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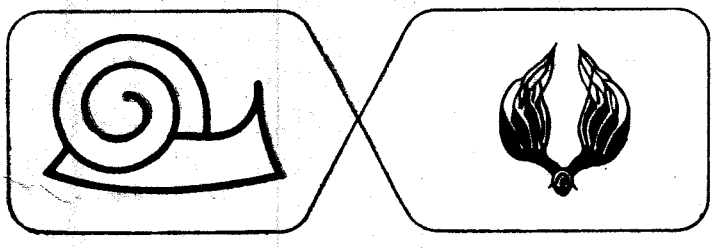

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Larval Development of the Hermit Crab, *Troglopagurus manaarensis* Henderson (Decapoda, Anomura, Diogenidae) observed in the Laboratory

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INTRODUCTION

The genus *Troglopagurus* consists of only four species (Gordon, 1956) viz., *T. manaarensis* Henderson, 1893, *T. jousseaumii* Bouvier, 1897, *T. jubatus* Nobili, 1903 and *T. persicus* Nobili, 1905. Of these, *T. manaarensis* Henderson, is the only species recorded so far from the intertidal zone from Karwar waters (Nayak, unpublished).

Though the larvae of many species of hermit crabs are known from plankton (Gurney, 1927, Menon, 1937, Lebour, 1942) and laboratory hatchings (Hart, 1937, Kurata, 1968, Shenoy, 1967, Shenoy & Sankolli, 1975, 1976, 1977, Nayak & Kakati, 1977, 1978), so far no information is available on the larvae of the genus *Troglopagurus*. As far as the authors are aware, this is the first account of the larvae in the genus. The paper describes the complete metamorphosis of *Troglopagurus manaarensis* Henderson, reared in the laboratory.

MATERIAL AND METHODS

A berried female was collected on December 2, 1975, from the intertidal rocky shore at Binga, about 8 km. from the Department of Marine Biology, Karwar, along the West Coast of India, and was kept alive in an aquarium with filtered sea water with a few stones encrusted by algae so as to simulate the natural habitat. A few eggs were removed carefully with the help of a brush to study the egg size. The larvae hatched out on the morning of December 5, 1975. Most of the larvae hatched as prezoea, which immediately moulted to zoea, and some directly as first zoea. A few larvae were reared individually and the rest in groups of 5 in bowls of approximately 150 ml capacity. The rearing technique used was the same as described by Shenoy (1967). Freshly hatched *Artemia* nauplii were readily accepted as food by the larvae.

During the course of the experiment, sea water temperature ranged from 26 to 28° C and the salinity was about 34 ppt.

Eggs are fairly large, rounded or slightly oval; diameter being 0.52 - 0.55 x 0.57 - 0.59 mm.

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The larvae pass through 3 zoeal stages before the glaucothoe, which readily entered the tiny gastropod shells provided in the rearing container. None moulted to crab instar. The entire metamorphosis lasted for about 22 - 23 days. The intermoult period between the first and second and second and third zoea is about 8 - 9 days and between 3rd and glaucothoe is about 6 days.

RESULTS

DESCRIPTION OF LARVAL STAGES

FIRST ZOEA (Fig. 1)

Carapace length : 0. 8 *mm* *Abdomen length* : 1. 0 *mm*

Larvae fairly big; eyes sessile, comparatively small; rostrum pointed and smooth reaching upto tip of spine on scale; carapace smooth and postero-lateral margin rounded: 1st and 2nd maxillipeds bear 4 natatory setae on exopod; third maxilliped rudimentary; pereiopods appear as 4 pairs of rudimentary buds; abdomen 5-segmented, all segments smooth; telson process formula 7+7.

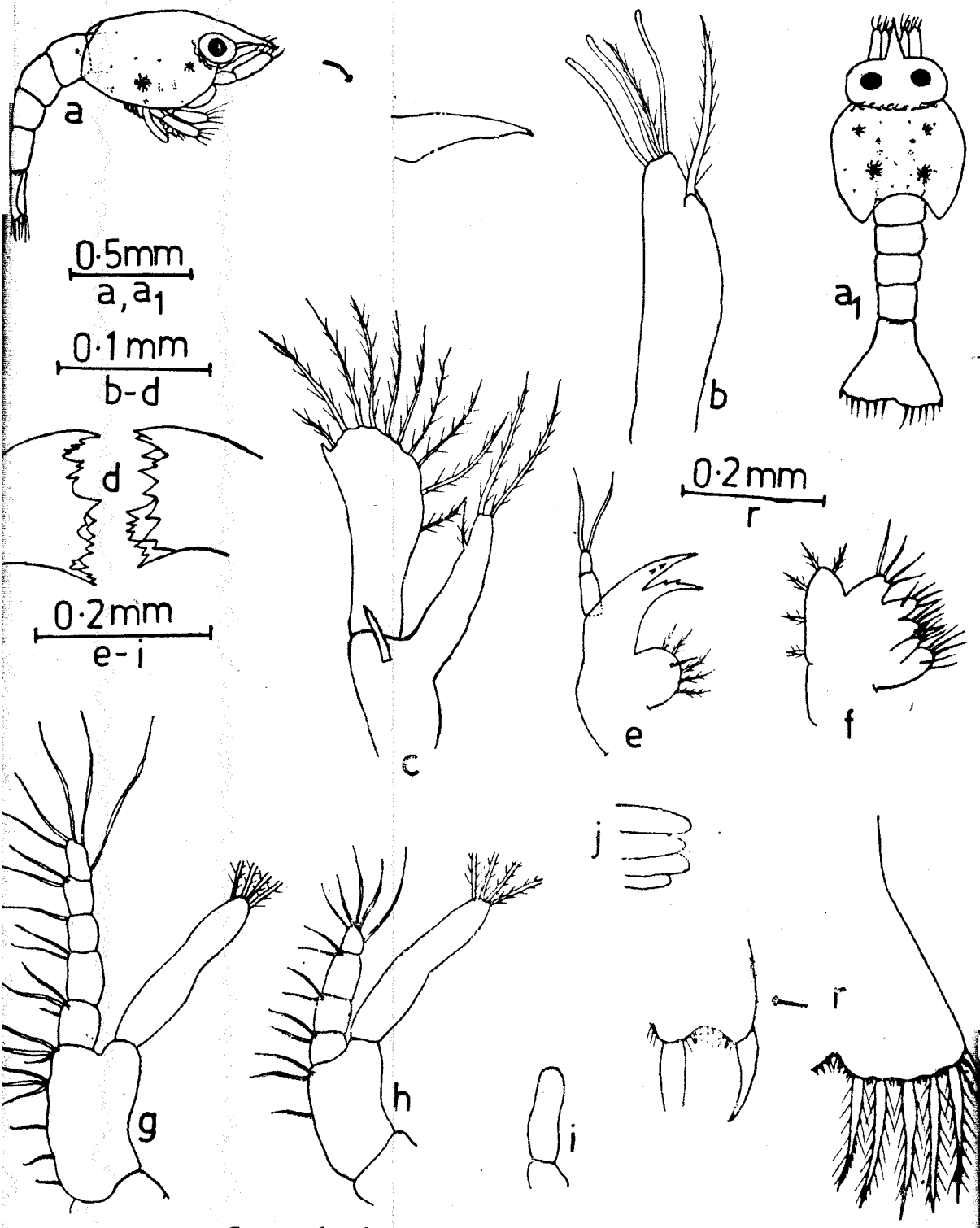
Antennule (fig. 1, b) uniramous, with 3 terminal aesthetascs and a plumose seta, subterminally it bears a long plumose seta on a rudimentary palp representing future endopod. *Antenna* (fig. 1, c): Scale elongated, with a small outer spine and 10 marginal, plumose setae, the first and the last being smaller; endopod nearly 2/3 scale with 2 terminal subequal setae and a smaller subterminal seta; basis with long spine serrated on one side. *Mandibles* (fig. 1, d): unequal with sharp, pointed spines over cutting edge. *First maxilla* (fig. 1, e): coxal endite with 5 plumose setae and a simple seta; basal with 2 serrated teeth; 2-segmented palp with 2 terminal setae. *Second maxilla* (fig. 1, f): Bilobed coxal and basal endites with 5+4 and 4+4 setae respectively; endopod with a notch distally and 4 setae scaphognathite bears 5 plumose marginal setae. *First maxilliped* (fig. 1, g): Basis with 8-9 setae as illustated; exopod unsegmented terminating in 4 long plumose swimming setae; endopod 5-segmented 3, 2, 1, 2 and 4+1 (outer) setae. *Second maxilliped* (fig. 1, h): Basis with 3 setae; exopod as in 1st maxilliped; 4-segemented endopod with 2, 2, 2 and 4+1 (outer) setae distalwards. *Third maxilliped* (fig. 1, i): uniramous bud. *Pereiopods* (fig. 1, j): appear as 4 pairs of tiny buds, 4th being the smallest. *Abdomen* (fig. 1, a & a_1): 5-segmented; 1st to 4th broader than long while the 5th longer than broad: all segments smooth. *Telson* (fig. 1, r): triangular posterior margin convex and with spinules and hairs all along margin including median notch; telson and the fused 6th abdominal segment together slightly longer than broad; process formula 7+7; 1st an articulated, incurved spine, 1/3 length of 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.

Blood red chromatophores present on base of antennule, mandible, and maxillipeds, a ganglionated yellowish or yellowish orange chromatophore at base of maxilla; scattered red dot-like chromatophores over carapace and a light yellow patch at base of 5th abdominal segment.

SECOND ZOEA (Fig. 2)

Carapace length : 1. 0 *mm* *Abdomen length* : 1. 15 *mm*

Eyes stalked; rostrum reaching beyond antennule and antenna; exopod of 1st and 2nd maxillipeds with 6 natatory setae, 3rd maxilliped functional with 5 setae on exopod; pereiopod buds 5 pairs; telson process formula 8+8.



Carapace length : 0.8 *mm* *Abdomen length* : 1.0 *mm.*

Fig. 1. *Troglopagurus manaarensis* Henderson, First Zoea.
a, entire larva, lateral view; a1, entire larva, dorsal view; b. antennule; c, antenna; d,mandibles; e, first maxilla; f, second maxilla; g, first maxilliped; h, second maxilliped; i, third maxilliped; j, pereiopods; r, telson.

Antennule (fig. 2, b) still uniramous, with 4 aesthetascs and 3 unequal setae terminally, of which one is long and plumose; an additional seta subterminally opposite the long plumose seta. *Antenna* (fig. 2, c) as in 1st zoea. *Mandibles* (fig. 2, d) more enlarged with addition of spines on cutting edge. *First maxilla* (fig. 2, e) : Basal endite now with 4 serrated teeth. *Second maxilla* (fig. 2, f): Proximal lobe of coxal and basal endites with 2 and 1 additional setae respectively; scaphognathite with 7 marginal setae. *First maxilliped* (fig. 2, g): exopod 2-segmented, terminating in 6 natatory setae; endopod with an additional long plumose seta on outer distal margin of 1st to 3rd segments. *Second maxilliped* (fig. 2, h): Exopod as in 1st maxilliped; endopod with addition of a plumose seta on outer distal angle of 2nd segment and outer middle of 3rd segment. *Third maxilliped* (fig. 2, i): Biramous; 2-segmented exopod with 5 long natatory setae; endopod rudimentary. *Pereiopods* (fig. 2, j) : All 5 pairs present as elongated buds, 5th being the smallest. *Telson* (fig. 2, r): Addition of a pair of plumose setae near median notch, thus reducing the cleft of the notch and convexity of the posterior margin of telson; all processes being plumose; 8th nearly half the length of 5th process.

THIRD ZOEA (Fig. 3)

Carapace length : 1. 25 *mm* *Abdomen length* : 1. 25 *mm*

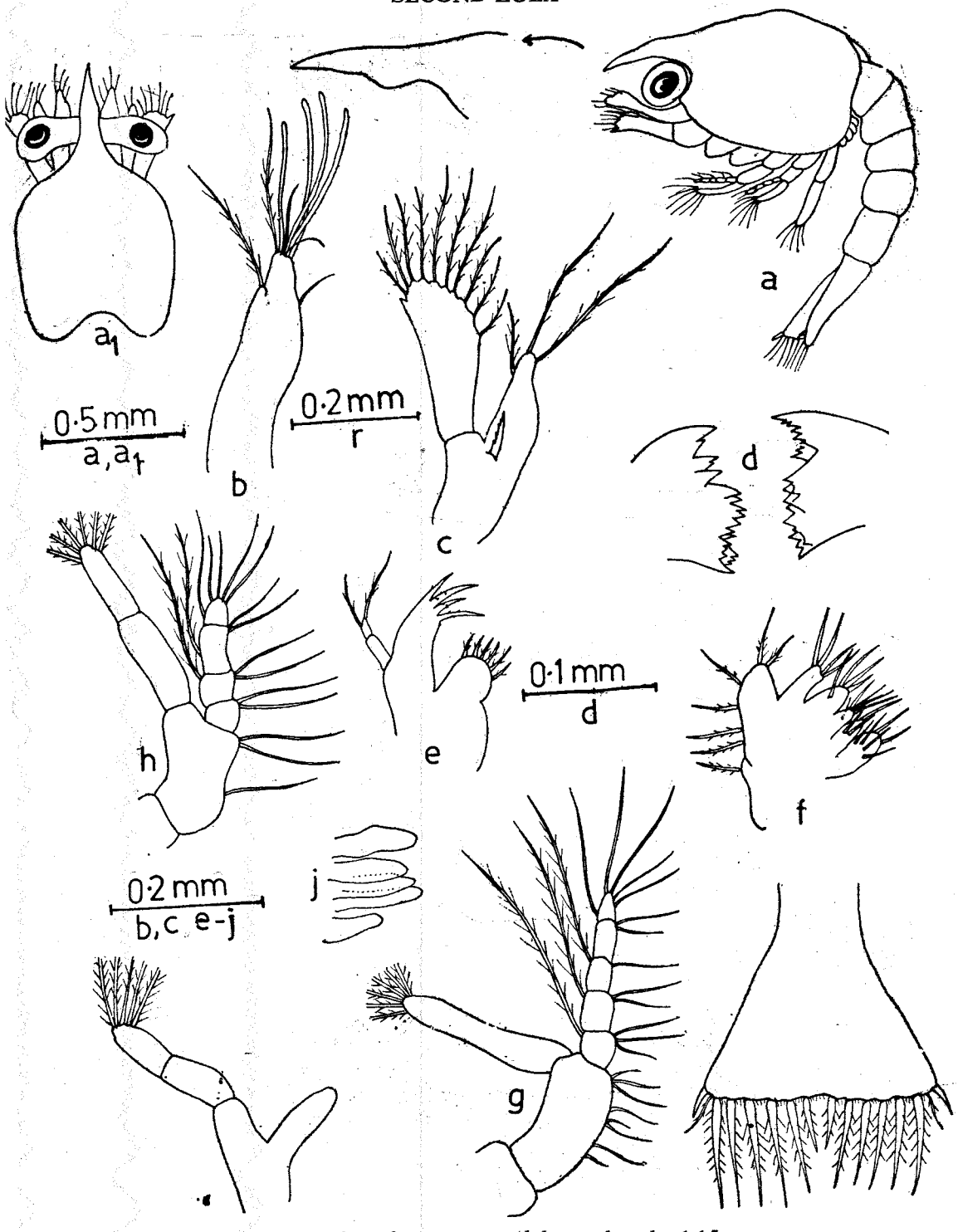
Antennule and antenna reach well beyond the rostrum; antennule biramous; mandible with a rudimentary palp; exopod of all three maxillipeds with 6 natatory setae; pereiopod buds more elongated and show segmentation; abdomen 6-segmented; 3 pairs of pleopod buds appear; uropods functional; telson process formula 7+7.

Antennule (fig. 3, b): Both inner and outer ramii separated from peduncle; outer ramus with 4 aesthetascs and 3 unequal setae; inner with a terminal plumose seta; peduncle bears 3 long plumose setae and 3 hair-like setae distally. *Antenna* (fig. 3, c): Scale with 11 marginal setae in addition to a small spine; endopod elongated considerably, reaches well beyond scale, 5-segmented; segmentation fainter distally and with one short and 3 long setae terminally and 2 long setae at base of 4th segment distalwards; basis with another smaller spine on outer distal angle. *Mandibles* (fig. 3, d): Palp bud developed. *First maxilla* (fig. 3, e): Coxal endite with 7 setae; basal with 5 long serrated teeth and a small seta; endopod remains unchanged. *Second maxilla* (fig. 3, f) : Posterior lobe of scaphognathite developed but without any setae; distal lobe with 8 plumose marginal setae. *First and Second maxillipeds* (fig. 3, g & h): unchanged. *Third maxilliped* (fig. 3, i): Exopod with 6 natatory setae; endopod segmented but devoid of setae. *Pereiopods* (fig. 3, j, k & n): All 5 pairs well developed and show segmentation, 1st chelate and 5th subchelate. *Abdomen* (fig. 3, a) now 6-segmented; 6th separated from telson; 3 pairs of pleopod buds present on segments 2 - 4; pleopod buds show small spinules at the tip (fig. 3, q). *Uropods* (fig. 3, r) biramous and articulated at base to protopod; exopod long, terminating in a pointed distolateral spine and 6 long plumose setae, the tip of spine reaching up to posterior margin of telson; endopod oval and bud-like, without setae. *Telson* (fig. 3, r): Posterior margin straight; process formula reduced to 7+7, 4th process disappears leaving space between the 3rd and 5th processes (in some a tubercle could be seen), processes 3 to 8 each with their tips spinuous; 5th process remains the longest.

GLAUCOTHOE (Figs. 4 & 5)

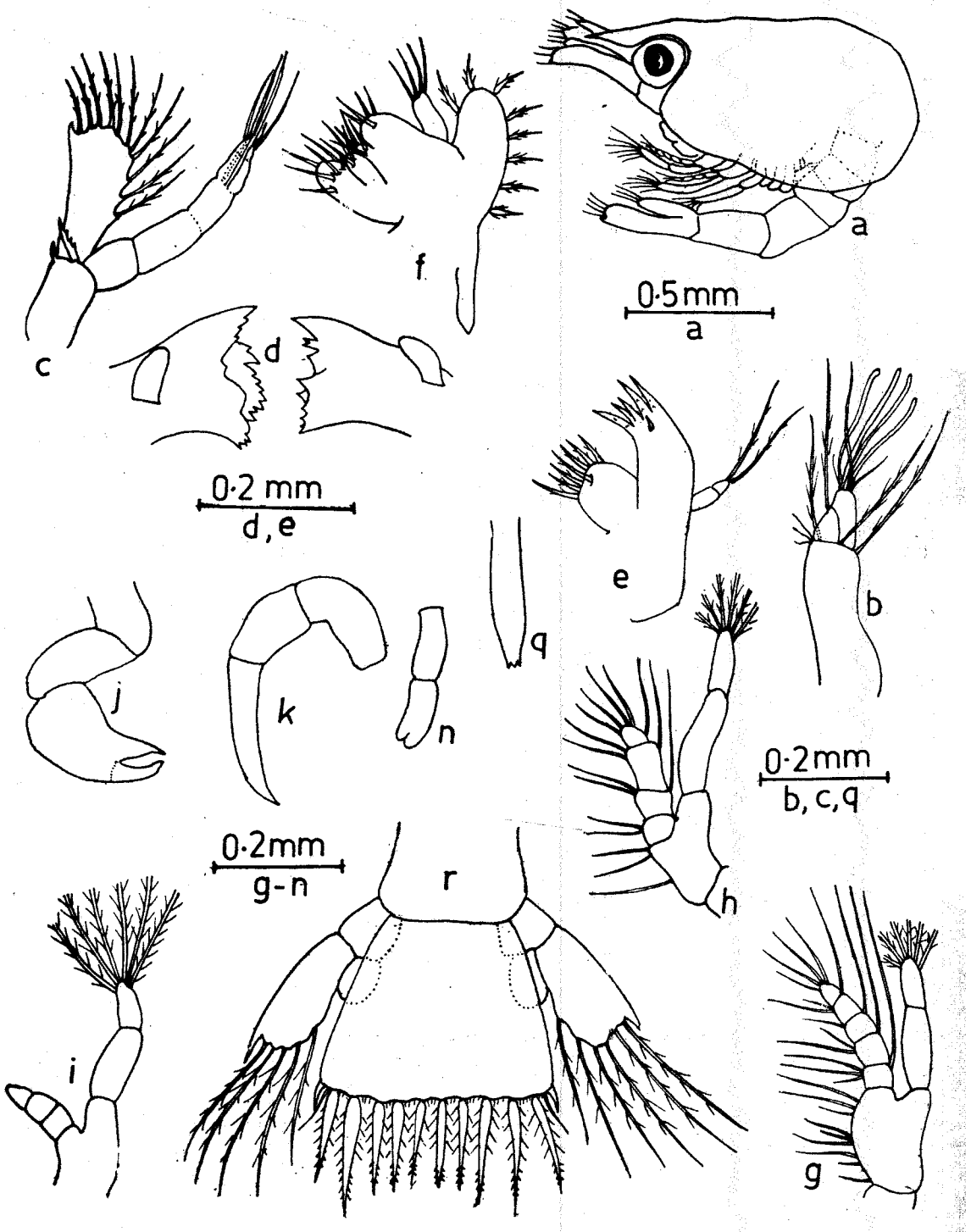
Carapace length : 0. 8 *mm* *Abdomen length* : 0. 9 *mm*

The glaucothoe resembles adult. They swim for about one hour and settle to the bottom of rearing bowl. Glaucothoe entered tiny shells provided in the rearing container almost immediately after settling. None of them moulted to crab.



Carapace length : 1.0 *mm* *Abdomen length* : 1.15 *mm*

Fig. 2. *Troglopagurus manaarensis* Henderson, Second zoea.
a, entire larva, lateral view; a1, carapace, b, antennule; c, antenna; d, mandible; e, first maxilla; f, second maxilla; g, first maxilliped; h, second maxilliped; i, third maxilliped; j, pereiopods; r, telson.

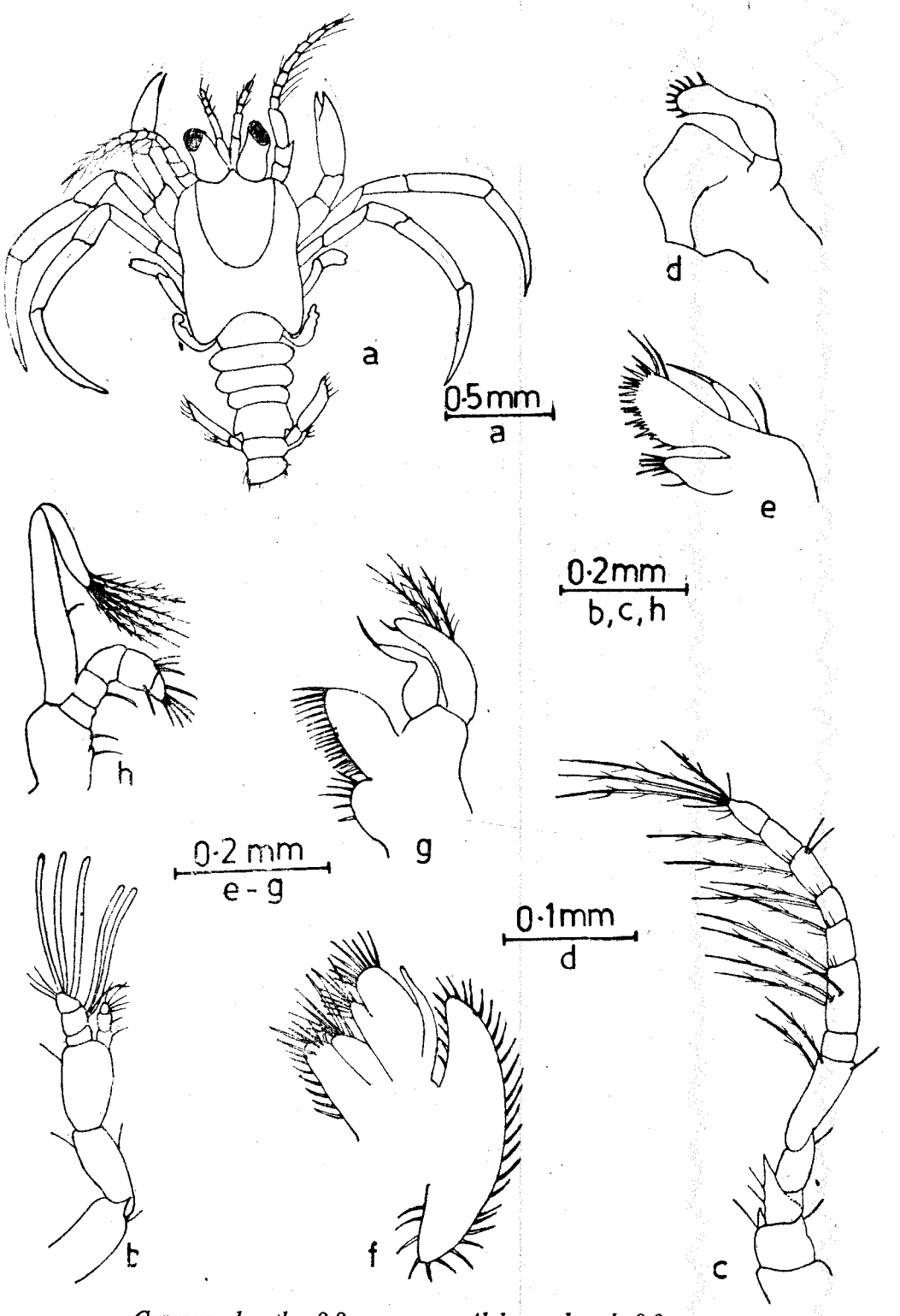


Carapace length: 1.25 mm *Abdomen length* : 1.25 mm

Fig. 3. *Troglopagurus manaarensis* Henderson, Third zoea.
a, entire larva, lateral view; b, antennule; c, antenna; d, mandibles; e, first maxilla; f, Second maxilla; g, first maxilliped; h, second maxilliped; i, third maxilliped; j, first pereiopod; k, second pereiopod; n, third pereiopod; q, pleopod; r, telson and uropod.

Carapace (fig. 4, a) shorter than abdomen in length; anterior shield clearly demarcated; rostrum blunt, projecting slightly beyond the front; antero-lateral margin smooth; ocular scales absent; eye-stalks stout, twice as long as broad, reaching upto tip of antennular peduncle; chelipeds subequal or slightly unequal; 3 pairs of pleopods, 3rd being bud-like.

Antennule (fig. 4, 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 distalwards; outer flagellum also 3 segmented, second longest with 2 aesthetascs and a simple seta on distal margin; distal segment with 3 aesthetases and 3 simple setae distally. *Antenna* (fig. 4, c): Peduncle 5-segmented, 2nd with a tooth-like spine, scale covering the 3rd segmente, triangular, with spinuous tip and with few setae; flagellum of 7 segments with few long plumose setae and many small hair-like setae as illustrated. *Mandibles* (fig. 4, 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. 4, e): Coxal endite with 6-7 setae, basal with 16-18 short, conical teeth and 2 moderately long setae and a single seta at base below commencement of palp; palp unsegmented, with a prominent seta distally. *Second maxilla* (fig. 4, f): Scaphognathite well developed, fringed with about 35 plumose setae all along margin; endopod elongated, finger-like, without setae; basal and coxal endites bilobed and fringed with setae as illustrated. *First maxilliped* (fig. 4, g): Flat, leaf-like, exopod lacks flagallated portion; with 3 long marginal plumose setae and a small seta distally; endopod unsegmented with a seta terminally; bilobed protopod with 18-20 and 6-8 setae respectively on distal and proximal lobes. *Second maxilliped* (fig. 4, h): Exopod 2-segmented, incurved with 6 long plumose setae terminally on distal segment; proximal with a median seta; endopod 5-segmented with setation as illustrated. *Third maxilliped* (fig. 5, i), well developed exopod as in 2nd maxilliped; endopod long, 5-segmented, densely setose; spines of adult absent. *Pereiopods* (fig. 5, j-n): First pair chelate and stouter than remaining legs; 2nd and 3rd similar; 4th subchelate and 5th faintly chelate, like those of adult. *First pair of pereiopods-chelipeds* (fig. 5, j): Almost equal or subequal; ischium nearly as long as broad; merus longest, nearly as long as propodus; carpus 1/2 length of propodus; propodus longer than broad; fingers when closed leave a gap in the centre; all segments bear sharp, curved spines and scattered setae. *Second and third pereiopods* (fig. 5, k & l), similar and armed with setae and spines as illustrated. Ischium small, less than 1/2 merus; merus as long as propodus, and without spines; carpus 1/2 propodus with 2 spines; dactylus longest, terminating in a short, incurved acutely pointed claw. *Fourth pereiopod* (fig. 5, m), sub chelate; merus longest, 3 times the ischium and 1½ times as long as 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 pereiopod* (fig. 5, n) shows faintly 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. 4, a): 3 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. 5, o & p), 3rd bud-like (fig. 5, q), *Uropods* (fig. 5, r): Typically like those in adult, biramous; inner ramus small, oval, with a row of corneous granules and setae;



Carapace length : 0.8 *mm.* *Abdomen length*: 0.9 *mm.*

Fig. 4. *Troglopagurus manaarensis* Henderson, Glaucothoe.
a, entire larva, dorsal view; b, antennule; c, antenna; d, mandible; e, first maxilla; f. second maxilla; g, first maxilliped; h, second maxilliped.

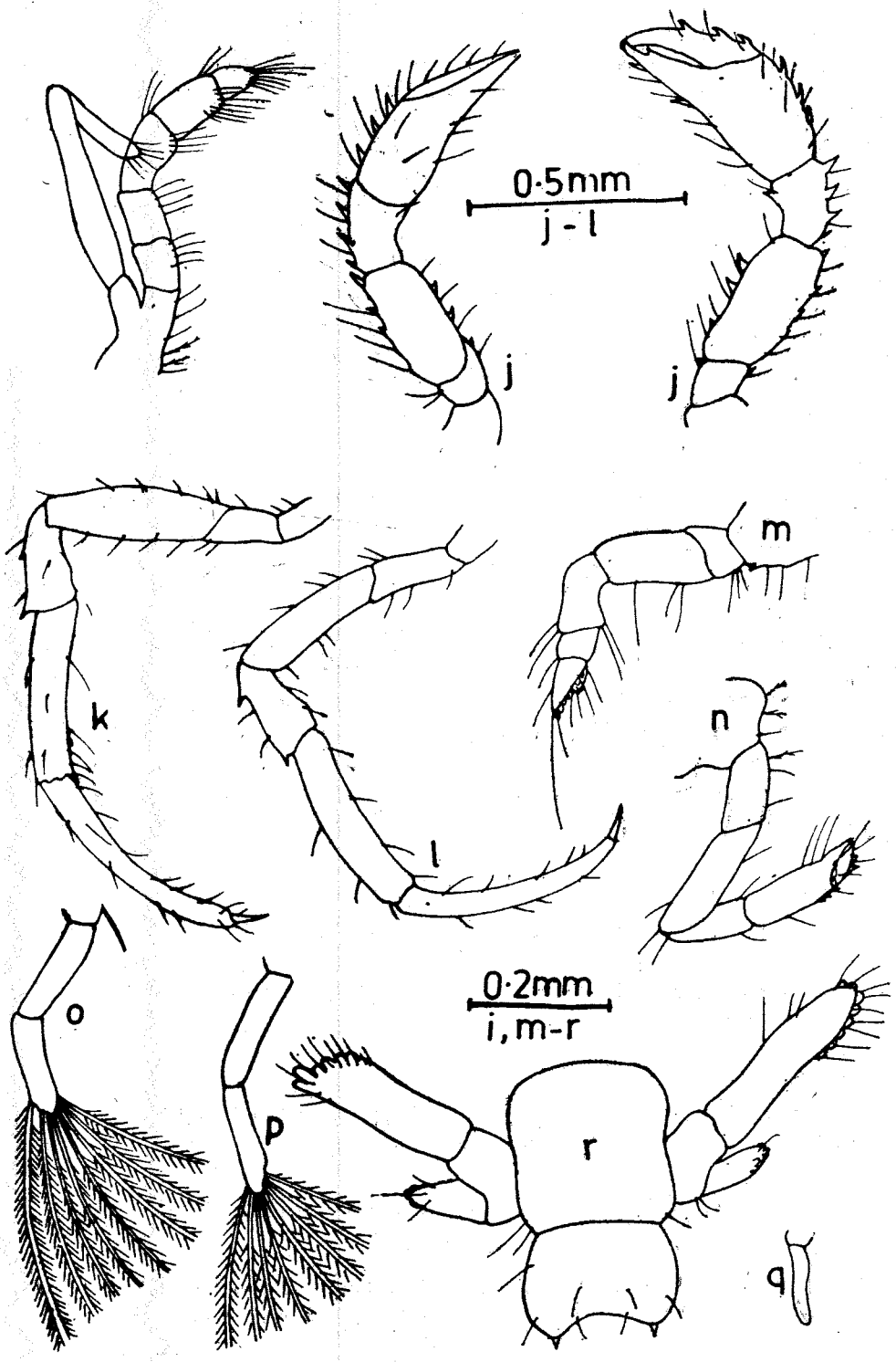


Fig. 5. *Troglopagurus manaarensis* Henderson, Glaucothoe.
i, third maxilliped; j, chelipeds; k, second pereiopod; l, third pereiopod; m, fourth pereiopod; n, fifth pereiopod; o, first pleopod; p, second pleopod; q, third pleopod; r, telson and uropods.

outer ramus long, more than twice as long as inner, with a row of corneous, blunt teeth, and 11-14 setae *Telson* (fig 5, r): As in adult, concave posteriorly, broader than long, with 2 tooth-like spines laterally and setae as illustrated.

DISCUSSION

Karwar, on the west coast of India, has six genera of hermit crabs, viz., *Paguristes*, *Clibanarius*, *Dardanus*, *Diogenes*, *Troglopagurus* and *Pagurus* (Nayak, unpublished). Descript ions of laboratory reared larvae are available for ten species representing all the six genera as listed in Table I.

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 process of telson; 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 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* on the basis of the following characters: rostrum long and beak-like; first process of telson finger-like, antennal scale without a terminal spine. From the genus *Diogenes*, the larvae of present genus differ 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 *Paguristes* in having a smooth abdomen, first spines 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 *Troglopagurus* differ from those of *Pagurus* in the following: carapace smooth; abdomen without any spines; antennal scale with a short spine in the former, whereas in the latter genus, 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 importance.

KEY TO THE IDENTIFICATION OF HERMIT CRAB LARVAE FROM KARWAR WATERS

To facilitate the quick identification of larvae of hermit crabs upto geuns level from the local plankton, following key may be formulated.

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

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

TABLE–I

Name of species	No. of stages				Year	Authors
1. *Pagurus kulkarnii* Sankolli	3	Zoeal	+	Glaucothoe	1967	Shenoy
2. *Clibanarius padavensis* de Man	4	,,	+	,,	1975	Shenoy & Sonkolli
3. *Diogenes avarus* Heller	3	,,	+	,,	1975	,, ,,
4. *Clibanarius arethusa* de Man	4	,,	+	,,	1976	,, ,, (abstract only)
5. *Clibanarius infraspinatus* Hilgendorf	4	,,	+	,,	1977	Shenoy & Sankolli
6. *Diogenes diogenes* (Herbst)	3	,,	+	,,	1977	Nayak & Kakati
7. *Dardanus setifer* (H. Milne Edwards)	1	Zoea			1978	,, ,,
8. *Paguristes incomitatus* (Alcock)	2	Zoeal	+	,,	1980	,, ,, (abstract only)
9. *Clibanarius acquabilis* var *merguiensis* de Man	4	,,	+	,,	1980	Nayak (in press)
10. *Troglopagurus manaarensis* Henderson	3	,,	+	,,	(present)	

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

   Rostrum pointed and not broad at the base, reaching upto 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*

   Abdomen armed (5th abdominal somite with a pair of spines on its postero-lateral angle); telson with a longitudinal ridge; 1st telson process long, unarticulated spine; rostrum with dorsal carina ... ... *Dardanus*

4. Abdominal somites smooth; ... ... *Troglopagurus*

   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*

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