with broad, spine-like corneous teeth as that of proceeding pereiopod. Dactylus short, slightly inbent, forming a minute chela with propodus and armed with corneous spines as on propodus. Three long setae at the base of doctylus.

Abdomen (fig. 37, a & b): 6-segmented, second to fifth segments with 4 pairs of biramous pleopods. All segments broader than long, smooth except for few setae, the spines of coxal stages no longer present. Pleopods (fig. 38, f), with long peduncle, a broad oval exopod bearing 7 - 8 plumose setae and short endopod armed with 2 - 3 microscopic hooks on inner distal angle. Telson (fig. 38, i), almost rounded in outline with about 9 plumose setae posteriorly, 1 or 2 short setae on either lateral side and 3 - 4 spines as shown in the figure. Uropoda (fig. 38, h), slightly asymmetrical. Exopod large, oval with 18 - 20 long, plumose setae all along the margin and a row of 5 - 6 corneous spines posteriorly. Endopod much smaller than exopod, carrying 3 - 4 plumose setae and similar corneous spines as on exopod, but fewer in number.
First crab instar (figs 39 & 40)

Asymmetrical; abdomen coiled, segmentation fainter, left side appendages slightly larger than those of right or subequal; telson well developed and adult-like.

Carapace with well developed cephalic shield and deep cervical groove, scattered setae all over; groups of plumose setae laterally and at posterolateral angle; ocular peduncles large, stout and dilated at the base, reaching up to the tip of antennular peduncle. Ocular scale now prominent with a small tooth-like projection distally. Rostrum acute (fig. 39, a & b).

Antennule (fig. 39, c): Peduncle 3-segmented with setae as illustrated, as in adult. Inner flagellum as in glaucothoe. Outer flagellum now 4-segmented with 4 aesthetascs, 2 each on distal second and proximal third segments, distalmost with 2 long and 4 - 5 short setae. Antenna (fig. 39, d): Peduncle almost reaching the distal end of ocular peduncles, 5-segmented, as in adult. Scale elongated, reaching beyond the base of ultimate segment. Flagellum now 5-segmented, segments of unequal length with setation, 0, 3 - 4, 6 - 7, 5-7, and 6-8 distalwards. Mandible (fig. 40, a): Cutting edge cup-shaped, number of teeth increased. Palp as in glaucothoe.

First maxilla (fig. 39, e): More like in adult. Setae on coxal endite increased to 11 - 13. Basal endite now with 1: - 16
strong conical teeth and 2 - 4 setae. Palp unsegmented, tip bilobed with 1 subterminal and 1 terminal setae. Second maxilla (fig. 39, f): Scaphognathite fringed with 30 - 32 bushy hair-like plumose setae. Endopod smooth except for a short, blunt, tooth-like seta terminally. Basal endite partially bilobed, with setation increased to 9 and 6 respectively on distal and proximal lobes. Coxal endite completely bilobed, with two tires of setae, distal endite with 4 terminal and 3 subterminal and the proximal with 7 terminal and 5 subterminal setae. First maxilliped (fig. 39, g): As in adult. Exopod now with 3 plumose setae at the flagellar portion. Endopod smooth and palp-like with a basal seta. Protopod bilobed, with 16 to 20 setae on distal and 5 terminal and 2 subterminal setae on proximal lobes. Second maxilliped (fig. 39, h): As in glaucothoe except for increase in setation on endopod as illustrated. Third maxilliped (fig. 39, i): Crista dentate of adult more pronounced with 6 strong spines. Setation on all segments of endopod and protopod increased as illustrated. Pereiopods: Chelipeds (first pair of pereiopods) (fig. 40, b) subequal as in adult. Setae scattered all over as illustrated. Second and third pereiopods (fig. 40, c), more or less similar; dactylus and propodus of equal length and longer than all other segments on right side whereas, propodus is the longest segment on the left side; setae more than in glaucothoe and scattered all over the segments. Fourth pereiopod (fig. 40, d), as in glaucothoe, setation increased as illustrated; ischium and merus bearing few very long plumose setae. Fifth pereiopod (fig. 40, e),
with ischium, merus and carpus smooth except for few scattered setae; propodus and dactylus as in glaucothoe. Abdomen segmentation very faint; segments could be made out by the presence of tufts of plumose setae; 3 uniramous pleopods on left side only. Pleopods (fig. 40, f, g & h): Peduncle moderately long. Exopod setation being 9, 9 and 6 respectively on first, second and third pleopods. All setae long and plumose. Endopod absent. Telson (fig. 46, i): Adult-like in appearance with broad posterior lobe; 1 or 2 blunt spines could be seen. Setae scattered all over, more on posterolateral margin of anterior and posterior lobes, as illustrated. Uropods (fig. 40, l) like in adult, asymmetrical; left nearly twice as large as the right. Exopod nearly three times the endopod. Cornuous teeth covering the distal margin of the large exopod and a short endopod. Setae scattered all over as illustrated.

Second crab instar (figs 41 & 42)

Cephalic shield pronounced, more or less triangular. Rostrum obtuse, cervical groove deep and well defined. Posterior carapace with tufts of plumose setae. Occular acicle enlarged. Occular peduncle elongated, nearly three-fourths the shield (fig. 41, a).

Antennule (fig. 41, b): Peduncle as in previous stage. No change in inner flagellum. Outer flagellum now with 4 - 8 aesthetascs. Antenna (fig. 41, c): Scale further increased in
size, with a bifid spine distally and 2 prominent spines marginally (like in adult). Flagellum now 6-segmented with 0, 5 - 6, 6 - 7, 7 - 8, 7 - 8 and about 10 setae progressing distally from 1st to 6th segments. Mandible (fig. 41, d) as in adult, cup-shaped. First maxilla (fig. 41, e): No change except for the increase in teeth and setae on endites. Second maxilla (fig. 41, f): Scaphognathite with 2 - 3 simple setae at the base of the posterior lobe and 2 at the base of anterior lobe in addition to about 34 plumose, marginal setae. Palp smooth. Setae on endites as illustrated. Maxillipeds (fig. 41, g, h & i): No change in first maxilliped. Number of setae increased on the endopod of second and third maxillipeds as illustrated. Periopods (fig. 42, a, b, c & d): No much change over previous stage except for the increase in the number of setae as shown in figures. Pleonopods (fig. 42, c, f & g): Number of plumose setae on third pleopod increased to 8. Endopod nearly twice the peduncle. Telson (fig. 42, h): broad, posterior lobe with 5 - 6 large, incurved teeth. Setae scattered all over the surface. Posterolateral margin of anterior lobe with tufts of long setae. Propods (fig. 42, h): Cornaceous teeth and setae increased on exopod and endopod. Protopod with 2 - 3 cornaceous teeth, like in adult.

Third crab instar (figs 43 & 44)

Occular peduncles well developed, dilated basally. Occular scicle (fig. 43, i) prominent, now with 2 distal spines.
Abdominal segmentation not clear.

**Antennule** (fig. 43, a): Few spines could be made out on peduncle as illustrated. Inner ramus of the flagellum as in previous stage. Outer flagellum with about 10 aesthetases.

**Antenna** (fig. 43, b): Scale nearly twice the length of penultimate segment, reaching up to one-third the ultimate segment. Flagellum as in previous stage. **Mandible** (fig. 43, c) and **first maxilla** (fig. 43, d): As in previous stage, increase in setae on endites of first maxilla. **Second maxilla** (fig. 43, e): Scaphognathite now with about 40 setae. Setae on endites increased as illustrated. **Maxillipeds** (fig. 43, f, g & h): No change over previous stage. **Pereiopods** (fig. 44, a, b, c, d & e): First pair of pereiopods (chelipeds) now with more spines; merus with series of spines as illustrated; setae plumose like in adult. Second and third pereiopods with increased spines; setae thickly scattered over all segments. Fourth and fifth pereiopods as in adult. **Pleopods** (fig. 44, f) with more setae.

**Telson** (fig. 44, g): Number of spines and setae increased.

**Uropods** (fig. 44, g) with increase in cornaceous teeth and setae.

**Fourth crab instar** (figs 45 & 46)

Shield (fig. 45, a) well developed like in adult. Cervical groove deep. Dorsal surface of shield with tufts of plumose setae. Occular peduncles elongated, with setae over the surface like in adult. Occular ocicile now with 3 acute spines (fig. 45, b).
Antennule (fig. 45, c): Peduncle as in previous stage. Inner flagellum now 3-segmented, with setae as illustrated. Outer flagellum 6-segmented with about 16 aesthetascs covering second to fourth segments distally. Setae present on third, fifth and sixth segments. Antenna (fig. 45, d): Scale now well developed with increase in spines. Flagellum with 3 segments. Number of setae increased on all segments as illustrated.

Mandible (fig. 45, e): Typically like that of adult. First maxilla (fig. 45, f): Basal and coxal endites well developed and with increase in number of setae. Coxa now with about 20 setae in two tiers and basis with about 20 - 24 denticles and about 12 setae as illustrated. Palp unchanged. Second maxilla (fig. 45, g): Almost like in adult. Scaphognathite now with about 56 setae. Endopod with 2 - 3 marginal setae. Setae on proximal and distal endites of basis increased to 25 - 30 and 12 - 13. Coxal endites now with about 30 and 10 setae arranged in two tiers respectively on proximal and distal endites. First maxilliped (fig. 45, h): Endopod now with about 8 plumose setae on the non-flagellar margin and two setae on flagellar margin. Palp simple, bilobed protopod with about 25 - 28 and 7 - 8 setae on distal and proximal endites. Second and third maxillipeds (fig. 45, i and 46, a): More or less like in adult. Setae all over the endopod. Few setae present on exopod as illustrated, in addition to natatory setae. Crista dentata of third maxilliped like in adult with 7 - 8 sharp teeth. First pereiopod (cheliped) (fig. 46, b): Spines of adults could be seen. All
spines with corneous tips. Spines spread all over segments as illustrated. Second and third pleopods (fig. 46, c) as in adult. Dactylus with a row of prominent tooth. Setae spread all over the segments. Fourth and fifth pleopods (fig. 46, d & e) like adult appendages. Corneous denticles cover the distal portion of the propodus. Pleonods (fig. 46, f) like adult pleopods. Setae increased to about 18 to 20 on first to third pleopods. Telson (fig. 46, g): Posterior margin of the posterior lobe with series of spines as in adult. Uropods well developed.

Fifth crab instar (figs 47 & 48)

These crabs resemble adults in external appearance. Ocular peduncles well developed. Ocular acicles like in adult (fig. 47, a), with 3 large tooth-like spines and scattered setae as illustrated.

Antennule (fig. 47, b): Peduncle and inner flagellum unchanged. Outer flagellum now 7-segmented. Aesthetascs increased to about 30, present on segments 2 to 5, distalwards. Setae as illustrated. Antenna (fig. 47, c): Scale well developed, reaching up to nearly three-fourths the ultimate segment. Flagellum 8-segmented. Setae increased on all segments as illustrated. Mandible (fig. 47, d) as in adult. First maxilla (fig. 47, e) like adult appendage, distal portion of basal endite studded with about 27 large and short spine-like setae and few simple
setae. Coxal endites with about 30 setae, some of which are plumose, arranged in two tiers. Palp as in adult. Second maxilla (fig. 47, f) like in adult. Scapeognathite with about 65 setae. All the endites are fringed with setae as in adult. First maxilliped (fig. 47, g): Exopod now with about 12 plumose marginal setae, flagellar portion as in previous stage. Palp with a subdistal seta. Increase in setae on endites. Second and third maxillipeds (fig. 47, h & i): As in adult, well developed. Pereiopods: Chelipeds (fig. 48, a & b) well developed, subequal with tufts of plumose setae and rows of corneous tipped spines, a typical adult character. Second and third pereiopods (fig. 48, c) with well developed setae and spines as illustrated. Fourth and fifth pereiopods (fig. 48, d & e) show plumose setae and spines of adult. Pleopods (fig. 48, f) with about 25 to 30 long, plumose setae like in adult. Telson (fig. 48, g): Posterior lobe with well developed spines marginally; short, stiff setae cover the surface and margin; posterolateral margin of anterior lobe with a tuft of long setae. Uropods: Number of denticles increased considerably, resembling the adult uropod.

Discussion

The present study supports the opinion of Rice and Provenzano (1965) that of all the hermit crabs of which the development has been studied in the laboratory, those of the genus Paguristes, except P. spinipes, seems to have the shortest
duration of larval development. Even amongst the laboratory
reared larvae of only seven species so far known in the genus
Paeuristes (including the present work), larvae show variation
in number of stages as well as in period of metamorphosis as
shown in Table II.

Thus, in Paeuristes soriceus and the present species,
larvae pass only through 2 zoeal stages while in the remaining
generally through 3 stages. Rico and Provenzano (1965), while
describing the development of P. soriceus, gave a table of
comparison of first zoea amongst the 3 then known Paeuristes
species. Larvae of P. digitalis and P. spinipes were described
subsequently by Kurata (1968) from Japan and Provenzano (1978)
from west Indian waters respectively. The larvae of P. digitalis
and P. spinipes can easily be distinguished from other known
larvae by the presence of dorsal corna in anterior half of
the carapace which is not found in other species hitherto
described.

As regards the present species, the only species comparable
is P. soriceus, in respect of number of stages. However,
metamorphosis in the present one was quite fast (about 48
hours) and the larvae did not feed, while in P. soriceus, 4 -
9 days were required for metamorphosis and the larvae did
feed. Also, larvae of these two species distinctly differ in
degree of development, particularly of antennule, oral
appendages and maxillipeds. In the first stage of the present
TABLE II

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of stages</th>
<th>Period of metamorphosis</th>
<th>Temperature</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. turgidus</td>
<td>3 zoeal + glau.</td>
<td>5 - 8 days</td>
<td>15 - 20°C</td>
<td>Hart</td>
</tr>
<tr>
<td>P. oculatus</td>
<td>3 zoeal + glau.</td>
<td>20 - 30 hrs.</td>
<td>21 - 22°C</td>
<td>Pike &amp; Williamson</td>
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<tr>
<td>P. abbreviatus</td>
<td>-- + glau.</td>
<td>---</td>
<td>---</td>
<td>DeChance</td>
</tr>
<tr>
<td>P. sericeus</td>
<td>2 zoeal + glau.</td>
<td>4 - 6 days (fed)</td>
<td>25°C</td>
<td>Rice &amp; Provenzano</td>
</tr>
<tr>
<td>P. sericeus</td>
<td>2 zoeal + glau.</td>
<td>7 - 9 days (starved)</td>
<td>25°C</td>
<td>Rice &amp; Provenzano</td>
</tr>
<tr>
<td>P. spinipes</td>
<td>(3)4 zoeal + glau.</td>
<td>42 days</td>
<td>20°C</td>
<td>Provenzano</td>
</tr>
<tr>
<td>P. digitalis</td>
<td>3 zoeal + glau.</td>
<td>7 days</td>
<td>?</td>
<td>Kurata</td>
</tr>
<tr>
<td>P. incomitatus</td>
<td>2 zoeal + glau.</td>
<td>48 hrs.</td>
<td>26 - 28°C</td>
<td>Present work</td>
</tr>
</tbody>
</table>
species, antennule is already segmented into distinct rami; mandible with palp developed and maxillae have more adult-like form than zoeal, and endopod of maxillipeds do not show clear segmentation. In the corresponding stages of *P. sericeus*, antennule is still uniramous; mandible with toothed cutting edges and without palp; maxillae are of typical zoeal type and endopod of maxillipeds clearly 4 or 5 segmented and setose.

The first stage characters of the present species compare well with those of corresponding stage of *P. oculatus*, a species with metamorphosis of shorter duration (20 - 30 hours) and comprising 3 but not 2 zoeal stages. Moreover, *P. oculatus* larvae differ not only from the present species but also from all the known larvae in one important feature, i.e. absence of medio-dorsal spine on abdomen, these spines being present in all the other known species.

The first zoea of *P. incomitatus* differs from *P. turridus* in having 6 marginal setae of scaphognathite, 5 aesthetascs plus 2 setae of antennule whereas in *P. turridus* there are 10 setae and 6 aesthetascs respectively on these appendages.

Rice and Provenzano (1965) have stressed the generic importance of the anterolateral carapace spines of the zoeal stages and a paired, posterolateral spines on the fifth abdominal somite. These characters are also shared by *P. spinipes* (Provenzano, 1973) and the present species.
The following tentative key can be suggested to differentiate the first zoeae of the hitherto known species of the genus *Poruristes*. The key is based on only a few specific characters such as the setation of antennule and scaphognathite of second maxilla and it excludes *P. abbreviatus* (DeChamco, 1963), the larvae of which directly emerge as glaucothoe. The key also excludes *P. digitalis* (Kurata, 1968) since the literature is in Japanese, and lacks required illustrations. However, the pertinent characters of *P. digitalis* with reference to this key are enlisted at the end of key.

1. Antennal scale with 12 setae and scaphognathite either unarmed or having more than 5 setae  ...  ...  2
   Antennal scale with 9 - 10 setae and scaphognathite with 5 setae  ...  ...  ...  ...  ...  4

2. Scaphognathite of second maxilla without setae, antennule with 1 setae but devoid of aesthetases  ...  ...  ...  ...  ...  *P. oculatus*
   Scaphognathite of second maxilla with 6 or 10 setae and antennule with more than one setae and aesthetases  ...  ...  ...  ...  ...  ...  ...  3

3. Scaphognathite with 10 setae, antennule with 6 aesthetases  ...  ...  ...  ...  *P. tergides*
Scaphognathite with 6 setae, antennule
with 5 aesthetascs and 2 setae \( \ldots \ldots \) \( P. \) incomitatus

4. Antennal endopod only half the scale length, with 2 long setae and 1 shorter one on the antennal endopod, endopod of first maxilla
3-segmented \( \ldots \ldots \ldots \ldots \ldots \) \( P. \) spinipes

Antennal endopod two-thirds the scale length and with 3 subequal setae, endopod of first maxilla unsegmented \( \ldots \ldots \ldots \ldots \ldots \) \( P. \) sericeus

Key characters of \( P. \) digitalis: Antennal scale with 10 setae; antennal endopod two-thirds the scale length and with 2 long and 1 short setae; endopod of first maxilla 3-segmented.

In glaucothoe, a blunt, broad tooth on the basal peduncular segment of antenna; the small number of antennal segments support the view of Rice and Provenzano (1965) that these characters might be considered as having great importance. The mandibular palp shows variation in segmentation among the known glaucothoe, and is 3-segmented in \( P. \) incomitatus and \( P. \) turgidus, 2-segmented in \( P. \) sericeus and \( P. \) spinipes, unsegmented in \( P. \) oculatus. Endopod of pleopods with 2 hooks in \( P. \) turgidus, \( P. \) spinipes and \( P. \) sericeus whereas 3 hooks in \( P. \) oculatus. In \( P. \) incomitatus they are either 2 or 3 in number. Exopod of pleopods with 7 - 8 setae in \( P. \) incomitatus, 9 in
The glaucothoe of the present species can be distinguished from other species in having anterolateral angles of carapace smooth and rounded, devoid of spines, subequal chelipeds and telson almost rounded in outline, shorter than in others.

Paguristes incomitatus was first described by Alcock (1905). The detailed illustration of appendages was not shown. Provensano and Rice (1966) gave importance of antennule in relation to ocular peduncles in classification. In their words "the length of the antennule relative to the length of the eyestalks is a frequently used character in pagurid taxonomy but its morphology is seldom considered. However, we know from the recent work on the glaucothoe stages of diogenid hermits that the antennular flagella may vary from genus to genus in the number of segments they possess". It is evident from the present observation that in P. incomitatus the number of segments in the antennular flagellum increases during juvenile development, and so does the number of aesthetascs.

A similar observation is made on the antennal flagellum, wherein, number of segments increased progressively (in adult about 30 segments). Antennal scicle also shows the progressive development, increase in length and number of spines and setae. Mandibles do not show much change except for increase in bristles on the terminal segment of palp, which is hardly of
value in identification of adults.

The first maxilla shows consistent increase in number of setae and spines (spine-like setae of basal endites) on the endites. However, palp do not show appreciable change.

In second maxilla, except for palp, all endites have increase in setation. The armature of scaphognathite which varies during the larval stages and in gecrothoe, has been of some aid in differentiating different larvae, may not be of much use in specification of adults due to the consistent variation. Provenzano and Rice (1966) also opined the same.

The development of crista dentata may have some significance. In *P. acricornis* (Provenzano and Rice, 1966), in first crab, crista dentata is rather poorly developed, whereas in the present species it shows a complete development, forming an uninterrupted, straight row.

Provenzano and Rice (1966) observed a completely developed adult-like manus of cheliped, in *P. acricornis* whereas in *P. incomitatus* a steady progressive increase in spines is observed. Also, the tufts of plumose hairs of adult start appearing only in the later crab instars in the present species. Only in fourth and fifth instars a regular arrangement of corneous teeth is observed.

The remaining pereiopods do not help much in identification of the stage. Fourth and fifth pereiopods show very little
development during the crab instar except for increase in number of corneous granules.

Telson and uropods start showing adult characters like lobed telson and asymmetrical uropods from the first juvenile stage. However, armature of posterior margin of telson, an useful feature in specific identification shows progressive development. The lobes remain unequal throughout the juvenile stages, like in adult, however, in the first two crabs it is subequal. The armature of adult are seen in the fourth and fifth crab instars only.

At as early as fifth crab instar, sex of the individual could not be made out. Provenzano and Rice (1966), indicate that the individuals of different sex may not have same degree of development. They also mention that the sex could be identified in the later stages.

The present investigation needs further elaboration to have direct bearing on the growth and differentiation of sex.
Genus - CLIPANARIUS

Pike and Williamson (1960) described the first zoeal stages of *Clibanarius erythropus* (Latreille), the first stage being obtained in the laboratory and the remaining stages collected from plankton. DeChance and Forest (1958) described the glaucothoe of the same species. Lewis (1960) described unspecified zoeae of *C. tricolor*. Lang and Young (1977) gave a detailed account of laboratory reared larvae of *C. vittatus* from South Carolina waters. Nasima Tirmizi reared two species, *C. signatus* and *C. virescens* from Pakistan (Abstract only, 1980).

In India, Menon (1937) dealt with the first two and the fourth zoeae and the glaucothoe of what he doubtfully referred to the genus *Clibanarius* collected from the Madras plankton. He further remarked that his larvae closely resembled those of *Diogenes*. Sankolli (1959, unpublished) described the first
zoea of *C. padavensis* from Bombay waters. Shenoy and Sankolli described the complete larval development of 3 species, viz., *C. padavensis* (1975), *C. arethusa* (1976) and *C. infraspinatus* (1977) from the west coast of India. Ajmal Khan and Natesh San gave an account of laboratory reared larvae of two species, *C. longitarsis* and *C. olivaceous* (1976, 1981) and Ajmal Khan et al (1980) gave an account of the larval development of *C. clibanarius*, the latter three from the east coast of India.

The present account deals with the complete larval history of *Clibanarius aceabilis* var. *merguiensis* de Man as observed in the laboratory.

An ovigerous female of *Clibanarius aceabilis* var. *merguiensis* was collected from a tide pool of Kinkade rocky shore and was kept in a glass trough containing filtered sea water until the larvae hatched out.

The larvae reached the glaucothoe stage after passing through four successive zoeal stages in about 22 days after hatching.

The eggs are oval, pinkish to brick red immediately after oviposition turning transparent and pale when about to hatch. Egg size ranged from $0.37 \times 0.30 \text{ to } 0.38 \text{ mm}$. 

Description of larval stages

First zoea (fig. 49)

Duration of the stage: 6 - 8 days; carapace length: 1.0 mm; abdomen length: 1.2 mm.

Rostrum beak-like, acutely pointed at the tip and broad at the base, projects beyond the antennule and antenna (fig. 49, b). Eyes sessile. Carapace smooth, rounded on posterolateral angle. Abdomen nearly as long as carapace, inclusive of rostrum. Telson process formula $7 + 7$, first slightly laterally situated and blunt, finger-like.

Antennule (fig. 49, c) with 2 terminal aesthetascs and 2 unequal setae. Inner ramus represented by a long, plumose seta. Antenna (fig. 49, d): Endopod nearly two-thirds the length of scale, with 3 terminal setae. Scale long and narrow with 11 plumose setae. Endopod and scale distinctly articulated to the peduncle. Peduncle with a minutely serrated, ventral spine on the distal margin. Mandibles (fig. 49, e): Asymmetrical and stout. Ventral plate with 4 - 5 large but unequal teeth in the middle, whereas, the dorsal plate provided with several unequal small teeth all along the edge. First maxilla (fig. 49, f): Coxal endite with 6 setae of which 3 - 4 simple and others bristle-like. Basal endite armed with 2 serrated spines and 1 short spine-like seta. Unsegmented palp with 2 terminal and
1 subterminal setae. **Second maxilla** (fig. 49, g): Coxal and basal endites bilobed. Proximal of coxal with 5 terminal and single subterminal setae; distal with 3 terminal and 1 sub-terminal setae. Proximal lobe of basal endite with 4 and distal with 3 terminal and a short subterminal setae. Endopod with 2 groups of 2 setae each. Scaphognathite bears 5 marginal plumose setae. **First maxilliped** (fig. 49, h): Endopod nearly as long as exopod, 5-segmented, setation being, 1, 2, 1, 2 and 4 + 1 (outer) distalwards. Exopod 2-segmented with 4 natatory setae. Basis with 8 setae as shown in figure. **Second maxilliped** (fig. 49, i): Endopod 4-segmented, 3rd being the longest, setation, 2, 2, 2 and 4 + 1 (outer) distalwards. Exopod as in first maxilliped. Basis with 4 setae as illustrated. **Third maxilliped** (fig. 49, j), rudimentary and uniramous. **Abdomen** (fig. 49, a & b): Five segmented, segments smooth and broader than long. **Telson** (fig. 49, k), broader than long, process formula, 7 + 7; first, finger-like process, articulated and situated laterally; second reduced, an 'anomuran' hair; third to seventh, plumose setae; fourth being the longest, seventh alone spinose on the outer margin; posterior margin of telson and median notch fringed with microscopic hairs.

**Chromatophores**: The chromatophores of the larvae are of diffuse type, giving orange yellow to red appearance to the larvae. The chromatophores are stellate with mainly orange, crimson red and light yellow components, (fig. 49, a & b).
Second zoea (fig. 50)

Duration of the stage: 4 - 7 days; carapace length: 1.2 mm; Abdomen length: 1.6 mm.

Larvae increase in size. Eyes stalked. Number of setae on exopod of first two maxillipeds increased to 6. Exopod of third maxilliped well developed with 5 setae, but endopod bud-like. Telson process formula, 8 + 8.

Antennule (fig. 50, b): Peduncle with 3 long, plumose setae at its distal margin. Outer ramus now distinctly articulated with peduncle, bearing 2 aesthetascs (of which one is quite prominent) and 3 unequal setae. Antenna (fig. 50, c): No considerable change over previous stage. Mandibles (fig. 50, d): No change except for a slight increase in size and prominence of teeth. First maxilla (fig. 50, e): Coxal endite and endopod unchanged. Basal endite now with 4 serrated spines and 2 short setae. Second maxilla (fig. 50, f): Coxal and basal endites with 7 + 4 and 4 - 5 + 3 setae respectively. Scaphognathite now with 6 - 7 marginal setae. No change in endopod. First maxilliped (fig. 50, g): Exopod with 6 natatory setae. Addition of a plumose seta each on the outer margin of first 3 segments of endopod. Second maxilliped (fig. 50, h): Exopod as in first maxilliped. Addition of 1 seta each on 2nd and 3rd segments of endopod. Third maxilliped (fig. 50, i): Exopod well developed, partially 2-segmented with 5 natatory
setae. Endopod as indistinct bud. Telson (fig. 50, j): Slightly broader than long. Process formula, 8 + 8, median pair being spinulose distally.

**Third zoea (fig. 51)**

Duration of the stage: 5 - 8 days; Carapace length: 1.4 mm; Abdomen length: 1.7 mm.

Zoae increase considerably in size and can be distinguished by the following characters: Antennal endopod with a single seta. Third maxilliped now with 6 setae. Four pairs of pereiopod buds developed. Abdomen 6-segmented. Telson process formula, 8 + 1 + 8, fourth process reduced to a spine. Uropods biramous.

Antennule (fig. 51, b): Peduncle with 4 long, plumose and 4 fine hair-like setae distally. Inner ramus separated from peduncle. Outer now with 3 aesthetascs and 4 unequal setae. Antenna (fig. 51, c): Endopod elongated, reaching upto the tip of the scale and with a single seta. Scale now with 12 setae. Mandibles and first maxilla (fig. 51, d & e): As in previous stage. Second maxilla (fig. 51, f): Coxlal and basal endites with 8 + 4 and 4 + 3 setae respectively. Scaphognathite with 10 plumose setae. No change in endopod. Maxillipeds (fig. 51, g, h & i) No change in first and second. Exopod of third with 6 natatory setae. Endopod slightly elongated. Pereionops (fig. 51, j): Four pairs of rudimentary buds clearly seen. Abdomen (fig. 51, a): Sixth segment separated from telson. Telson
(fig. 51, k): Somewhat rectangular in shape. Process formula, 8 + 1 + 8. Fourth process now reduced to an unarticulated spine. All the processes plumose except 1st and 4th, somewhat spinose tip. Uropods (fig. 51, k) biramous, with a functional exopod and a rudimentary endopod. Exopod with 8 plumose setae on its posterior margin. Endopod present as a bud.

Fourth zoa (figs 52 & 53)

Duration of the stage: 6 - 9 days. Carapace length: 1.7 mm; Abdomen length : 1.9 mm.

This stage exhibits following advanced features over the previous stage: Inner ramus of antennule now gets distinctly separated from peduncle. Mandibular palp developed as rudimentary bud. Five pairs of pereiopod buds present. Four pairs of pleopod buds developed. Endopod of uropods functional.

Antennule (fig. 52, d): Peduncle now with 4 long, plumose and 3 hair-like setae distally. Inner ramus clearly separated and tip devoid of setae. Outer with 3 aesthetascs and 4 unequal setae terminally. Antenna (fig. 52, e): Endopod 2-segmented, about one and one-half times longer than scale and with a single terminal seta. Scale with 13 marginal setae. Mandible (fig. 52, f): Palp developed as a bud. First maxilla (fig. 52, g): No change except for the addition of a plumose seta on the coxal endite. Second maxilla (fig. 52, h): Coxal and basal endites with 9 + 3 and 4 - 5 + 5 setae respectively.
Endopod unchanged. Scaphognathite fringed with about 14 setae. Maxillipeds (fig. 53, a, b & c): First and second unchanged. Endopod of third, segmented with a terminal seta. Pereiopods (fig. 53, d): Represented as 5 pairs of elongated buds showing partial segmentation, first being chelate and fifth subchelate. Abdomen (fig. 52, a & c): Four pairs of pleopods (fig. 53, e) present as buds from 2nd to 5th segments. Telson (fig. 53, f): Process formula, $8 + 1 + 8$. Fourth process continues to be present, but reduced. Uropods (fig. 53, f): Both exopod and endopod functional. Exopod rather oval with 9 - 10 plumose setae. Endopod with 4 - 6 setae.

Glaucothoe (figs 54 & 55)

Carapace length: 1.2 mm; Abdomen length: 1.9 mm.

Rostrum short and broad at the base. Abdomen about one and one-half the length of carapace. Chelipeds more or less equal or subequal. Occular peduncles nearly twice as long as broad and almost reaching the distal end of antennular and antennal peduncle. Occular acicles small. Fourth and fifth pereiopods smaller, subchelate and chelate respectively. Four pairs of biramous pleopods developed. Uropods slightly unequal.

Antennule (fig. 54, c): Peduncle 3-segmented, first segment somewhat globular, second and third segments somewhat cylindrical. Outer ramus 5-segmented with 0, 5 - 6, 4 and 2 aesthetascs respectively from 1st to 4th segments, distalwards
and 3 - 4 setae on 5th, in addition to few simple setae on 2nd and 3rd segments. **Antenna (fig. 54, d):** Peduncle 5-segmented. Scale with 3 outer, marginal and 2 distal setae, reaching nearly to the distal margin of 4th segment of peduncle, with a pointed process on the outer distal angle. Nine-segmented flagellum with 0, 3, 3, 3, 4, 3, 4, 5 and 7 setae from 1st to 9th segments progressing distally. **Mandible (fig. 54, e):** As in adult. Palp 3-segmented with about 12 bristle-like setae distally on terminal segment. **First maxilla (fig. 54, f):** Both coxa and basis membraneous bordered with setae and plumose hairs. Coxa with about 19 setae and basis, 15 - 17 setae. Inner margin of basis with 2 simple setae. Endopod short and unsegmented with a short, knob-like projection terminally on the outer side, bearing a single seta. Inner margin with 1 or 2 setae. **Second maxilla (fig. 54, g):** Similar to adult except that palp is simple. Scaphognathite well developed and fringed with about 50 setae. **First maxilliped (fig. 54, h):** As in adult, except that the exopod lacks the terminal flagellated portion. **Second maxilliped (fig. 54, i):** Of the endopod segments merus is the longest as in adult. Exopod shows distinct flagellated and non-flagellated portions. The flagellated portion 3-segmented, bearing 5 - 6 plumose and few simple setae. **Third maxilliped (fig. 55, a):** Distal two segments of endopod bear many setae, remaining 3 segments with 2 + 2, 2 + 1 and 4 + 1 setae, distallywards. The flagellated portion of exopod do not show clear segmentation and with 6 plumose setae.
Pereiopods (fig. 55, b–e): First pair of pereiopods (chelipeds) (fig. 55, b): As in adult, distinctly chelate, in almost horizontal plane. Merus is the longest segment. Carpus somewhat triangular, one-third the length of merus. Propodus longer than broad and devoid of tubercles. Fingers hoofed. Dactylus more or less equal to propodus in length with slightly curved but somewhat hoofed tip. Few scattered setae present on all segments but no spines and tubercles. Second pereiopods (fig. 55, c): More or less similar. Segments long and cylindrical. Propodus is the longest segment. Carpus one-half the length of propodus. Dactylus nearly three-fourths the length of propodus, unlike in adult, wherein dactylus 1.7 times the propodus, with 2–3 spinules on its posterior margin. Third pereiopods: Similar to the second leg, except for 2–3 spinules on its posterior margin. Fourth pereiopods (fig. 55, d): Quite small, smaller than fifth leg. Merus and carpus more or less of equal length. Propodus as broad as long and with about 4–6 pectinate granules and tufts of setae distally. Dactylus claw-like with no spines but bearing tufts of setae and a long seta. Fifth pereiopods (fig. 55, e): Minutely chelate. Merus being the longest segment. Carpus nearly two-thirds the length of merus and bears few setae on either margins. Anterior part of propodus and proximal part of dactylus show corneous granules, the latter forming a chelate structure with dactylus. Very long setae present on both propodus and dactylus. Abdomen
(fig. 54, a & b): Nearly one and one-half the length of carapace, 6-segmented. Second to fifth segments with a pair of pleopods each. Pleopods (fig. 55, f - i) biramous with a long peduncle. A setose exopod with about 8 - 9 setae. Endopod with 2 hooks in the inner margin. Telson (fig. 55, k) somewhat obtuse, slightly broadening anteriorly, with about 9 plumose setae on its plain posterior margin and 2 pairs of small, simple setae laterally and dorsally and a pair of submarginal setae posteriorly. Uropods (fig. 55, j) well developed. Both rami being somewhat rectangularly triangular and armed with corneous granules on the posterior end, with 14 plumose setae on the posterior and inner lateral margins of the exopod and about 11 on posterior margin of the endopod.

Discussion

Based on the hitherto described larvae, the features of generic importance of Clibanarius may be summarized as under for the first zoeal stage: Carapace and abdominal somites smooth. Rostrum long, broad at the base, blunt or acutely pointed at the tip, reaching beyond the antennule and antenna, beak-like. Antennal scale without a terminal spine, endopod with three long, plumose setae. Telson deeply notched. First process laterally situated, blunt, finger-like except for C. erythrops wherein it is a small spine.

The table III gives a list of species wherein larval
**TABLE III**

<table>
<thead>
<tr>
<th>Species</th>
<th>Author/s</th>
<th>Year</th>
<th>No. of stages</th>
<th>Described from</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. erythrops</em></td>
<td>Pike &amp; Williamson</td>
<td>1960</td>
<td>3 zoeal</td>
<td>Bay of Naples, plankton</td>
</tr>
<tr>
<td><em>C. tricolor</em></td>
<td>Lewis</td>
<td>1960</td>
<td>---</td>
<td>West Indies, plankton</td>
</tr>
<tr>
<td><em>C. padavensis</em></td>
<td>Shenoy &amp; Sankolli</td>
<td>1975</td>
<td>4 zoeal + glau.</td>
<td>West coast of India</td>
</tr>
<tr>
<td><em>C. arthusa</em></td>
<td>Shenoy &amp; Sankolli</td>
<td>1976</td>
<td>4 zoeal + glau.</td>
<td>West coast of India (abs)</td>
</tr>
<tr>
<td><em>C. longitarsis</em></td>
<td>Ajmal Khan &amp; Natarajan</td>
<td>1981</td>
<td>4 zoeal + glau.</td>
<td>East coast of India</td>
</tr>
<tr>
<td><em>C. olivaceus</em></td>
<td>Ajmal Khan &amp; Natarajan</td>
<td>1976</td>
<td>4 zoeal + glau.</td>
<td>East coast of India (abs)</td>
</tr>
<tr>
<td><em>C. infraspinosus</em></td>
<td>Shenoy &amp; Sankolli</td>
<td>1977</td>
<td>4 zoeal + glau.</td>
<td>West coast of India</td>
</tr>
<tr>
<td><em>C. vittatus</em></td>
<td>Lang &amp; Young</td>
<td>1977</td>
<td>4/5 zoeal + glau.</td>
<td>United States</td>
</tr>
<tr>
<td><em>C. signatus</em></td>
<td>Tirmizi</td>
<td>1980</td>
<td>4 zoeal + glau.</td>
<td>Pakistan (abs)</td>
</tr>
<tr>
<td><em>C. viracena</em></td>
<td>Tirmizi</td>
<td>1980</td>
<td>4 zoeal + glau.</td>
<td>Pakistan (abs)</td>
</tr>
<tr>
<td><em>C. glibanerius</em></td>
<td>Ajmal Khan <em>et al</em></td>
<td>1981</td>
<td>4 zoeal + glau.</td>
<td>East coast of India (abs)</td>
</tr>
<tr>
<td><em>C. aequabilis</em></td>
<td>Present work</td>
<td></td>
<td>4 zoeal + glaucothoe</td>
<td>West coast of India</td>
</tr>
</tbody>
</table>

*Note:* *merquiensis*
information is available. It is evident from the Table that, of the 10 species for which complete laboratory reared larval account is available, only two species, *C. olivaceous* and *C. vittatus* pass through five zoeal stages, whereas in the remaining eight species the larvae pass through four zoeal stages only. Lang and Young (1977) observed 4 and 5 stages before a glaucothoe in the same hatchings of *C. vittatus*.

Though laboratory reared larvae are recorded for all the 4 species available in Karwar waters, the materials for comparison of larval stages in the published form is available only in 3 species, viz., *Clibanarius padavensis*, *C. infraspinatus* and the present species.

The first stage larva of *Clibanarius aequabilis* var. *merguensis* differs from those of *C. padavensis* and *C. infraspinatus* in the following: The posterior border of telson along with the notch fringed with fine hairs. Exopods of first and second maxillipeds 2-segmented. Outer margin of endopod of second maxilla without hairs. Also, the larvae of the present species differs from other larvae in setation of appendages.

The third zoea of *Clibanarius aequabilis* var. *merguensis* differs from those of *C. padavensis* and *C. infraspinatus* in the telson having an unarticulated spine as the fourth process as against a minute tubercle in the latter two species.

Shenoy and Sankolli (1977) consider the reduced fourth
process of *C. infraspinatus* as a generic character. However, in the larvae of *G. vittatus* (Lang and Youn, 1977), *G. longitarsis* (Ajmal Khan and Natarajan, 1981) and *G. aquabilis* var. *merguiensis* (the present species), the fourth process changes into an unarticulated spine and retains its prominence throughout the zoeal stages. Hence, the reduced fourth telson process in *C. infraspinatus*, *C. padavensis* and *C. erythropus* cannot be considered as a generic feature.

In the fourth zoeal stage, the fourth telson process continues to remain prominent. Similar observation is made for *G. vittatus* (Lang and Young, 1977) and *C. longitarsis* (Ajmal Khan and Natarajan, 1981). Ajmal Khan and Natarajan illustrate a prominent fourth telson process. However, in discussion they agree as it disappears or is reduced and agree with Shenoy and Sankolli (1977). However, the process disappears completely leaving a tubercle in *G. erythropus* (Pike and Williamson, 1960), *C. infraspinatus* (Shenoy and Sankolli, 1977) and *C. padavensis* (Shenoy and Sankolli, 1975). From the above observation it appears that the presence or absence of fourth process in the fourth zoeal stage have some taxonomic significance.

A key to the first zoeal stages may be formulated for the species for which published account is available as under by considering only few characters:

1. First telson process, a small spine ... *C. erythropus*
First telson process blunt, finger-like ... ... 2

2. Antennule with 2 aesthetascs ... ... . ... 3
Antennule with more than 2 aesthetascs ... ... 4

3. Scaphognathite of second maxilla with
   4 marginal setae ... ... ... C. nadavensis

   Scaphognathite of second maxilla with
   5 marginal setae ... ... ... C. nsequabilis var. mrruiensis

4. Antennule with 3 aesthetascs ... ... . ... 5
   Antennule with 4 aesthetascs ... ... C. longitarsis
   (other characters could not be considered
   owing to poor illustrations and descriptions)

5. Telson notch fringed with hairs; inner
   margin of endopod segments 1 - 4 smooth. C. infraspinatus

   Telson notch smooth; inner margin of
   endopod segments 1 - 4 fringed with hairs. C. vittatus

The generic features of the glaucothoe may be summerised
as under: Body symmetrical. Occular acicles present. Chelipeds
subequal with all smooth segments. Fingers hoofed. Posterior
margin of telson with not more than 9 plumose setae. The
detailed discussion on the taxonomic position of the genus is
made elsewhere in the thesis on the basis of the larval
morphology.

The major differences in the glaucothoe of three Karwar species are: the antennule in the present species bears 11-12 aesthetases as against 14 and many respectively in C. infraspinatus and C. padavensis; flagellum of antenna with 9, 10 and 11 segments respectively in C. aqueabilis var. merguiensis, C. padavensis and C. infraspinatus; the scaphognathite bears 40, 50 and many marginal setae in C. infraspinatus, C. aqueabilis var. merguiensis and C. padavensis respectively; the first maxilliped of the present species differs from other two species in having a smooth palp, flagellar portion without any setae. Many other differences in the armature may be listed, but they are only of minor differences.
Genus - DIOGENES
Of the 42 species (Gordon, 1956) so far described in the genus *Diogenes*, authentic information on the larvae is available in only 4 species, viz., *D. rugilator* (MacDonald *et al.*, 1957 and Pike & Williamson, 1960) from British waters, first zoea obtained in the laboratory, remaining stages collected from plankton; *D. bicristimanus* (Sarojini and Nagabhushanam, 1968), 5 zoeal stages and a glaucothoe; *D. avarus* (Sankolli and Shenoy, 1975), 4 zoeal stages, a glaucothoe and a crab instar and *D. miles* (Shenoy and Sankolli, 1980), 3 zoeal stages and a glaucothoe, all the latter three reared in the laboratory from the Indian waters. However, authors like Gurney (1927) and Manon (1937) refer some of their larvae collected from plankton.

*Diogenes diogenes* (Herbst)

A berried female was obtained from trawlers operating in the Karwar bay, west coast of India. The depths sampled by the otter trawl during this tow varied from 10 to 15 fathoms. The specimen was maintained alive in aquarium with filtered sea water until the larvae were released.

During the course of the experiment, the temperature of sea water ranged from 24 to 26 °C and the salinity about 33 ppt.

The complete metamorphosis up to the glaucothoe stage takes about 21 days.
Eggs are oval, violet when young, turning to pink and later transparent, when about to hatch. In formalin eggs loose colour and become pale gray. Egg size being, 0.58 to 0.67 x 0.49 to 0.59 mm.

**Description of larval stages**

**First zoea (fig. 56)**

Duration of the stage: 6 - 7 days. Carapace length: 0.92 mm; Abdomen length: 0.92 mm.

Carapace smooth, posterolateral margin slightly triangular, almost as long as the abdomen (carapace including rostrum). Rostrum smooth, pointed, reaching well beyond the antennule and antenna (fig. 56, a & b). Eyes sessile. Abdomen 5-segmented, 5th somite with a pair of large posterolateral and a pair of medio-dorsal spines. Exopods of first and second maxillipeds each with 4 natatory setae, third a rudimentary bud. Telson triangular, with more or less straight posterior margin; process formula, 7 + 7.

**Antennule (fig. 56, c)** uniramous with 2 unequal aesthetascs and 2 setae terminally and 3 fine hairs subterminally. Inner ramus represented by a single large, plumose seta. **Antenna** (fig. 56, d): Scale large, twice as long as the antennal endopod with a short spine terminally and 11 long, plumose setae
marginally, the one near the spine being the smallest, and is hair-like. Endopod with 2 long, plumose, subequal setae terminally and a small seta subterminally. Peduncle bears a strong spine, serrated on one side only, distally. Mandibles (fig. 56, e) asymmetrical, cutting edges bear a number of corneous, unequal, pointed teeth. **First maxilla** (fig. 56, f): Coxal endite with 5 plumose and 2 simple setae. Basal with 2 serrated teeth. Palp, 2-segmented and bears 2 setae distally. **Second maxilla** (fig. 56, g): Bilobed coxal and basal endites bear 6 + 1 and 4 + 3 setae respectively on their proximal and distal endites. Unsegmented palp with a median notch and bears 4 setae in 2 groups of 2 each terminally. Scaphognathite bears 5 marginal setae, posterior lobe not yet developed. **First maxilliped** (fig. 56, h): Basis with 7 - 8 setae. Five-segmented endopod bears 2, 2, 1, 2 and 4 + 1 (outer) setae distalwards. Exopod unsegmented with 4 natatory setae terminally. **Second maxilliped** (56, i): Basis with 3 setae. Endopod 4-segmented, with 2, 2, 2 and 4 + 1 (outer) setae progressing distalwards from 1st to 4th segments. Exopod as in first maxilliped. **Third maxilliped** (fig. 56, j): It is an uniramous bud. **Pereiopods** (fig. 56, k): Four pairs of pereiopod buds are clearly visible. **Abdomen** (fig. 56, a & b): Five segments are clearly articulated, 6th being fused with the telson; segments 1 to 4 broader than long, while the 5th, longer than broad; fifth segment on its posterior margin bears a pair of strong, lateral spines and a pair of dorsal spines as illustrated. **Telson** (fig. 56, l):
More or less triangular with the maximum width equals to the length of telson (including the fused 6th segment of abdomen). Process formula, $7 + 7$, the first, an articulated spine, nearly one-fourth as long as the fifth process, 2nd an 'anomuran' hair, as long as the 1st process, 3rd to 7th long, plumose setae, the 5th being the longest, almost as long as the 4th. The posterior margin of the telson including the notch with spinules and fine hairs.

Second zoea (fig. 57)

Duration of the stage: 7 - 8 days.

This stage is marked by the following changes over the previous stage. Eyes are now movable (fig. 57, a). Exopod of first and second maxillipeds with 6 natatory setae each, third now biramous and with 5 natatory setae on exopod. Telson process formula, $8 + 8$.

Antennule (fig. 57, b): Inner ramus with a long, plumose seta terminally. Outer ramus as in previous stage. Both rami separated by a median notch. Antenna (fig. 57, c): Scale as in previous stage. Endopod slightly elongated, with only 2 terminal subequal setae. Peduncle now adds another small spine at the outer distal angle. Mandibles (fig. 57, d): No change except for the addition of few more spines over the cutting edge, over the previous stage. First maxilla (fig. 57, e):
Basal endite now with 4 serrated teeth and 2 small setae.
Coxal endite and endopod as in first zoea. Second maxilla
(fig. 57, f): Scaphognathite with 7 plumose, marginal setae.
Endopod as in previous stage. Basal and coxal endites with
3 + 4 and 3 + 6 setae respectively on distal and proximal lobes.
First maxilliped (fig. 57, g): Exopod with 6 natatory setae.
Endopod segments 1 to 3 each add a long, plumose seta on the
outer distal angle. Second maxilliped (fig. 57, h): Exopod as
in first maxilliped. Second and third segments of endopod add
one long, plumose seta each on the outer margin. Third
maxilliped (fig. 57, i): Exopod now functional with 5 natatory
setae. Endopod bud-like. Pereiopods (fig. 57, j): Buds more
elongated and all 5 pairs are prominent. Telson (fig. 57, k):
Notch disappears. Process formula, 8 + 8, a pair of plumose
setae added at the inner margin near the notch, nearly half
as long as the 5th process; the 5th continues to be the
longest process.

Third zoea (fig. 58)

Duration of the stage: 7 - 8 days.

This stage is advanced over the previous stage in the
following. Antennal endopod segmented. Sixth abdominal segment
completely separated from the telson. Mandibles with a
rudimentary palp. Pleopods developed as 3 pairs of buds.
Uropods developed. Telson process formula reduced to 6 + 1 + 6.
Antennule (fig. 58, b): Inner ramus partially separated from peduncle with a long plumose seta terminally. Outer ramus completely separated from peduncle and with 2 aesthetascs and 2 unequal setae terminally and a single aesthetasc subterminally. Peduncle bears 2 long, plumose setae distally. Antenna (fig. 58, c): Scale now with 12 marginal setae. Endopod elongated considerably, reaching beyond the scale, 2-segmented, with a single terminal seta. Mandibles (fig. 58, d), increased in size, a rudimentary palp developed. First maxilla (fig. 58, e): No change over previous stage. Second maxilla (fig. 58, f): Coxal and basal endites with setation as follows: Proximal lobe of coxal with 4 terminal and 4 subterminal, the distal with 3 terminal and 2 subterminal setae. Proximal lobe of basal with 4 terminal and a single subterminal seta and the distal with 3 terminal and 1 subterminal respectively. Unsegmented endopod with 4 setae as in previous stage. Scaphognathite with 10 marginal setae, proximal lobe developed, but without any setae. First and second maxillipeds (fig. 58, g & h): No change except for increase in size. Third maxilliped (fig. 58, i): Unsegmented exopod now with 6 natatory setae. Endopod bud elongated. Pereiopods (fig. 58, j): All five pairs elongated and show segmentation, first show chelate and the fifth subchelate nature. Uropods (fig. 58, k): Rami unarticulated, inner ramus small, bud-like, oval, without setae; outer ramus elongated, terminating in a long, unarticulated spine, reaching up to the posterior margin of the telson, with 7 long, plumose,
marginal setae. Telson (fig. 58, l): Broader than long, process formula, $6 + 1 + 6; 3$ setae disappear, probably the 4th and 5th of one side and 4th of the other side as evidenced by the gap between the successive setae.

Glaucothoe (figs 59 & 60)

Carapace length: 0.97 mm; Abdomen length: 0.83 mm.

This stage resembles adult in general appearance except for its symmetrical, clearly segmented abdomen and for its free swimming nature.

Appendages such as chelipeds, second and third pereiopods, uropods and telson of left side rather more developed than those of the right side. Reduction in size, reduced rostrum, unequal chelipeds (left the larger); very long second and third pereiopods are the characteristic features of this stage.

Carapace smooth, posterolateral margins rounded (fig. 59, a & b), with well marked cephalic shield, typical of adult. Rostrum much reduced. Ocular peduncles stout, reaching to one-half the length of the last segment of antennular peduncle. Carapace with numerous hairs as illustrated.

Antennule (fig. 59, c): Peduncle 3-segmented, segments almost of equal length, with setation as illustrated. Outer ramus 3-segmented with 2 and 3 aesthetascs on the inner distal
angle of the 2nd and 3rd segments respectively progressing distalwards, and 3 small setae terminally. Inner ramus slender, 2-segmented, reaching up to the base of the 3rd segment of the outer ramus, with 4 setae terminally. Antenna (fig. 59, d): Peduncle 5-segmented; 1st, short; 2nd with reduced, serrated scale; 3rd partially covered by the second; 5th being the longest. Flagellum 7-segmented, with setae as illustrated. Mandible (fig. 59, e): Typically like adult with dorsal and ventral plates well developed. Two-segmented palp armed with about 9 bristles distally. First maxilla (fig. 59, f): Coxal and basal endites armed with setae as illustrated. Palp bilobed with a single terminal seta on the proximal lobe. Second maxilla (fig. 59, g): Coxal endite divided into two unequal lobes. Basal endites partially bilobed. All endites carrying tufts of setae as in adult. Endopod slender, reduced and without any setae. Scaphognathite fringed with about 38 setae marginally and a single simple seta on the distal lobe slightly below the marginal one. First maxilliped (fig. 59, h): Coxal and basal endites with setation as illustrated. Endopod slender, ribbon-like, but without setae. Exopod with broad basal part and a flagellar distal part with 4 long, plumose setae on the outer distal margin. Second maxilliped (fig. 60, a): Endopod reduced, nearly half the exopod, 5-segmented (segmentation at the base is not very clear) with setose dactylus and distal part of propodus. Exopod with incurved flagellum, typical of adult, with 6 long, plumose setae. Third maxilliped (fig. 60, b): Endopod long, reaching well
beyond the exopod, 5-segmented with setae as illustrated, thicker on the distal two segments. Exopod with 5 long, plumose setae. **Pereiopods**: Unequal, pereiopods of left side slightly longer than those of the right. **First pereiopod (chelifed)** (fig. 60, c): Chelate, fingers long and smooth, crossing at the tip. Merus being the longest segment. Few spines and setae present as illustrated. **Second and third pereiopods** (fig. 60, d): More or less similar except for the size, 2nd slightly longer than the third. Dactylus is the longest segment, nearly twice as long as the propodus and one-fourth the carpus. Merus nearly one and one-half the carpus. Segments smooth except for the setation as illustrated. **Fourth pereiopod** (fig. 60, e): Subchelate, smallest of all the pereiopods. Propodus ending in a broad pad of corneous spines forming a subchela with the dactylus. Dactylus elongated with tufts of setae as shown in the figure. **Fifth pereiopod** (fig. 60, f): Corneous granules covering the distal part so as to hide the minutely chelate nature of the pereiopod, long setae cover the segments. **Abdomen** (fig. 59, a & b): Six-segmented, all segments broader than long. Three pairs of pleopods (fig. 60, g) present on 2nd to 4th segments. All pleopods uniramous, first and second with 8 plumose setae each terminally, while the third with only 6 plumose setae, the third nearly half as long as the first pleopod. **Uropods** (fig. 60, h): Asymmetrical, left the larger, much like in adult. Rami with corneous granules and setae as shown in figure.
Telson (fig. 60, i): Posterior margin convex with 3 setae (2 dorsal and 1 dorsomedian) and spines at the posterolateral angle, 4 setae laterally on each side.

*Diogenes planimanus* Henderson

Two ovigerous females were collected from intertidal sandy shore of Anjadv Islands, about 8 kms from Karwar, and were kept alive in aquaria separately with filtered sea water until the larvae hatched out. The duration of the entire larval development comprising 3 zoeal stages, a glaucothoe and a crab instar at room temperature range of 25 to 27°C and salinity of about 33 ppt is 21 days.

The eggs were more or less oval, pink, immediately after oviposition, becoming transparent when about to hatch. Larval features may be seen through a lens in the egg. In formalin the colour turns to light orange and then to pale colour. The egg size ranges from 0.44 to 0.59 x 0.58 to 0.70 mm.

**Description of larval stages**

**First zoea** (fig. 61)

Carapace length = 0.96 mm; abdomen length = 0.92 mm; duration of the larval stage = 5 - 6 days.
Eyes sessile. Rostrum smooth, pointed, reaching beyond antennule and antenna (fig. 61, a & b). Carapace smooth, posterolateral margin rounded.

Antennule (fig. 61, c): Uniramous with 2 aesthetascs and 4 unequal setae terminally and a long, plumose seta subterminally, representing the future ventral ramus. Antenna (fig. 61, d): Scale large, nearly twice as long as the endopod, with a sharp, incurved spine terminally and 10 marginal, plumose setae of which 1st seta (one near the terminal spine) is the smallest and hair-like. Endopod with 2 large, plumose setae terminally and a small seta subterminally. Peduncle with a strong, stout ventral spine serrated on one side only.

Mandibles (fig. 61, e): Asymmetrical, cutting edges bear a number of unequal, short teeth. First maxilla (fig. 61, f): Coxal endite with 6 plumose setae. Basal with 2 serrated teeth. Palp 2-segmented with 2 terminal setae. Second maxilla (fig. 61, g): Both coxal and basal endites bilobed, the latter partially so. Proximal lobe of coxal with 5 terminal and 2 subterminal setae, the distal with 3 terminal and 1 subterminal setae. Basal bears 3 terminal and 2 subterminal on proximal lobe and 3 terminal setae on distal lobe. Palp (endopod) unsegmented with a distal median notch and bears 4 terminal setae in 2 groups of 2 each. Scaphognathite armed with 4 marginal plumose setae. First maxilliped (fig. 61, h): Basis fairly long with 8 setae as illustrated. Endopod 5-segmented,
setation being, 2, 2, 1, 2 and 4 + 1 (outer), distalwards, 2nd and 3rd fringed with fine hairs on outer margin. Exopod unsegmented, with 4 natatory setae terminally. **Second maxilliped** (fig. 61, i): Basis with 4 setae. Endopod 4-segmented with setation, 2, 2, 2 and 4 + 1 (outer) progressing distalwards. Exopod as in first maxilliped. **Third maxilliped** (fig. 61, j): A small unsegmented, uniramous bud. Pereiopods: Yet to be developed (in few larvae single pair of buds may be seen). **Abdomen** (fig. 61, a & b): Five-segmented, first 4 segments broader than long, whereas, the 5th longer than broad with a pair of postero-lateral and a pair of medio-dorsal spines. **Telson** (fig. 61, k): Triangular, as broad as the length of the telson and fused 6th abdominal somite. Posterior margin convex with a prominent median notch. Process formula 7 + 7, 1st a small, sharp, articulated spine; 2nd, an 'anomuran' hair; 3rd to 7th, long, plumose setae, 5th being the longest, one-half the telson breadth. Posterior margin armed with minute spinules between the processes, and fine hairs in the notch.

**Chromatophores** (fig. 61, a & b): Chromatophores are few and mostly distributed in the cephalothorax as described below. A well branched chromatophore present at the base of antennule and antenna, forming a thick triangle of blood, extending up to the rostrum. Branched red chromatophores present at the base of 1st, 2nd and 3rd maxillipeds. Light yellow colour on 5th abdominal somite posteriorly as illustrated.
Second zoea (fig. 62)

Carapace length = 1.07 mm; abdomen length = 1.04 mm; duration of the larval stage = 4 - 6 days.

This stage is marked by the following changes over the previous stage. Eyes now movable (fig. 62, a & b). Exopod of first and second maxillipeds with 6 natatory setae each. Third maxilliped functional with 5 setae on exopod. Four pairs of pereiopod buds developed. Telson process formula, 8 + 8.

Antennule (fig. 62, c): No change over previous stage except for a constriction at the distal end. Antenna (fig. 62, d): Long hair-like setae of previous stage (first process, near the spine) now long and plumose. Endopod setae reduced to 2 terminal setae. Mandibles (fig. 62, e): Slightly enlarged and the serrations increased. First maxilla (fig. 62, f): Except for increase of teeth on basal endite to 4, no other change. Second maxilla (fig. 62, g): Addition of a single seta on scaphognathite. First maxilliped (fig. 62, h): Exopod now with 6 swimming setae. Addition of a long, plumose seta each on the outer margin of proximal three segments of endopod. Second maxilliped (fig. 62, i): Exopod as in first maxilliped. Addition of an outer plumose seta each on proximal 2nd and 3rd segments of endopod. Third maxilliped (fig. 62, j): Exopod now functional with 5 swimming setae. Endopod unsegmented and bud-like. Pereiopods (fig. 62, k): Pereiopods developed as 4
pairs of small buds. **Telson** (fig. 62, 1): An addition of a pair of small setae near the notch. Process formula, 8 + 8, 8th process less than one-half the length of 5th process which continues to remain the longest.

**Third zoea** (fig. 63).

Carapace length = 1.24 mm; abdomen length = 1.20 mm; duration of the larval stage = 4 - 6 days.

Larvae of this stage can be distinguished by the following characters. Both rami of antennule separated from peduncle. Antennal endopod elongated and segmented, basis with an additional spine. Abdomen 6-segmented. Pereiopods developed as 5 pairs of elongated buds. Three pairs of pleopod buds developed. Telson process formula reduced to 7 + 7. Uropods functional.

**Antennule** (fig. 63, c): Inner ramus with 2 long plumose setae. Outer with 4 aesthetasc and 4 unequal setae terminally as illustrated. Peduncle with 3 long, plumose setae. **Antenna** (fig. 63, d): Scale with 12 marginal setae in addition to the pointed spine. Endopod now elongated, 2-segmented, reaching beyond the terminal spine of scale with a short terminal seta. Addition of a small spine on the distal margin of basis. **Mandibles** (fig. 63, e): No change except for a rudimentary palp (absent in some). **First maxilla** (fig. 63, f): Setae on
coxal endite increased to 7. Second maxilla (fig. 63, g): Coxal and basal endites with 4 + 2, 1 + 2, 4 + 1 and 3 setae respectively on their proximal and distal lobes. No change in palp. Scaphognathite with 10 marginal, plumose setae; posterior lobe well developed, but devoid of any setae.

Maxillipeds (fig. 63, h, i & j): Endopod of third maxillipeds enlarged. No other change. Pereiopods: All 5 pairs as well developed buds, 1st (fig. 63, k) shows chelate nature, 5th being subchelate. Abdomen (fig. 63, a & b): Sixth segment separated from telson. Three pairs of uniramous pleopod buds developed from 2nd to 4th segments, 1st (fig. 63, l) being the longest. Uropods (fig. 63, n): Rami unarticulated. Outer ramus long, with elongated, pointed terminal spine, reaching nearly to the base of the posterolateral margin of telson, with 7 plumose setae marginally. Inner ramus small, bud-like and without any setae. Telson (fig. 63, m): Process formula reduced to 7 + 7, leaving a gap at the place of 4th process of the previous stage. Median notch reduced. Fourth process the longest (5th of the previous stage).

Glaucothoe (figs 64 & 65)

Carapace length = 0.92 mm; abdomen length = 0.87 mm; duration of the larval stage = 7 - 8 days.

The larvae of this stage resemble adult in general appearance except for its almost symmetrical, clearly segmented
abdomen. Larvae swim for some time after which they settle to the bottom and occupy tiny shells provided in the rearing containers. The glaucothoe were observed to change shells several times before selecting a suitable shell in which they stay for almost a week, when they moulted to the first crab instar.

Carapace smooth (fig. 64, a & b); posterolateral margin rounded, with a well developed cephalic shield as in adult. Rostrum pointed, extends up to the ocular acicle or slightly beyond. Ocular acicles minute and simple. Ocular peduncles stout, longer than broad, reaching beyond the base of antennular peduncle.

Antennule (fig. 64, c): Peduncle 3-segmented, segments almost of equal length with 2 – 3 setae. Outer ramus 4-segmented with 0, 4, 3 and 2 aesthetascs distalwards and a single simple seta on the distalmost segment. Inner ramus slender, 2-segmented, reaching up to the base of 4th segment of outer ramus, with 1 setae terminally. Antenna (fig. 64, d): Peduncle 5-segmented, 1st short; 2nd with a reduced scale terminating in a pointed spine; 5th being the longest segment; setation as illustrated. Flagellum 7-segmented with 0, 2, 2 + 3, 2, 2 + 3, 2 + 1 and 7 – 8 setae distalwards. Mandible (fig. 64, e): As in adult, both dorsal and ventral plates well developed, armed with one or two blunt teeth. Palp 2-segmented with 9 – 10 short bristles distally. First maxilla (fig. 64, f): Coxal endite with 15 – 18
short, bristle-like setae. Basal endite armed with 15 - 20
short, spine-like setae in addition to 2 long setae on the
inner distal margin. Palp unsegmented with a single seta
terminaly. Second maxilla (fig. 64, g): Coxal and basal
endites bilobed, the former completely and the latter partially,
all the endites carrying tufts of setae as illustrated. Palp
slender, reaching upto the distal end of scaphognathite,
devoid of any setae. Scaphognathite fringed with about 30
marginal plumose setae. First maxilliped (fig. 65, a): Flat,
as in adult. Coxal and basal endites with setation as
illustrated. Endopod slender, ribbon-like, without setae.
Exopod with broad basal part and a flagellated distal portion
with 3 long, plumose setae marginally. Second maxilliped
(fig. 65, b): Endopod reduced, less than half the length of
exopod, 5-segmented, with setation, 0, 1, 1, 4 - 5 and 7 - 8
distalwards. Exopod 2-segmented, with incurved flagellum with
6 setae. Third maxilliped (fig. 65, c): Endopod long, 5-
segmented, with setae on all segments more on the distal margin
of 3rd to 5th distal segments. Endopod as in second maxilliped.

Pereiopods: Unequal, left side pereiopods slightly longer
than those of the right. First pair of pereiopods (fig. 65, d):
Chelate, left little larger than the right. Fingers long and
smooth except for few minute tubercles on the inner margin.
Merus is the longest segment. Carpus with 2 spines on the
distal margin. Propodus with a single spine at the base of
movable finger. Setae scattered all over as illustrated. Second
and third pereiopods (fig. 65, e): More or less similar in structure, except for the size, left ones are little longer than right. Second pereiopod longer than the third. Dactylus is the longest segment, almost twice as long as propodus, terminating in a spine-like corneous claw. All segments smooth with scattered setae as illustrated. Fourth pair of pereiopods (fig. 65, f): Subchelate like in adult, smallest of the pereiopods. Propodus short, broad at the base, ending in a pad of corneous granular denticles, forming a subchelate structure with dactylus; bears 1 or 2 long setae distally. Long and short setae present on all segments as illustrated. Fifth pair of pereiopods (fig. 65, g): Minutely chelate, corneous denticles covering the distal part, hide the chelate portion. Long setae present on the inner margin of propodus, carpus and merus. Abdomen (fig. 64, a & b): Nearly as long as carapace. Six-segmented, all segments broader than long. Three pairs of pleopods (fig. 65, h, i & j) present on segments 2nd to 4th, laterally. First pair of pleopods longest, with 8 long, plumose setae terminally. Endopod represented by a small seta. Third pleopod nearly one-third the length of 1st pleopod, with 3 setae. Fifth abdominal somite bears 2 - 3 setae. Uropods (fig. 65, l): Asymmetrical, the left larger than the right as in adult. Both rami with corneous granules and setae as illustrated. Telson (fig. 65, m): Nearly as long as broad. Posterior margin more or less convex with 3 - 4 setae in 2 rows distally and laterally. Posterior margin with 3 - 4 setae.
Posterolateral margins slightly thickened to form a tubercle-like structure.

First crab instar (figs 66 & 67)

This stage shows the typical asymmetrical nature of adult. Abdomen coiled, segmentation fainter, left side appendages larger than those of the right. Telson well developed and adult-like.

Carapace with well developed cephalic shield and cervical groove, scattered setae all over, groups of plumose setae on lateral and posterolateral angles. Occular peduncles large, stout, dilated at the base. Occular acicles well developed and serrated distally. Rostral scale reaches up to the tip of occular acicles, simple with 1 or 2 terminal setae (fig. 66, a & b).

Antennule (fig. 66, c): Peduncle 3-segmented, as in glaucothoe. Inner ramus of flagellum now 3-segmented with 2, 1 and 7 setae distally. Outer ramus 5-segmented with 0, 2, 6, 4 and 0 aesthetascs from 1st to 5th segments, 5th bears 2 simple setae terminally. Antenna (fig. 66, d): As in adult. Peduncle slightly longer than antennular peduncle, 5-segmented, 2nd segment bears a spinose acicle reaching up to the half of the penultimate segment. Nine-segmented flagellum with setation as illustrated. Mandible (fig. 66, e): As in adult,
cup-shaped. Palp 3-segmented, distal segment with 10 setae. 
First maxilla (fig. 66, f): As in glaucothoe and adult. Setae increased as illustrated. Second maxilla (fig. 66, g): As in previous stage, but for addition of setae on all endites and scaphognathite. First maxilliped (fig. 66, h): More like in adult. Endopod reduced further. Flagellar portion of exopod narrow and distinct but number of plumose setae continue to remain 3. Basal and coxal endites setose. Second maxilliped (fig. 67, a): As in previous stage, but for the increase of endopod setae. Third maxilliped (fig. 67, b): As in adult. Proximal segment of endopod with a prominent incurved spine-like projection. Exopod 3-segmented, with 4 - 5 long, plumose setae, 3 on ultimate and 1 or 2 on the penultimate segments. 
Pereiopods: More setose and spinose than in the glaucothoe. First pair of pereiopods (fig. 67, c): Fixed and movable fingers of the cheliped with spine wherein there were tubercles in the previous stage. Addition of a spine on the propodus on the inner margin. Long, plumose hairs on ischium and merus. Second and third pairs of pereiopods (fig. 67, d): Carpus with a spine on the distal margin. Setae as illustrated. Fourth pair of pereiopods (fig. 67, e): More like in adult, subchelate. Corneous granules increase in number. Fifth pair of pereiopods (fig. 67, f): As in adult, minutely chelate, with spinules and corneous granules at the base of the chelate portion. Abdomen (fig. 66, a): Coiled, asymmetrical as in adult. Segmentation not clear. However, a faint depression with tufts of hairs
mark the segmented nature of the body. Setae all over the abdomen, more on the anterior region. Four pairs of pleopods present on 2nd to 5th segments (fig. 67, g), uniramous, setose on left side, reduced to bud-like ones on the right side. Pleopods shorter than those in the glaucothoe, like in adult, with undulatory margin provided with plumose setae on either side. Basis (peduncle) provided with a single seta.

**Uropods** (fig. 67, h): Those of left side larger than right, with a short protopod, bearing a larger outer and shorter inner rami. Right nearly two-thirds the left, as in adult. Protopod produced into a short lobe. Both rami of each side armed with spines and cornaceous granules, as illustrated.

**Telson** (fig. 67, h): With prominent spines posteriorly, one on each side and 1 or 2 minute spinules in the centre. Resembles adult telson.

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**Diogenes violaceus** Henderson

Berried females of *Diogenes violaceus* Henderson were collected for the present work from the sandy shore in front of the department of Marine Biology, Karnatak University, Kodibag, during the intertidal collections. The hermit crabs were kept alive in aquaria with filtered sea water until the larvae hatched out. During the course of the experiment, the room temperature ranged from 23 to 24°C and salinity of the sea water used was about 30 ppt.
The larvae could reach up to 3rd zoea. All the larvae died before reaching the next stage (possibly glaucothoe). Larvae entered third zoeal stages on the 10th day after hatching.

Eggs were oval, pink when young, turning transparent when about to hatch. In formalin, the eggs lose color and appear pale. Egg size ranges from 0.49 to 0.54 x 0.41 to 0.52 mm.

**Description of larval stages**

First zoea (fig. 68)

Carapace length = 0.55 mm; abdomen length = 0.50 mm; duration of the larval stage = 4 - 6 days.

Rostrum pointed and long reaching beyond the antenna and antennule. Eyes sessile. Carapace smooth, posterolateral angle rounded. Third and 4th abdominal segments bear a dorsomedian spine posteriorly, 5th segment with a pair of articulated, lateral spines and a single dorsomedian spine, posteriorly. Telson triangular, process formula, 7 + 7. Exopods of first and second maxillipeds with 4 natatory setae.

Antennule (fig. 68, c): Uniramous, bears 2 aesthetases and 3 unequal setae on its distal margin; subterminally it bears a single long, plumose setae on a palp representing the future endopod. Antenna (fig. 68, d): Scale twice as long as
broad, with a prominent, unarticulated, incurved spine and 10 plumose, marginal setae of which the first, near the spine is the smallest and hair-like, reaching up to the spine. Endopod short, reaching nearly half way between 9th and 10th process of the scale, and distally bears 2 long, plumose setae. Basis distally bears a strong spine, serrated on both sides.

Mandibles (fig. 68, e): Unequal, cutting edges covered with many sharp spines. Palp not developed. First maxilla (fig. 68, f): Endopod two segmented and bears 2 unequal setae terminally. Basal endite large with 2 serrated teeth. Coxal endite bears 6 setae of which 3 plumose. Second maxilla (fig. 68, g): Scaphognathite bears 5 setae on its margin, posterior lobe not yet developed. Endopod simple with 2 setae distally. Bilobed basal and coxal endites bear 3 + 4 and 5 + 7 setae respectively on distal and proximal lobes as illustrated. First maxilliped (fig. 68, h): The 2-segmented exopod bears 4 natatory setae distally. Endopod 5-segmented, the 5th segment bears 4 distal and a single proximal (outer) setae, setation on other segments being 3, 2, 1 and 2 progressing distally from 1st to 4th segments. Basis bears 6 - 7 setae as illustrated. Second maxilliped (fig. 68, i): Exopod as in first maxilliped. Endopod 4-segmented, distal segment bears 4 + 1 (outer) setae, proximal 3 segments bear 2 setae each on distolateral margin. Basis with 3 setae. Third maxilliped (fig. 68, j): Uniramous bud. Pereiopods (fig. 68, k): Three pairs of tiny buds appear.

Abdomen (fig. 68, a & b): Five segmented, 3rd and 4th each with
a dorsomedian spine posteriorly, 5th with a pair of lateral spines in addition to a dorsomedian spine as in preceding segments. Telson (fig. 68, 1): More or less triangular, broader than the combined length of the fused 6th abdominal segment and the telson. Process formula, 7 + 7; 1st, an articulated spine, 2nd, a typical 'anomuran' hair; 3rd to 7th long, plumose setae, 5th being the longest, nearly one-half the breadth of the telson; 7th process on its outer margin bears spinules. Posterior margin of telson, including the notch bears bristles and fine hairs.

Second zoea (fig. 69).

Carapace length = 0.65 mm; abdomen length = 0.70 mm; duration of the larval stage = 4 - 5 days.

This stage is advanced over the previous stage by the following characters. Eyes free from carapace (fig. 69, a & b). Leg buds well developed and elongated. Exopods of 1st and 2nd maxillipeds with 6 natatory setae each, of 3rd with 5 setae. Telson process formula, 8 + 8.

Antennule (fig. 69, c): No change over the previous stage. Antenna (fig. 69, d): Scale and endopod as in previous stage. Basis bears an additional spine on the distal outer margin. Mandibles (fig. 69, e): No change except increase in size. First maxilla (fig. 69, f): Basal endite adds 2 more serrated
teeth. Coxal endite with 7 setae. Second maxilla (fig. 69, g): Scaphognathite now with 8 marginal setae. First maxilliped (fig. 69, h): Exopod now with 6 natatory setae. First three segments of endopod bear one long, plumose seta each on the inner distal margin. Second maxilliped (fig. 69, i): Exopod as in first maxilliped. Endopod bears long, plumose setae, one each on the distal inner margin of 2nd and mid-inner margin of the 3rd segment distalwards. Third maxilliped (fig. 69, j): Exopod 2-segmented with 5 natatory setae. Unsegmented endopod bud-like. Pereiopods (fig. 69, k): All 5 pairs developed as buds. Telson (fig. 69, l): Telson notch completely reduced. Addition of one more pair of plumose setae on the inner margin. Process formula, 8 + 8, 5th continues to be the longest, almost as long as the 4th. Processes 3 to 8 bear spinules on the posterior half only.

Third zoea (fig. 70)

Carapace length = 0.70 mm; Abdomen length = 0.85 mm.

Following are the advancements over the previous stage. Increase in size. Leg buds elongated and show segmentation. Pleopod buds developed. Mandible with a palp bud. Sixth segment separated from telson. Uropods developed. Telson process formula, 8 + 8.

Antennule (fig. 70, b): Outer ramus separated with 3
terminal aesthetascs and 3 unequal setae, subterminally it bears 2 aesthetascs. Inner ramus unarticulated with a single distal, plumose seta. Basis bears 2 long, plumose setae and 3 small, simple setae as illustrated. Antenna (fig. 70, c): Endopod 2-segmented and reaches beyond the scale with a simple, terminal seta on the distal segment. Setae on scale increased to 12. Mandibles (fig. 70, d): Size increased with more, elongated spines. Rudimentary palp appears. First maxilla (fig. 70, e): As in previous stage. Second maxilla (fig. 70, f): Setation in scaphognathite increased to 12, posterior lobe developed, but devoid of any setae. First and second maxillipeds (fig. 70, g & h): No change over the previous stage. Third maxilliped (fig. 70, i): Exopod now with 6 natatory setae. Endopod shows segmentation, but devoid of setae. Pereiopods (fig. 70, j): All 5 pairs well developed, 1st chelate and the 5th subchelate. Abdomen (fig. 70, e): Six-segmented, 6th being separated from the telson. Segments 2nd to 4th each bear a pair of pleopod buds (fig. 70, k, l, & m), uniramous, first pair being the longest, reduced in size, posteriorly. Uropods (fig. 70, n): Biramous, inner ramus long, with a long, unarticulated spine and 8–9 setae marginally. Both rami unarticulated. Telson (fig. 70, n): Broader than long, 4th process slightly reduced than in previous stage. Process formula continues to be 8 + 8. All the processes except the outer 2 pairs with spinules at the distal end, in addition to fine hairs.
Several ovigerous females were collected from intertidal region from Baithkol area, and were kept alive in aquaria individually in filtered sea water until the larvae hatched out. The duration of the entire larval development comprising 3 zoeal stages and a glaucothoe at room temperature range of 26 to 28°C and salinity of about 30 ppt. was about 16 days. However, only first zoea is described here as the remaining stages were not preserved.

The eggs were oval, dark gray in colour immediately after oviposition, turning to light gray and pale when about to hatch. The egg size ranged from 0.30 to 0.36 x 0.38 to 0.45 mm.

Description of the larval stage

First zoea (fig. 71)

Carapace length = 0.55 mm; abdomen length = 0.55 mm; duration of the larval stage = 4 - 5 days.

Eyes sessile. Rostrum smooth, pointed, reaching beyond antennule and antenna (fig. 71, a & b). Carapace smooth, posterior lateral margin rounded, Abdomen 5-segmented. Exopod of 1st and 2nd maxillipeds each with 4 natatory setae, third
a rudimentary bud. Telson process formula, 7 + 7.

**Antennule** (fig. 71, c): Uniramous with 2 aesthetases, 2 long and 2 short setae terminally, and a long, plumose seta subterminally representing future ventral ramus. **Antenna** (fig. 71, d): Scale moderately large, nearly one and one-half the length of endopod, with a short, acute spine terminally and 10 marginal, plumose setae of which one near the spine small and hair-like. Endopod with 2 large subequal setae terminally and a short seta subterminally. Peduncle with a strong spine serrated on one side only. **Mandibles** (fig. 71, e): Asymmetrical, cutting edges with a number of unequal, short teeth. **First maxilla** (fig. 71, f): Coxal endite with 6 plumose setae. Basal with 2 serrated teeth. Two-segmented endopod with 2 terminal setae. **Second maxilla** (fig. 71, g): Both coxal and basal endites bilobed, the latter partially. Proximal lobe of coxal with 3 terminal and 4 subterminal and distal with 3 terminal setae. Basal endite with 4 + 3 setae. Unsegmented endopod with 2 setae distally. Scaphognathite armed with 5 marginal, plumose setae. **First maxilliped** (fig. 71, h): Basis fairly long, with 5 setae as illustrated. Endopod 5-segmented with 2, 2, 2, 1 and 4 + 1 (outer) setae distalwards from 1st to 5th segments. Exopod unsegmented with 4 natatory setae. **Second maxilliped** (fig. 71, i): Basis with 3 setae. Four-segmented endopod with 2, 2, 2 and 4 + 1 (outer) setae distalwards. Exopod as in first maxilliped. **Third maxilliped** (fig. 71, j): A small, uniramous bud. **Pereiopods**: Yet to develop.
Abdomen (fig. 71, a & b): Five segmented; 5th segment with a pair of posterolateral spines and a single dorsomedian spine in addition to a pair of dorsal setae on 2nd to 5th segments. Telson (fig. 71, k): More or less triangular; posterior margin straight with fringe of fine hairs and spinules. Process formula, 7 + 7; 1st an articulated spine; 2nd an 'anomuran' hair; 3rd to 7th, long, plumose setae, 5th being the longest.

Chromatophores: Blood red chromatophores present at the base of antennule, antenna and maxillipeds; light orange red chromatophores on 5th abdominal somite and posterior carapace; yellow chromatophores on telson as illustrated (fig. 71, a & b).

**Diogones B. sp. nov.**

Ovigerous females were collected from Kali estuary and were kept alive in aquaria individually with filtered sea water until the larvae hatched out. The duration of the entire larval development comprising 3 zoeal stages and a glaucothoe at room temperature range of 26 to 28°C and salinity of about 28 ppt was 14 days. However, only first zoea is described here as the remaining stages were not preserved properly.

The eggs were oval, dark brown to dirty green in colour immediately after oviposition. The egg size ranged from 0.30 to 0.34 x 0.23 to 0.25 mm.
Description of the larval stage

First zoea (fig. 72)

Carapace length = 0.50 mm; abdomen length = 0.57 mm; duration of the larval stage = 4 - 5 days.

Eyes sessile. Rostrum smooth, acute, reaching beyond antennule and antenna (fig. 72, a & b). Carapace smooth, posterolateral margin rounded. Abdomen 5-segmented. Exopod of 1st and 2nd maxillipeds with 4 natatory setae each; 3rd a rudimentary bud. Telson process formula, 7 + 7.

Antennule (fig. 72, c): Uniramous with 2 aesthetases, 3 long and 1 short setae terminally and a long, plumose seta subterminally, representing the future ventral ramus. Antenna (fig. 72, d): Scale twice the length of endopod, with a moderately short, terminal spine and 9 marginal, plumose setae. Endopod with 2 subequal, long setae terminally and a short seta subterminally. Peduncle with a strong spine serrated on one side only, distally. Mandibles (fig. 72, e): Asymmetrical, cutting edges with a number of unequal, short teeth. First maxilla (fig. 72, f): Coxal endite with 6 setae. Basal with 2 serrated teeth. Two-segmented endopod with 3 setae. Second maxilla (fig. 72, g): Both coxal and basal endites bilobed, the latter partially. Proximal lobe of coxal with 6 and distal with 4 setae. Proximal and distal lobes of basis with 3 setae.
each. Endopod unsegmented with 2 terminal setae. Scaphognathite armed with 4 marginal setae. **First maxilliped** (fig. 72, h): Basis with 6 setae as illustrated. Endopod 5-segmented with 1, 2, 1, 2 and 4 + 1 (outer) setae distalwards. Exopod unsegmented with 4 long, swimming setae. **Second maxilliped** (fig. 72, i): Basis with 3 setae. Endopod 4-segmented with 2, 2, 2 and 4 + 1 (outer) setae distalwards. Endopod as in first maxilliped. **Third maxilliped** (fig. 72, j): An uniramous bud. **Pereiopods**: Not yet developed. **Abdopen (fig. 72, a & b)**: Five-segmented, all segments broader than long; 4th and 5th with a median spine each dorsally; 5th with a pair of unarticulated spines in addition to dorsal spine on the dorsal surface, posteriorly. **Telson** (fig. 72, k): More or less triangular; posterior margin somewhat convex with fine hairs and spinules. Process formula, 7 + 7; 1st an unarticulated spine; 2nd an 'aţomurăn' hair; 3rd to 7th, long, plumose setae, 5th process being the longest.

**Chromatophores**: Base of antennule and antenna with blood red chromatophores. Stellate chromatophores of red colour at the base of third maxilliped. Thoracic region and telson with light yellow chromatophores.

**Discussion**

Laboratory hatched larvae in the genus *Diogenes* are known
so far in 9 species (including the present work). MacDonald 
et al (1957) described 4 zoeal stages and a glaucothoe in 
D. pugilator from British water. However, they mention the 
possibility of 5th zoal stage, as their 4th zoea lacks 
p leaps buds and mandibular palp. They obtained the first zoea 
in the laboratory and remaining stages were collected from 
plankton. Pike and Williamson (1960) further remark "this is 
the normal number of zoal stages for this species in Mediterr­
amanean and Indian waters" for D. pugilator. Sarojini and 
Nagabhushanam (1968) record 5 zoal stages and a glaucothoe 
D. bicristimanus, reared in the laboratory, from the east coast 
of India. Sankolli and Shenoy (1975) gave an account of D. 
averua comprising 4. zoal, a glaucothoe and a first crab instar, 
obtained in the laboratory. Shenoy and Sankolli (1980) reared 
D. miles recording 3 zoal and a glaucothoe stage (abstract 
only), the latter two from the west coast of India.

In the present account, larvae of 5 species, viz., 
Diogenes diogenes, D. planimanus, D. violaceus, Diogenes A. 
and Diogenes B. are described.

Thus among the 9 species wherein larvae are known, 5 species 
pass through 3 zoal stages before a glaucothoe, viz., Diogenes 
diogenes, D. planimanus, D. miles, Diogenes A. and Diogenes B. 
Diogenes violaceus also possibly have only 3 zoal stages before 
a glaucothoe, as the third zoela shows advanced characters such 
as - mandibles with palpbud; pereiopod buds show segmentation;
pleopod buds appear - like in other third zoæae from Karwar waters. Thus all the karwar forms have 3 zoæal stages before a glaucothoe.

As the published information is not available so far on Diogenes miles, only 7 Indian species are considered for comparison. Table IV gives the first zoæal characters of Diogenes larvae.

On the basis of description of the larvae, generic features of the first zoæa in the genus Diogenes may be summarised as under: Rostrum smooth and pointed; carapace smooth; a pair of posterolateral spines on 5th abdominal somite; telson with a pointed spine as 1st process; dorsal spine(s) on the abdominal somites; antennal scale with a terminal spine, peduncle with a prominent spine, serrated mostly on one side.

Among the known larvae, armature on 5th abdominal somite and endopod setae on second maxilla appear to have taxonomic significance. All the larger varieties - true marine forms have 2 dorsal spines on 5th abdominal somite and 4 endopod setae on second maxilla, whereas those varieties which are estuarine and available in low saline waters have only one dorsal spine on the 5th abdominal somite and only 2 setae on endopod of second maxilla.

A key for the identification of larvae of hermit crabs from Karwar waters of genus Diogenes based on the armature of abdomen and mouth parts is formulated.
TABLE IV

<table>
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2-segmented, 2-segmented, unsegmented, unsegmented.

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<tr>
<th></th>
<th>Description</th>
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<tr>
<td>1</td>
<td>A pair of mid-dorsal spines over 5th abdominal somite posteriorly; endopod of second maxilla with 4 setae</td>
<td>D. diogenes</td>
</tr>
<tr>
<td></td>
<td>Abdominal somite with a single mid-dorsal spine over 5th; endopod of second maxilla with 2 setae</td>
<td>D. planimanus</td>
</tr>
<tr>
<td>2</td>
<td>Antennal scale with 11 marginal setae; coxal endite of first maxilla with 7 setae; scaphognathite of second maxilla with 5 marginal setae</td>
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</tr>
<tr>
<td></td>
<td>Antennal scale with 10 marginal setae; coxal endite of first maxilla with 6 setae; scaphognathite of second maxilla with 4 marginal setae</td>
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</tr>
<tr>
<td>3</td>
<td>Abdominal segments 2 - 4 with hairs only</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abdominal segments 2 - 4 with spines and hairs</td>
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<td>4</td>
<td>Antennule with 2 aesthetascs and 3 setae terminally; endopod of first maxilla unsegmented; endopod of second maxilla</td>
<td></td>
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maxilla with fringe of hairs; exopod of 1st and 2nd maxillipeds 2-segmented ... D. svarus

Antennule with 2 aesthetes, 2 long and 2 short setae; endopod of first maxilla 2-segmented with 2 setae; endopod of second maxilla without hairs; exopod of 1st and 2nd maxillipeds unsegmented ... Diogenes A. (n. sp.)

5. Third and 4th abdominal somites with a mid-dorsal spine each; antennal endopod with 2 setae; scale with 18 marginal setae; endopod of first maxilla with 2 setae; scaphognathite of second maxilla with 5 marginal setae ... ... D. violaceus

Fourth abdominal somite with a mid-dorsal spine; antennal endopod with 2 long and 1 short setae; scale with 9 marginal setae; endopod of first maxilla with 3 setae; scaphognathite of second maxilla with 4 marginal setae ... ... Diogenes B. (n. sp.)

The second zoas of the three species Diogenes diogenes, D. planimanus and D. violaceus may be distinguished from the following characters: Peduncle of antenna with 2 spines in D. diogenes and D. violaceus, whereas only one in D. planimanus; scale with 10 setae in D. planimanus and D. violaceus and...
11 in *D. diogenes*; all 5 pairs of pereiopods appear in *D. diogenes* and *D. violaceus* whereas only 4 pairs appear in *D. planimanus*.

In third zoea, antennule with 3 aesthetascs, 3 unequal setae; 3 aesthetascs, 2 unequal setae; and 4 aesthetascs and 4 unequal setae on outer ramus and 2 long + 3 short, 2 and 3 setae respectively on the endopod of *D. violaceus*, *D. diogenes* and *D. planimanus*. Telson process formula, 6 + 1 + 6, 7 + 7, and 8 + 8 respectively in *D. diogenes*, *D. planimanus* and *D. violaceus*.

The glaucothoe of *D. planimanus* may be differentiated from *D. diogenes* in having 9 aesthetascs on 4-segmented outer ramus of antennule; 3rd pleopod with 3 plumose setae and other variations in number of setae on appendages.
Genus - Dardanus
**Dardanus setifer** (H. Milne Edwards)

In the genus *Dardanus*, authentic larval information is available, so far, only in one species, *D. arrosor* (Kurata, 1968). First zoeal stage of *D. arrosor* was described by Issel (1910), Boraschi (1921), Pike and Williamson (1960), Bourdillon-Casanova (1960), DeChance (1962) and Kurata (1968). DeChance obtained larvae of 3 species of *Dardanus* from plankton and compared them with *D. arrosor*. But his identification is only up to the genus level. The complete larval development, at present, is known in only one species, *Dardanus arrosor* described by Kurata (1968), reared in the laboratory.

The present account on *Dardanus* forms the first one from the Indian waters. A single, berried female was collected from the intertidal rocky shore at Binga, Karwar, and was kept alive in the aquarium with filtered sea water until the larvae hatched out.

Eggs were oval, orange red (when the eggs were in early embryonic development) turning to pale and semitransparent condition just before hatching. Egg size ranged from 0.22 to 0.26 x 0.25 to 0.28 mm.

The larvae did not feed properly and within 5 days after hatching, all larvae died and none moulted to second zoa.
Description of the larval stage

First zoea (fig. 73)

Rostrum length = 0.37 mm; carapace length = 0.99 mm; abdomen length = 1.10 mm.

Rostrum long, extending well beyond the antennule and antennal scale, sides almost parallel up to nearly two-thirds the distance and then tapering to form a sharp, pointed spine. A short carina present at the base of the rostrum. Posterior carapace smooth and posterolateral angle rounded. Abdomen smooth, except for a pair of curved lateral spines situated subterminally on the 5th segment. Absence of a terminal spine on the antennal scale.

Antennule (fig. 73, c) extends nearly to one-half the rostral length and bears 3 aesthetascs and 2 unequal setae terminally and a single large, plumose seta subterminally on a palp, representing the inner ramus. Antenna (fig. 73, d): Endopod more than half as long as the scale and terminally bears 2 long subequal setae and a short outer one, about one-seventh as long as the other two. Scale bears 10 setae on its inner margin, the outermost being the smallest. Outer margin of the scale with fine hairs. Basis with a stout spine, serrated on the inner margin, distally. Mandibles (fig. 73, e): Asymmetrical and with numerous strong teeth on the cutting
edges. Palp but yet to develop. **First maxilla** (fig. 73, f):
Coxal endite with 7 setae. Basal with 2 stout, serrated tooth-like spines and 2 small setae. Endopod unsegmented and elongated with 2 unequal setae terminally. **Second maxilla** (fig. 73, g):
Scaphognathite with 5 plumose, marginal setae. Endopod with a median notch and 4 setae in groups of 2 each terminally. Coxal and basal endites bilobed, former completely and the latter partially. Basal endite with 4 + 5 and Coxal with 4 + 6 setae respectively on their distal and proximal endites as illustrated. **First maxilliped** (fig. 73, h):
The unsegmented exopod bears 4 natatory setae terminally. The setation on the 5-segmented endopod being, 3, 2, 1, 2 and 4 + 1 (outer) respectively from 1st to 5th segments distalwards. Inner margin of 2nd and 3rd segments bear fine hairs. The latero-proximal corner of the basis terminated in a blunt, curved lobe with a tiny spine-like seta. Basis bears 8 setae as illustrated. **Second maxilliped** (fig. 73, i):
Exopod as in first maxilliped. Endopod 4-segmented with setation, 2, 2, 2 and 4 + 1 (outer distalwards. Basis with 3 setae and the latero-proximal angle smooth. **Third maxilliped** (fig. 73, j), a small uniramous bud. Pereionods not yet developed. **Abdomen** (fig. 73, a & b), 5-segmented, segments 1 - 4 smooth and broader than long, 5th with a pair of short, unarticulated, latero-median spines, segments longer than broad. **Telson** (fig. 73, k): Maximum width of telson slightly greater than the combined length of telson and the 6th fused abdominal somite. Presence of a longitudinal ridge on
either side of telson as shown in the figure. Process formula, 7+7; 1st, rather long, unarticulated and incurved spine; 2nd a typical 'anomuran' hair, falling short of the 1st process; 3rd to 7th, long, plumose setae, 3rd being the longest, 7th with spinules on the outer margin; telson notch and posterior margin with fine hairs.

Chromatophores not distinct, but the rostrum and abdominal regions light orange. Mouth parts pale, like the remaining parts of the body. Diffused light yellow chromatophores around the eye.

Discussion

Though, DeChanee (1962) described three species in the genus Dardanus, his identification was only upto genus level, and his material was collected from plankton. Thus, so far authentic information is available only on the larvae of D. arrosor (Pike and Williamson, 1960; Kurata, 1968) in the genus. Therefore, in the present discussion, only D. arrosor has been considered for comparison.

The surface of the cuticle has a scale appearance in Dardanus arrosor (Pike and Williamson, 1960; DeChanee, 1962) whereas, no such scale is seen in the present species. Pike and Williamson (1960) give the length of 1st zoea of D. arrosor as 3.1 mm whereas in the present material it is only 2.09 mm;
Carapace length in the former is 1.6 mm against only 0.99 mm in the present species. A single aesthetasc and 1 seta present in the antennule of *D. arrosor* whereas, 3 aesthetascs and 2 setae, in addition to a common plumose seta, in *D. setifer*. According to DeChance (1962) the palp of 1st maxilla in *D. arrosor* bears 3 setae whereas, Pike and Williamson (1960) observe in the same species only 2 setae. In the present material, the unsegmented palp bears 2 setae.

The following characters on the basis of the available information may be considered as important generic features in the first zoea of the genus *Pardanus*. Rostrum with a dorsal carina. Presence of a lobe at the lateral proximal angle of the basis of first maxilliped. A longitudinal ridge present on either side of mid-dorsal line of the telson.
Genus - *Troglopagurus*
The genus *Troglopagurus* is represented by only 4 species (Gordon, 1956), viz., *T. manaarensis* Henderson, 1893, *T. jousseaumii* Bouvier, 1897, *T. jubatus* Nobili, 1903 and *T. periscus* Nobili, 1905. Of these, *T. manaarensis* Henderson is the only species recorded so far from the intertidal zone from Karwar waters.

Though larval information for other genera is available, so far no information is available on the larvae in the genus *Troglopagurus*.

A berried female was collected from the intertidal rocky shore at Binga, Karwar along the west coast of India, and was kept alive in an aquarium with filtered sea water with stones encrusted by algae to simulate the natural habitat, until the larvae hatched out. Most of the larvae hatched as prezoeae, which immediately moulted to zoeae and some directly as zoeae. During the course of the experiment, temperature of the sea water used ranged from 26 to 28°C and the salinity about 34 ppt. The larvae pass through three zoeal stages before a glaucothoe, which readily entered the tiny gastropod shells provided in the rearing chambers. None moulted to crab instar. The entire metamorphosis took about 22 - 23 days.

The eggs fairly large, rounded or slightly oval, pale
and transparent; diameter of eggs being, 0.52 to 0.57 × 0.57 to 0.59 mm.

Description of larval stages

First zoea (fig. 74)

Carapace length = 0.8 mm; abdomen length = 1.0 mm; duration of the larval stage = 8 - 9 days.

Larvae fairly big. Eyes sessile, comparatively small. Rostrum pointed and smooth, reaching up to the tip of the spine of scale. Carapace smooth and posterolateral margin rounded. First and second maxillipeds bear 4 natatory setae each on respective exopods, third maxilliped rudimentary. Pereiopods appear as 4 pairs of rudimentary buds. Abdomen 5-segmented, all segments smooth. Telson process formula, 7 + 7 (fig. 74, a & b).

Antennule (fig. 74, c), uniramous with 3 terminal aesthetascs and a plumose seta, subterminally it bears a long, plumose seta on a rudimentary palp, representing the future endopod. Antenna (fig. 74, d): Scale elongated, with a small outer spine and 10 marginal plumose setae, the first and the last being the smaller. Endopod nearly two-thirds the scale with 2 terminal subequal setae and a subterminal seta nearly one-fifth the length of remaining two. Basis with a long spine
serrated on one side only. Mandibles (fig. 74, e): Unequal with sharp, pointed spines over the cutting edge. First maxilla (fig. 74, f): Coxal endite with 5 terminal, plumose setae and a single subterminal, simple seta. Basal with 2 serrated teeth. 2-segmented palp with 2 terminal setae. Second maxilla (fig. 74, g): Bilobed coxal and basal endites with 5 + 4 and 4 + 4 setae respectively on their proximal and distal lobes. Endopod with a notch distally and 4 setae in two groups of 2 each. Scaphognathite bears 5 plumose, marginal setae. First maxilliped (fig. 74, h): Basis with 8 - 9 setae as illustrated. Exopod unsegmented, terminating in 4 long, plumose, swimming setae. Endopod 5-segmented with setation, 3, 2, 1, 2 and 4 + 1 (outer) progressing distally. Second maxilliped (fig. 74, i): Basis with 3 setae. Exopod as in first maxilliped. Four-segmented endopod with 2, 2, 2 and 4 + 1 (outer) setae distalwards. Third maxilliped (fig. 74, j), an uniramous bud. Pereionods (fig. 74, k), appear as 4 pairs of tiny buds, 4th being the smallest. Abdomen (fig. 74, a & b): Five-segmented, 1st to 4th, broader than long while, the 5th, longer than broad. All segments smooth. Telson (fig. 74, l): Triangular, posterior margin convex and with spinules and tufts of hairs all along the margin, including the median notch. Telson and the fused 6th abdominal segment together, slightly longer than broad. Process formula, 7 + 7; 1st, an articulated, incurved spine, one-third the length of the longest telson process; 2nd, an 'anomuran' hair; 3rd to 7th, long, plumose
setae, 5th being the longest, 7th with spinules on the outer, posterior margin.

Chromatophores were recorded immediately after hatching of the first zoea and are illustrated in fig. 74, a & b. Blood red chromatophores are present on the base of antennule, mandible and maxillipeds. A ganglionated yellowish or yellowish orange chromatophores present at the base of maxilla. Scattered red dot-like chromatophores present over the carapace and a light yellow patch present at the base of fifth abdominal somite.

Second zoea (fig. 75)

Carapace length = 1.0 mm; abdomen length = 1.15 mm; duration of the larval stage = 8 - 9 days.

Larvae show following advancements over the previous stage. Eyes stalked and movable (fig. 75, a & b). Rostrum reaching beyond antennule and antenna. Exopods of first and second maxillipeds with 6 natatory setae each, while that of the third becomes functional with 5 natatory setae. Pereiopod buds now 5 pairs. Telson process formula increased to 8 + 8.

Antennule (fig. 75, c) continues to be uniramous, with 4 aesthetascs and 3 unequal setae terminally of which one is a long and plumose seta. An addition of a seta terminally
opposite the long, plumose setae of previous stage. **Antenna** (fig. 75, d): As in first zoea. **Mandibles** (fig. 75, e): More enlarged with addition of spines on the cutting edge. **First maxilla** (fig. 75, f): Basal endite now with 4 serrated teeth. **Second maxilla** (fig. 75, g): Proximal lobe of coxal and basal endites add 2 and 1 setae respectively. Scaphognathite now with 7 marginal setae as illustrated. **First maxilliped** (fig. 75, h): Exopod 2-segmented, terminating in 6 natatory setae. Endopod adds a long plumose seta each on the outer distal margin of 1st to 3rd segments distalwards. **Second maxilliped** (fig. 75, i): Exopod as in first maxilliped. Endopod now with addition of a plumose seta each on the outer distal angle of second and the outer middle of 3rd segments respectively distalwards. **Third maxilliped** (fig. 75, j): Biramous. Two-segmented exopod with 5 long, plumose setae. Endopod being rudimentary. **Pereiopods** (fig. 75, k): All 5 pairs present as elongated buds, 5th being the smallest. **Telson** (fig. 75, l): Addition of a pair of plumose setae near the median notch, thus reducing the cleft of the notch and convexity of the posterior margin of the telson. All processes being plumose, except the 1st process. Eighth process nearly half the length of the 5th, which continues to remain the longest.

**Third zoea** (fig. 76)

Carapace length = 1.25 mm; abdomen length = 1.25 mm; duration of the larval stage = 6 days.
Following are the important features distinguishing the larvae of the third stage: Antennule and antenna reach well beyond the rostrum (fig. 76, a). Antennule biramous. Mandibles with a rudimentary palp. Exopod of all three maxillipeds with 6 natatory setae. Pereiopod buds more elongated and show segmentation. Abdomen 6-segmented. Three pairs of pleopod buds appear. Uropods functional. Telson process formula reduced to 7 + 7.

Antennule (fig. 76, b): Both inner and outer rami separated from the peduncle. Outer ramus with 4 aesthetasc and 3 unequal setae. Inner ramus with a terminal plumose seta. Peduncle bears 3 long, plumose setae and 3 hair-like setae distally. Antenna (fig. 76, c): Scale with 11 marginal setae in addition to a small spine. Endopod elongated considerably, reaching well beyond the scale, 5-segmented; segmentation fainter distally and with 3 long and a small setae terminally and 2 long setae at the base of 4th segment distally. Basis adds another small spine on the outer distal angle. Mandibles (fig. 76, d): Palp bud developed. First maxilla (fig. 76, e): Coxal endite with 7 setae. Basal now with 5 long serrated teeth and a small seta. Endopod remains unchanged. Second maxilla (fig. 76, f): Posterior lobe of scaphognathite developed, but devoid of any setae, distal lobe now with 8 plumose, marginal setae. First and second maxillipeds (fig. 76, g & h) as in previous stage, but increased in size. Third maxilliped (fig. 76, i): Exopod now with 6 natatory setae. Endopod shows segmentation but
devoid of any setae. **Pereiopods** (fig. 76, j): All 5 pairs well developed buds and show segmentation, 1st chelate and the 5th subchelate. **Abdomen** (fig. 76, a): Six-segmented, 6th separated from telson. Three pairs of pleopod buds present from segments 2 - 4. Pleopod buds show small spinules at the tip (fig. 76, k).

**Uropods** (fig. 76, l) biramous and articulated at the base to the protopod. Exopod long, terminating in a pointed, unarticulated spine and 6 long, plumose, marginal setae, the tip of the spine reaching up to the posterior margin of telson. Endopod oval and bud-like, without setae. **Telson** (fig. 76, l): Posterior margin straight. Process formula reduced to 7 + 7, 4th process disappears leaving a gap between 3rd and 5th processes (in some a tubercle could be seen), processes 5th to 8th each with their tips spinuous. Fifth process (now 4th process) remains the longest.

**Glaucothoe** (figs 77 & 78)

Carapace length = 0.8 mm; abdomen length = 0.9 mm.

The glaucothoe resembles adult. They swim for about one hour and settle down to the bottom of the rearing bowl. Glaucothoe entered shells provided in the rearing container almost immediately after settling. None of the glaucothoe entered tiny shells moulted to crab instars and died within a week.
Following are the important distinguishing features of the glaucothoe: Carapace (fig. 77, a) shorter than abdomen in length; anterior shield clearly demarcated. Rostrum blunt, projecting slightly beyond the front. Anterolateral margin of carapace smooth. Occular acicles absent. Occular peduncles stout, twice as long as broad, reaching up to the tip of antennular peduncles. Chelipeds subequal or slightly unequal. Pleopods 3 pairs, 3rd being bud-like.

**Antennule** (fig. 77, b): Peduncle 3-segmented, all segments subequal, 1st with a spine on the distal margin, 2nd and 3rd cylindrical with few scattered setae. Inner flagellum 3-segmented, with 1, 1 and 5 setae distally. Outer flagellum also 3-segmented, 2nd the longest with 2 aesthetascs and 1 simple seta on the distal margin; distal segment with 3 aesthetascs and 3 simple setae distally. **Antenna** (fig. 77, c): Peduncle 5-segmented; 2nd with a tooth-like spine; scale covering the 3rd segment, triangular, with spinous tip and few setae. Flagellum of 7 segments with few long, plumose setae and many small hair-like setae as illustrated. **Mandible** (fig. 77, d): Well developed, as in adult, cup-shaped, with few small blunt teeth on cutting edge. Palp 2-segmented, distal segment long, with 8 short, bristle-like teeth terminally. **First maxilla** (fig. 77, e): Coxal endite with 6 - 7 setae. Basal with 16 - 18 short, conical teeth and 2 moderately long setae and a single seta at the base below the commencement of palp. Palp unsegmented with a prominent seta distally. **Second maxilla**
Scaphognathite well developed, fringed with about 35 plumose setae all along the margin. Endopod elongated, finger-like, without setae. Basal and coxal endites bilobed and fringed with setae as illustrated. **First maxilliped** (fig. 77, g): Flat, leaf-like, like in adult. Exopod lacks flagellated portion, with 3 long marginal plumose setae and a small seta distally. Endopod unsegmented with a seta terminally. Bilobed basis with 18 - 20 and 6 - 8 setae respectively on distal and proximal lobes. **Second maxilliped** (fig. 78, a): Endopod 2-segmented, incurved with 6 long, plumose setae terminally on the distal segment, proximal with a median seta, as shown in the figure. Endopod 5-segmented with setation as illustrated. **Third maxilliped** (fig. 78, b): Well developed, like in adult. Exopod as in second maxilliped. Endopod long, 5-segmented with setation as illustrated, spines of adult absent. **Pereiopods**: First pair chelate and stouter than remaining pereiopods. Second and third similar. Fourth sub-chelate and fifth faintly chelate, like those of adult. **First pair of pereiopods (chelipeds)** (fig. 78, c): Almost equal or subequal. Ischium nearly as long as broad. Merus is the longest segment, nearly as long as dactylus. Carpus one-half the length of dactylus. Propodus longer than broad. Fingers when closed leave a gap in the centre. All segments bear sharp, curved spines and scattered setae as illustrated. **Second and third pair of pereiopods** (fig. 78, d): Similar and armed with setae and spines as illustrated. Ischium small, less than one-
half the merus. Merus as long as propodus, and without spines. Carpus one-half the propodus with 2 spines. Dactylus is the longest segment, terminating in a short, incurved, acutely pointed claw. **Fourth pair of pereiopods** (fig. 78, e): Subchelate. Merus is the longest segment, 3 times the ischium and one and one-half the carpus. Propodus short, nearly as long as broad. Dactylus nearly twice the length of propodus. Both propodus and dactylus with corneous granules anteriorly and 2 long, plumose setae distally in addition to many simple setae. **Fifth pair of pereiopods** (fig. 78, f): Show minutely chelate nature of adult. Propodus broader at the base, forming a chelate structure with dactylus and bearing corneous granules and spinules distally. Entire appendage covered by simple and plumose setae as illustrated. **Abdomen** (fig. 77, a): Three pairs of pleopods present on 2nd to 4th segments, longest being on the 2nd; uniramous, with 8 long, plumose setae on 1st and 2nd (fig. 78, g & h), 3rd bud-like (fig. 78, i). **Uropods** (fig. 78, j): Typically like adult appendage, biramous. Inner ramus small, oval, with a row of corneous granules and setae. Outer ramus long, more than twice the length of the inner, with a row of corneous, blunt teeth and 11 - 14 setae as illustrated. **Telson** (fig. 78, j): As in adult, concave posteriorly; broader than long, with 2 tooth-like spines laterally and setae as shown in the figure.
Discussion

Karwar, on the west coast of India, is represented by 6 genera of hermit crabs viz., Paguristes, Clibanarius, Dardanus, Diogenes, Troglopagurus and Pagurus. Laboratory reared larval accounts are so far available in fifteen species representing all the 6 genera listed in Table V, and are common zooplankters of Karwar waters.

Among the larvae described so far, larvae of Troglopagurus may be easily differentiated from those of the other genera by the following characters.

From the genus Dardanus the larvae of Troglopagurus differ in having comparatively short rostrum; absence of dorsal carina; smooth abdomen; absence of dorsal ridge on telson; a short, terminal spine on antennal scale; a short, articulated spine as first telson process; 5th abdominal somite smooth; median notch of telson moderately short, as against the following characters of Dardanus: long rostrum with a dorsal carina; 5th abdominal segment with a pair of medio-lateral spines; telson with a pair of dorsal ridges; antennal scale without a terminal spine; first process of telson a long, unarticulated spine; telson with a deep median notch.

Genus Clibanarius may be distinguished from Troglopagurus in the latter having a pointed rostrum; first process of
telson, a spine; a spine on antennal scale; whereas, in the former, rostrum long and beak-like; first process of telson finger-like; antennal scale without a terminal spine.

From the genus Diogenes, the larvae of the present genus differs in having a smooth abdomen as against a pair of lateral spines and one or two dorsal spines on the 5th segment and few setae.

The present genus differs from the genus Paruristes in having a smooth abdomen, first spine of telson articulated, as against dorsal and lateral spines on abdomen; unarticulated spine on telson; antennal scale with a long, incurved terminal spine in Paguristes larvae.

The larvae of Troglonagurus differ from those of Pagurus in the following: Carapace smooth; abdomen without any spines; antennal scale without a short spine in the former, whereas, in the latter, lateral margin of carapace with spines; dorsal spines on segments 1-5 and lateral spines on 5th abdominal segments; antennal scale with a long, stout, straight spine.

Thus, antennal scale and abdominal armature seem to have taxonomic significance.
A key to the identification of hermit crab larvae from Karwar waters (first zoea)

To facilitate the quick identification of larvae of hermit crabs up to the genus level from the local plankton, following key is formulated (figs 79 & 80).

1. Posterolateral angle of carapace with spines; paired spines on posterior margin of abdominal somites 1 - 4. (terminal spine of scale long, stout, nearly one-half the length of scale) ... ... ... ... ... Pagurus

Carapace smooth; abdominal somites 1 - 4 unarmed or with a single dorsal spine and setae ... ... ... ... ... 2

2. Rostrum long, broad at the base; reaching beyond the antenna and antennule; antennal scale without a terminal spine ... ... ... ... 3

Rostrum pointed and not broad at the base, reaching up to the tip of antennule and antenna or slightly beyond, acutely pointed; antennal scale with a terminal spine ... ... ... 4

3. Abdomen without spines; telson without longitudinal ridge; 1st telson process
finger-like; rostrum without dorsal carina .. *Clibanarius*

Fifth abdominal somite with a pair of spines on its posterolateral angle; telson with a longitudinal ridge; 1st telson process long, unarticulated spine; rostrum with dorsal carina ... ... ... *Dardanus*

4. Abdominal somites smooth ... ... ... *Troglonagurus*

Abdominal somites armed with dorsal and lateral spines ... ... ... ... ... 5

5. Scale with a short spine; abdominal somites 2 - 4 smooth or with few setae; 5th with 1 or 2 dorso-median and a pair of lateral spines ... ... ... ... ... *Diogenes*

Scale with a long, incurved spine; abdominal somites 2 - 5 with a median spine; 5th with a pair of lateral spines ... *Paguristes*
Observations on egg size and number of larval stages before a glaucothoe, among the species studied in the present work, certain relationship at a definite carapace length range is revealed. Among the adults, *Paguristes incomitatus* with largest egg diameter (0.74 x 0.78 mm) with rich yolk content, have only 2 zoeal stages before a glaucothoe and the metamorphosis takes only 48 hours. *Diogenes diogenes*, *D. planimanus* and *Troglopagurus manaarensis* with egg size range from 0.53 x 0.64 mm (Table V) have 3 zoeal stages; *D. violaceus*, wherein only 3 zoeal stages are studied, also falls under the same range with egg size of 0.50 x 0.54 mm. *Clibanarius aquabilis* var. *merguiensis* with smallest eggs (0.34 x 0.42 mm) have 4 zoeal stages. Thus, the egg size appears to have direct bearing on the larval development.
### TABLE V

<table>
<thead>
<tr>
<th>Species</th>
<th>Egg size</th>
<th>No. of larval stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paguristes incomitatus</td>
<td>0.74 x 0.78 mm</td>
<td>2 zoeal + glau.</td>
</tr>
<tr>
<td>Diogenes diogenes</td>
<td>0.54 x 0.62 mm</td>
<td>3 zoeal + glau.</td>
</tr>
<tr>
<td>D. planimenus</td>
<td>0.53 x 0.64 mm</td>
<td>3 zoeal + glau.</td>
</tr>
<tr>
<td>D. violaceus</td>
<td>0.50 x 0.58 mm</td>
<td>3 zoeal + glau.</td>
</tr>
<tr>
<td>Troglopagurus</td>
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<td></td>
</tr>
<tr>
<td>manoarenensis</td>
<td>0.53 x 0.58 mm</td>
<td>3 zoeal + glau.</td>
</tr>
<tr>
<td>Clibanarius aequabilis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>var. merguiensis</td>
<td>0.34 x 0.42 mm</td>
<td>4 zoeal + glau.</td>
</tr>
</tbody>
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