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Levicaris mammillata (EDMONDSON), a Gnathophyllid Shrimp Associated with Slate-pencil Sea Urchin, *Heterocentrotus mammillatus* (LINNAEUS), from the Ogasawara and Ryukyu Islands

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In the rocky shores of the Ogasawara Islands, the typical form of the slate-pencil sea urchin, *Heterocentrotus mammillatus* (LINNAEUS) [Jap. name: Paipu-uni], is rather rare, but a related form with more slender spines named "Mitsukado-paipu-uni" in Japanese is surprisingly abundant. This sea urchin with beautiful color has been recorded as *H. trigonarius* (LAMARCK), but the validity of a specific distinction between these two forms has been doubted for a long time. Thus, in 1974, Messrs. H. OKADA and Y. KURATA did extensive work on this problem. On a close examination of a long series of specimens, in consultation with Dr. M. SHIGEI, they concluded that the so-called Ogasawara form is distinct from the true *H. trigonarius* and represents an extreme variation of *H. mammillatus*.

In the course of their taxonomic study on *H. mammillatus* they found by chance a curious shrimp clinging on to a large primary spine of a sea urchin preserved in formalin. It was very difficult to find shrimps with a similar color pattern to the sea urchins, but some additional individuals were found in the field. The shrimps and sea urchins were then kept in the glass tank at the Ogasawara Fisheries Center for observation of their behavior and relationship. Two of those specimens were sent us for identification.

When in the spring of 1976 the junior author visited the Marine Park Research Station at Kuroshima Island in the Yaeyama Group, Ryukyu Islands, he also examined a specimen preserved in spirit which was obtained from the typical form of *H. mammillatus*. In addition, Dr. Y. MIYA kindly sent us a pair of other specimens collected at the same locality.

These shrimps with depressed form were identified with *Levicaris mammillata* (EDMONDSON) through the kind help of Dr. A. J. BRUCE. This species which was described from Hawaii by EDMONDSON (1931) was tentatively referred to *Coralliocaris*

STIMPSON in the Pontoniinae of the family Palaemonidae. HOLTHUIS (1952) suggested that it might be transferred to *Gnathophylloides* SCHMITT in the family Gnathophyllidae, and thus CASTRO (1971) listed it as *G. mammillatus*. In 1973, however, BRUCE erected a new genus to accommodate this species living in commensal association with the slate-pencil sea urchin. Up to the present it has been found only in Hawaii, so that its occurrence in Japanese waters is remarkable to warrant its recording.

The authors' cordial thanks are due to Mr. Hideyuki OKADA of Tokai University, Mr. Yôji KURATA of the Ogasawara Fisheries Center, Dr. Michio SHIGEI of the Misaki Marine Biological Station, Mr. Kazushi OKAMOTO and Mr. Teruo FUKUDA of the Marine Park Research Station at Kuroshima, Dr. Yasuhiko MIYA of Nagasaki University, and Dr. Alexander J. BRUCE of the Heron Island Research Station, Queensland.

Family Gnathophyllidae

Genus ***Levicaris*** BRUCE, 1973

Levicaris mammillata (EDMONDSON, 1931)

(Figs. 1–5)

Coralliocaris mammillatus EDMONDSON, 1931, p. 5, fig. 2, pl. 1.
Gnathophylloides mammillatus: CASTRO, 1971, p. 398.
Levicaris mammillata: BRUCE, 1973, p. 30, figs. 8, 9.

Description. A small shrimp of depressed form with robust symmetrical second pereiopods.

Rostrum depressed with a distinct carina below, almost reaching beyond distal margin of second antennular peduncle; in dorsal view, rostrum broad near its base, narrowing anteriorly to pointed tip; four small and subequal spines present on its dorsal surface; first spine anterior to level of base of eye, and distal one located a certain distance behind tip; posterolateral border of rostrum continuous with triangular inferior orbital angle.

Carapace depressed and smooth, without antennal, hepatic and supraorbital spines; inferior orbital angle produced into a distinct triangular projection; anterolateral angle nearly quadrate.

Pleura of first three abdominal somites very broad; in fourth and fifth somites, each pleuron somewhat extending posteroventrally into a blunt process; sixth somite short and subequal to the fifth in length, with posteroventral angle produced triangularly.

Telson about twice as long as sixth abdominal somite, and two and a half times its maximum breadth; its lateral margin feebly convex; two pairs of small dorsal spines close to lateral margins; anterior pair located a little posterior to the middle of telson, and posterior pair close to posterior margin of telson; three pairs of small spines at posterior margin.

Eyes unusual in shape; peduncle somewhat curved inward and pointed anteriorly, with basal thickness, reaching level of distal end of first antennular peduncle; cornea

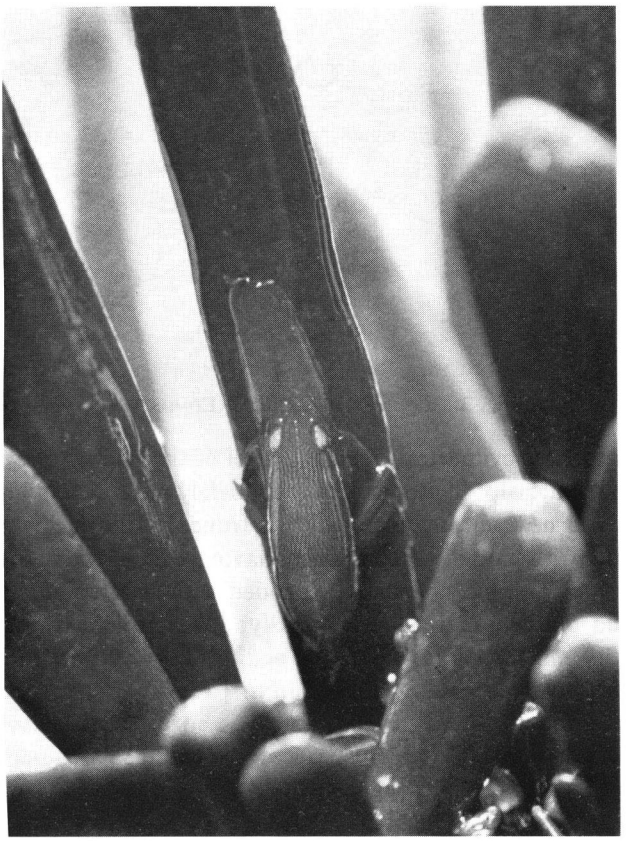

Fig. 1. *Levicaris mammillata* (EDMONDSON) clinging on to a primary spine of *Heterocentrotus mammillatus* (LINNAEUS).

situated laterally on peduncle.

Antennular peduncle extending somewhat beyond tip of rostrum; basal segment bears a small and narrow stylocerite with tip broadly angled which reaches the middle of same segment; lateral border slightly convex and anterior end markedly raised, anterolateral corner forming a triangular process with a small point which extends to end of second segment; second segment as long as broad, with an anterolateral lobular process distally rounded; third segment short and broad; outer flagellum biramous with five proximal fused segments; shorter free ramus consists of five segments; inner flagellum short and slightly longer than the outer, consisting of nine joints, basal one of which is the longest.

Antennal scale far exceeds end of antennular peduncle, being about two and a half times as long as maximum breadth which is at about middle; outer lateral margin of lamella gently convex with a distinct triangular tooth; lamella terminates anteriorly in a blunt angle which far exceeds anterolateral tooth; basicerite stout with a strong

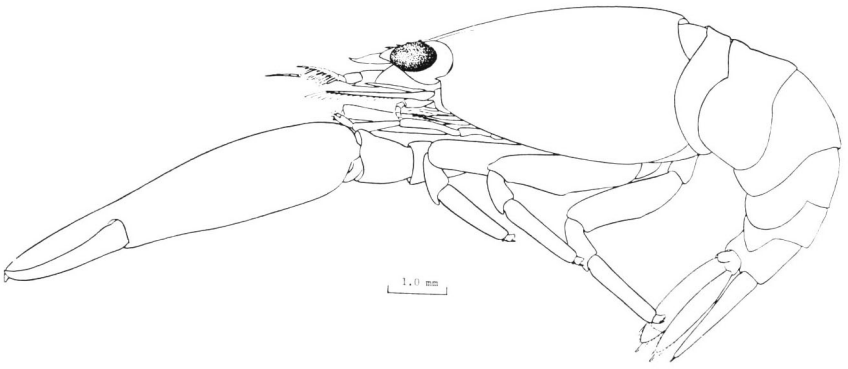

Fig. 2. *Levicaris mammillata* (EDMONDSON).

outer tooth; carpocerite cylindrical, reaching level of the middle of eye.

Mandible without palp; incisor process completely reduced and lost; molar process somewhat narrowed near cutting edge which is truncate and thickly covered with fine spines. Maxillula with palp of reduced form, having a slight notch distally and a small terminal spine; upper lacinia unusually expanded with long spinules and setae on its inner border, and outer border convex broadly; lower lacinia short and armed with long setae near its end. Maxilla devoid of endite; palp well developed and smooth, with tip narrowed; scaphognathite broad. In first maxilliped, exopod developed with a normal caridean lobe; palp large and elongate; coxal endite developed, exceeding caridean lobe; bilobed epipod present. Second maxilliped extremely large and expanded, exceeding first antennular segment by length of dactylus, propodus and carpus combined, being much longer than first pereiopods; dactylus short and broad, with a row of thick bristles along distal border; these bristles curved distally and lacking in hairs or plumose setae; propodus elongate, narrowed proximally and slightly convex in outer border, while concave in the inner, these borders having no setae nor spines; breadth of propodus at its distal end produced into a triangular process; merus also slender and distinctly longer than carpus, with a slight basal expansion; a well developed exopod and a simple epipod present, but no podobranch. Third maxilliped comparatively short, not reaching end of merus of first pereiopod; ultimate segment very narrow, about seven times as long as broad, with several short setae inside; penultimate segment short, broader than the distals, being broadened basally and more than two and a half times the length of distal two segments combined; maximum breadth at basal portion about four times the breadth at distal end of this segment; exopod developed, extending to end of antepenultimate segment; an epipod present, but no arthrobranch.

First pereiopod overreaches end of antennal scale by the length of chela; fingers, which are slightly shorter than palmar portion, have smooth cutting edges; tufts of long hairs near tips crooked and pointed; carpus cylindrical, about one and a half the length of chela; merus somewhat compressed and subequal to carpus in length.

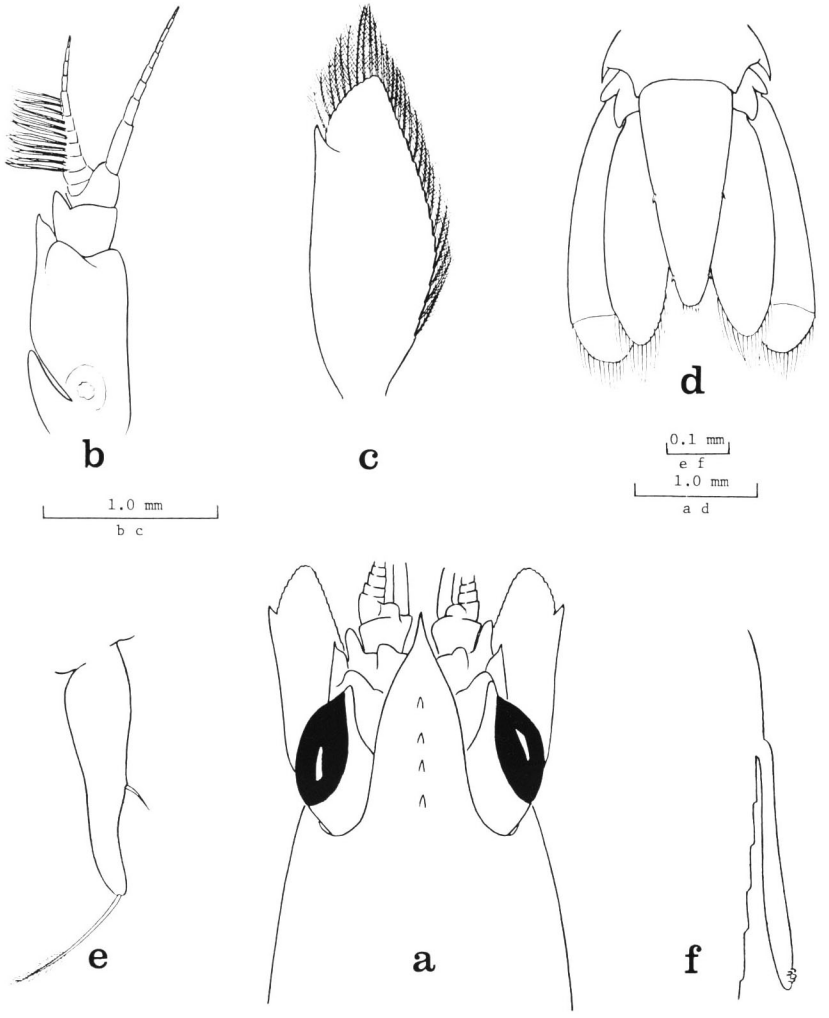

Fig. 3. *Levicaris mammillata* (EDMONDSON); a, anterior part of carapace and appendages in dorsal view; b, antennular peduncle; c, antennal scale; d, telson and uropods; e, endopod of first pleopod; f, appendix masculina.

Second pereiopods of both sides equal and robust, exceeding rostrum by the length of whole chelae; fingers about half the length of palm; movable finger curved and bluntly pointed distally, and cutting edge bears a slight convexity near the middle; immovable finger has cutting edge smooth except for a small tubercular projection at distal third and a large triangular process basally; tip of immovable finger curved and crossed with tip of movable finger; palm somewhat depressed and approximately three times longer than broad; carpus short and conical; merus and ischium short, stout

and subequal in length.

Ambulatory pereiopods stout and similar, but slightly more slender posteriorly. Third pereiopod reaches as far as proximal third of palm of second pereiopod; dactylus short and compressed and has peculiar structure, with a strong claw at its top anteriorly, which is articulated near base; posterior end of dactylus forms a strong, curved and distally notched unguis which is directed backward; behind this process a row of five or six stout tubercular spines and on either side of these spines many smaller spines or tubercles present; some tufts of long and short setae on this segment; propodus stout and narrowed distally without any spines and setae, measuring 3.3 times longer than its maximum breadth which lies at its proximal end; carpus short, conical and thicker distally, being about half the length of propodus; merus robust and slightly more than

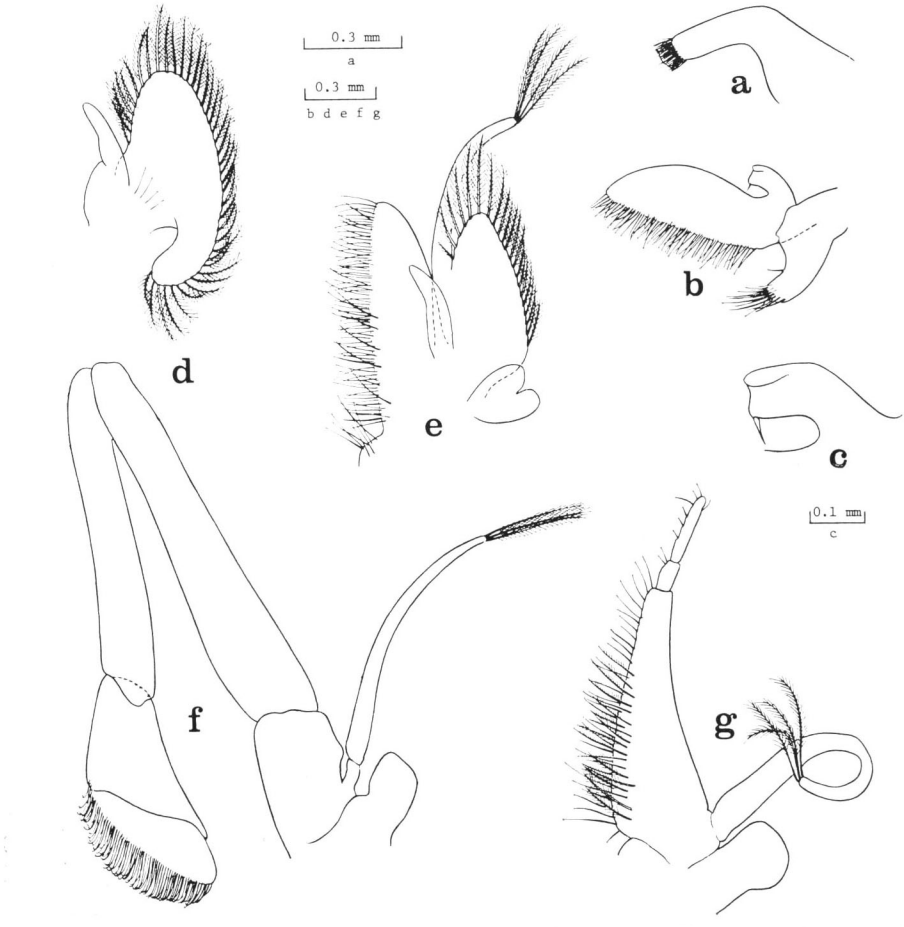

Fig. 4. *Levicaris mammillata* (EDMONDSON); a, mandible; b, maxillula; c, palp of maxillula; d, maxilla; e, first maxilliped; f, second maxilliped; g, third maxilliped.

three times as long as its maximum breadth which is at about middle, and 1.5 times as long as propodus; a low round convexity near the middle of posterior border; ischium about half the length of merus; posterodistal portion distinctly expanded forward; all segments unarmed. In fourth pereiopod merus has a low round projection at about middle on posterior border; posterodistal expansion of ischium less distinct than in third pereiopod. In fifth pereiopod no projection on posterior border of merus, and no posterodistal expansion in ischium.

No median sternal process between first pereiopods of both sides.

Pleopods normal. Endopod of first pleopod in female narrow and slightly narrowed distally, with only a long seta at its top. Appendix interna on second pleopod long and slender.

Uropods normal, exceeding end of telson; lateral terminal end of exopod bears a minute movable spine.

Color. Entirely brick-red or yellowish brown and closely similar to the color of host sea urchin. Eyes bright and brilliant. With enlargement many darker, finely waved longitudinal lines are on the carapace, and minute pigment spots of a similar color are thickly scattered on the chelipeds.

Material at hand. Miyanohama, Chichi-jima I., Ogasawara Is., 1 ♀, 1 sp. (NSMT–Cr. 5488), Aug. 18, 1974, H. OKADA coll. Kuroshima I., Yaeyama Group, Ryukyu Is., 1 ♂, 1 ovig. ♀, Jul. 26–30, 1974, K. OZAWA coll. Carapace length, 3.0–5.3 mm.

Host and shrimps. The only known host of this shrimp is the slate-pencil sea urchin, *Heterocentrotus mammillatus* (LINNAEUS), from Hawaii, even though this sea urchin is widely distributed in the Indo-West Pacific. In the Ogasawara Islands the shrimps were found on the primary spines of the so-called Ogasawara form of this sea urchin, while in the Ryukyu Islands they were collected from the typical form which is very common on the coral reef. In the typical form the primary spines of the anti-oral side are large, club-like and distally more or less triangular in cross section, while those of the oral side are smaller, markedly flattened and distinctly triangular in cross section for their whole length. In the Ogasawara form the primary spines of the anti-oral side are remarkably long and triangular in cross section throughout the length. These sea urchins are protected together with other invertebrates in some reserves, but many individuals are collected outside these areas by the native people for finishing as souvenirs.

CASTRO (1971) mentioned that at least one pair of the shrimps were found among all occupied sea urchins, and also that shorter and stouter individuals have been observed between the flat secondary [*sic*, primary] spines. In either case dealt with here, only a solitary individual was found on a host, and the present knowledge in Japanese waters fails to confirm the fact observed in Hawaii mainly due to the rare occurrence. As for the variation of body form, however, it is mentioned that in an ovigerous female from Kuroshima, which is the largest of the specimens examined, the rostrum length is 1.9 mm and the carapace length is 5.3 mm, and in the smallest specimens, a male from Kuroshima and a female from Chichi-jima, the rostrum and

carapace lengths are 1.5 and 3.0 mm, respectively. The proportionate length of the rostrum and carapace therefore varies considerably.

A shrimp kept with a sea urchin in a glass tank always clung to the underside of the flat spine, so that it could not be seen from above. It stayed toward the base of the spine and was oriented toward the distal end of the spine. Then, the ambulatory

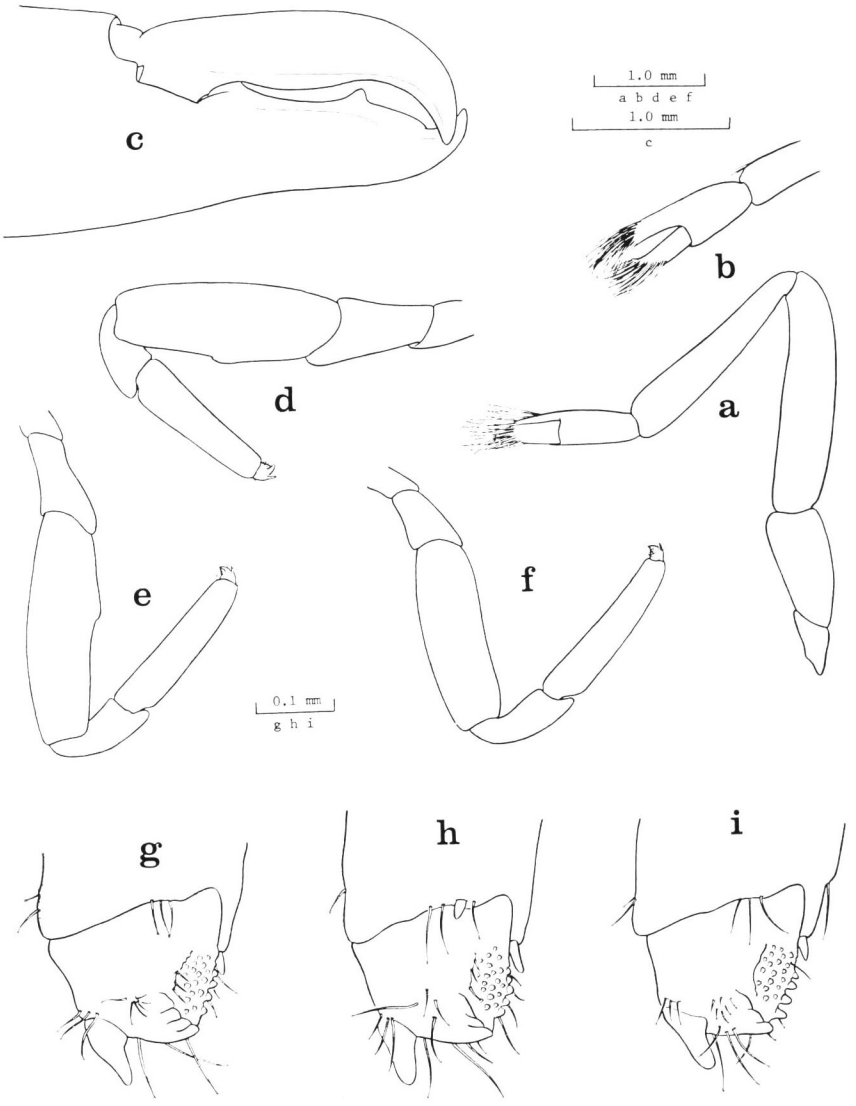

Fig. 5. *Levicaris mammillata* (EDMONDSON); a, first pereioped; b, chela of first pereiopod; c, chela of second pereiopod; d, third pereiopod; e, fourth pereiopod; f, fifth pereiopod; g, dactylus of third pereiopod; h, dactylus of fourth pereiopod; i, dactylus of fifth pereiopod.

pereiopods were used for embracing the spine, and the chelipeds were extended forwards. When disturbed, the shrimp turned to the upperside of the spine, or horizontally and lightly flitted to the other spine. According to the present observation, the shrimp clung to the club-like spine only in such a state of emergency. Considering the body form of the shrimp, its speedy horizontal jump without touching the small secondary spines is really surprising.

Its feeding habits could not be observed in detail, but the excessively elongated pediform second maxilliped and the unusually expanded upper lacinia of the maxillula seem to be useful for manipulating food. The second maxilliped is much longer than the first pereiopods and is turned down at the joint of the carpus and merus. The distal border of the dactylus bears thick setae or bristles. This form of the second maxilliped, as far as the authors are aware, is particularly noticeable among the carideans. As BRUCE (1973) rightly mentioned, fully extended second maxillipeds of both sides face each other at their flattened median aspects. The flexion of the carpomeral joint, therefore, enables the distal segments with short recurved setae to exert a rasping action upon the surface of the spine. It is highly probable that the shrimp acts as a cleaner in relation to the host rather than an ectoparasite feeding upon the tissues of the host. The depressed body with short and robust pereiopods having a peculiar structure of the dactyli appears to be well fitted for clinging on to stout spines of the host sea urchins. The color of the shrimp appears to be also well adapted to the commensal life, making it less easy to discover the shrimp among the spines of the host.

Remarks. The genus *Levicaris* BRUCE based upon *Coralliocaris mammillatus* EDMONDSON has the following remarkable diagnostic features, viz., the depressed body; the broad and depressed rostrum with teeth above and the median carina below; the anteriorly pointed eyepeduncle with the laterally situated cornea; the absence of the incisor process of the mandible; the unusually expanded upper lacinia of maxillula; the absence of endite of maxilla; the excessively elongated second maxilliped with the lengthened carpus; the robust, equal and similar second pereiopods; the robust ambulatory pereiopods with the short and compressed dactylus. This genus is differentiated from *Gnathophylloides* SCHMITT in that the second maxillipeds are greatly enlarged and much longer than the first pereiopods, and that the third maxillipeds are feebly developed, though broadened basally, having a small arthrobranch.

The species of *Gnathophylloides,* viz., *G. mineri* SCHMITT from the Caribbean Sea, Hawaii, the Seychelles and Zanzibar, and *G. robustus* BRUCE from Western Australia, are the commensals living in association with sea urchins. The genus *Pycnocaris* BRUCE erected in 1972 also shows the specialized morphological features, though the host was not identified. The original author inferred that the host might be a sea urchin possessing stout spines, because the shrimp had a "stoutly-built body form." The other genera of this family, viz., *Hymenocera* DANA, *Phyllognathia* BORRADAILE and *Gnathophyllum* LATREILLE are usually free-living and predatory, but may also be ecologically related to echinoderms.

Several alpheid shrimps of *Athanas* LEACH are also found on sea urchins. Ac-

cording to SUZUKI (1970), the species found in Japanese waters are: *A. kominatoensis* KUBO associated with *Anthocidaris crassispina* (A. AGASSIZ) [Murasaki-uni]; *A. indicus* (COUTIÈRE) and *A. acanthocarpus* MIYA et MIYAKE with *Echinometra mathaei* (BLAINVILLE) [Naga-uni]; and *A. dorsalis* (STIMPSON) with *Stomopneustes variolaris* (LAMARCK) [Kuro-uni]. According to JACQUOTTE (1964), *A. indicus* and *A. dorsalis* are common in Madagascar, and the former is associated with *Diadema* sp. and *Anthocidaris crassispina* and the latter with *Echinothrix calamaris* (PALLAS), *Stomopneustes variolaris* and *Heterocentrotus mammillatus,* the last of which was occupied in Hawaiian and Japanese waters by the species dealt with here. In these alpheid shrimps the morphological specialization and the commensal dependence on the hosts are less strong than in gnathophyllid and pontoniid shrimps. As for pontoniid shrimps, altogether eleven species of *Periclimenes* COSTA, *Stegopontonia* NOBILI, *Tulеariocaris* HIPPEAU-JACQUOTTE and *Allopontonia* BRUCE are known to be the commensals of sea urchins as summarized in a table by BRUCE (1974). The color and morphological adaptations to the hosts are really remarkable, and the slender body form in each species is a surprising contrast to the stumpy form in gnathophyllid shrimps.

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