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The Caridea (Decapoda) Collected by the Mid-Pacific Mountains Expedition, 1968¹

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ABSTRACT: Thirty-three species of caridean decapods have been identified from samples taken from the guyots and their vicinity, a little-sampled region of the mid-Pacific Ocean. Considering the oligotrophic character of the environment, a remarkably diverse collection has been collected. For the most part the species are mesopelagic and bathypelagic and have a widespread, if not cosmopolitan, distribution. Nevertheless, for many species these records extend their distribution much farther north and east in the Pacific than was previously known. The few epibenthic species present are more circumscribed in their distribution. Two of these were found to be previously undescribed and are described here.

THE MID-PACIFIC MOUNTAINS are a chain of submerged seamounts lying between 17° and 21° N latitude, with the main axis running between 165° W and 170° E for about 2775 km (Figure 1). The group is associated with the Marcus-Necker Ridge, which forms the northern part of the Darwin Rise. Numerous flat-topped seamounts (guyots) have been discovered along the Mid-Pacific Mountain Range at depths of 1300–1700 m (Hamilton 1956). Fossils indicate that the group existed as islands in the late Cretaceous ca. 80 million years ago (Ladd & Newman 1973, Ladd et al. 1974). It has been hypothesized that they acted as a series of stepping-stones facilitating the dispersal of shallow-water and terrestrial organisms across the Pacific (Hamilton 1956). A limited amount of information exists concerning the fauna of other guyots. Fish and invertebrates from the Nazca Ridge are Indo-West Pacific in affinity. This is striking because the Nazca Ridge extends 1500 km from the coast of South America, and the fauna of the latter belongs

to the distinct and different East Pacific Province (Zullo and Newman 1964, Zullo et al. 1964, Allison et al. 1967). Hamilton (1956) found outcrops with Cretaceous fossils in the Mid-Pacific Mountains and that these had Tethyan affinities. Therefore, the Mid-Pacific Mountain Expedition of the Scripps Institution of Oceanography of 1968 (leg 7 of the Styx Expedition) was multidisciplinary and designed to determine the composition and affinities of past and present faunas and the origins of the present faunas, speciation in relation to seamounts and the possible role of guyots in the evolution of the deep-sea fauna, and the role of seamounts in concentrating bathypelagic animals and acting as centers of speciation.

Sampling on and around the guyots was carried out with the aid of various rock dredges, Issacs-Kidd midwater trawls, Sigsbee trawls, set lines, and free-fall bottom fish and prawn traps. In all, 39 stations were sampled. In addition, a continuous depth-recording survey was mounted and also a continuous reflection profiling program with the aid of an arcser. Locations of the stations sampled are indicated in Figure 1 and described in Table 1.

A considerable quantity of rock, much of it fossiliferous, was obtained. The samples indicate that many guyots are coated with a

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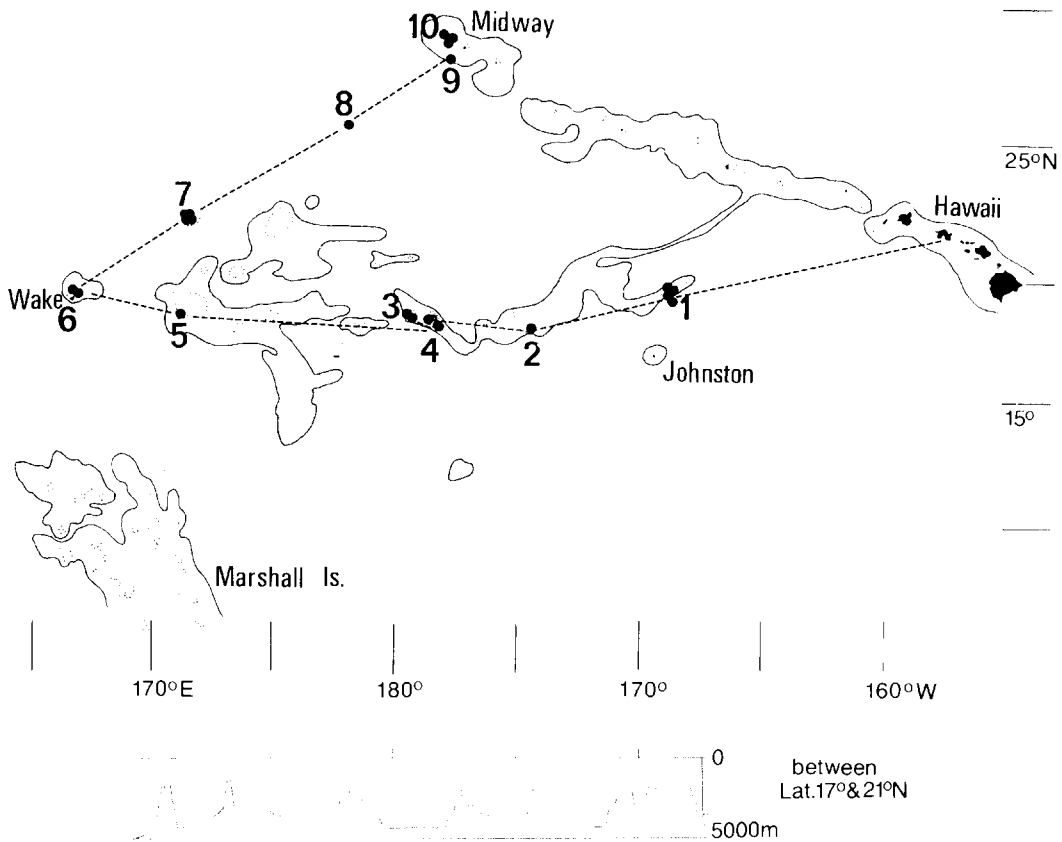


FIGURE 1. Cruise track of the Mid-Pacific Mountain Expedition and position of the stations at which caridean decapods were collected: 1, Horizon Guyot; 2, Hess Guyot; 3, Hamilton Guyot; 4, Agassiz Guyot; 5, unnamed guyot; 6, Wake Island; 7, Darwin Guyot; 8, unnamed seamount; 9, Nero Bank; 10, Palmer and Wentworth Seamounts. The seabed profile at the bottom of the figure is of a traverse between stations 1 and 5 that crosses several guyots.

thick layer of manganese dioxide and, except for small quantities of foraminiferan ooze, little sediment may be present. Little epifauna was present on the rocks obtained: only an occasional barnacle, solitary coral, mollusc, echinoid, ophiuroid, sponge, and tubiculous polychaete was recorded. Although the manganese coating might appear to act as an antifouling compound, the paucity of the epifauna may be a reflection of an impoverished fauna of the region. In the surface waters there was little plankton or fish. The guyots are below the center of a gyre current of large diameter in which there

is little replenishment of nutrients. Most living animals were caught via the Issacs-Kidd trawls and free-fall traps baited with fish. These traps remained on the bottom for 14 hr. A depth recorder was usually attached to the trawls. Fish, amphipods, and caridean decapods dominated these samples.

Thirty-three species of Caridea were taken; most were bathypelagic or mesopelagic, with a few bottom-living forms. Of these latter, two are new species, described here. For most species the known range is greatly extended. These specimens, including the two new species, are housed in the

TABLE 1
MID-PACIFIC EXPEDITION STATIONS FROM WHICH CARIDEA WERE OBTAINED

STATION	HAUL NO.	GEAR ^a	LONGITUDE	LATITUDE	DEPTH ^b	SPECIES
680826, Horizon Guyot	2	OT	168° 46.7' W	19° 31.1' N	1,701–1,706	<i>N. productus</i>
680827, Horizon Guyot	1	IKMWT	168° 54.0' W	19° 43.3' N	1,001	<i>H. gracilis</i> , <i>A. acutifrons</i> , <i>A. curtirostris</i> , <i>N. gibbosus</i>
680829, Horizon Guyot	2	IKMWT	168° 49.9' W	19° 07.3' N	3,629–4,926	<i>M. vesca</i> , <i>A. curtirostris</i> , <i>A. acutifrons</i> , <i>A. prionota</i>
680830, Horizon Guyot	2	OT	168° 56.2° W	19° 21.3' N	1,446–1,521	<i>A. smithi</i>
680831–680901, Hess Guyot	1	IKMWT	174° 24.1' W	17° 59.0' N	0–1,252	<i>S. debilis</i> , <i>J. spinicauda</i> , <i>O. gracilirostris</i> , <i>H. gracilis</i> , <i>A. acutifrons</i> , <i>A. prionota</i> , <i>N. gibbosus</i>
680903, Hamilton Guyot	1	OT	179° 36.0' W	18° 31.0' N	1,436–1,673	<i>N. productus</i>
680905, Hamilton Guyot	1	IKMWT	179° 13.6' W	18° 20.7' W	NR	<i>N. productus</i> , <i>S. debilis</i> , <i>A. eximola</i> , <i>A. quadrispinosa</i> , <i>A. curtirostris</i> , <i>S. richardi</i> , <i>L. profundus</i>
680907, Agassiz Guyot	3	IKMWT	178° 25.0' W	18° 08.7' N	0–1,601	<i>A. acutifrons</i> , <i>A. smithi</i> , <i>A. curtirostris</i> , <i>M. mollis</i> , <i>N. gibbosus</i>
680908, Agassiz Guyot	2	IKMWT	178° 04.2' W	17° 50.9' N	0 2,002	<i>A. curtirostris</i>
680910, unnamed guyot	3	ST	171° 15.0' E	18° 14.0' N	1,281–1,651	<i>G. joani</i> , <i>P. gracilis abyssii</i>
680912, Wake Island	1	IKMWT	166° 40.0' E	19° 12.6' N	0–1,151	<i>P. sivado</i> , <i>S. debilis</i> , <i>A. curtirostris</i> , <i>J. spinicauda</i> , <i>O. spinosus</i> , <i>O. gracilirostris</i> , <i>M. vesca</i> , <i>N. gibbosus</i>
680912–680913, Wake Island	3	IKMWT	166° 42.9' E	19° 06.5' N	0–2,101	<i>A. stylostrata</i> , <i>J. spinicauda</i> , <i>M. mollis</i>
680915, Darwin Guyot	2	IKMWT	171° 40.1' E	22° 00.0' N	0–1,252	<i>S. debilis</i> , <i>A. smithi</i> , <i>A. curtirostris</i> , <i>A. acutifrons</i> , <i>A. quadrispinosa</i> , <i>O. spinosus</i> , <i>M. mollis</i> , <i>M. marptocheles</i> , <i>N. gibbosus</i> , <i>S. richardi</i>
680915–680916, Darwin Guyot	2	FVT	171° 36.0' E	22° 07.7' N	1,281	<i>A. eximola</i> , <i>H. agassizi</i>
680916, Darwin Guyot	1	IKMWT	171° 36.0' E	22° 09.5' N	0 1,402	<i>N. productus</i> , <i>S. debilis</i> , <i>A. quadrispinosa</i> , <i>A. curtirostris</i> , <i>O. spinosus</i> , <i>M. mollis</i> , <i>H. gracilis</i> , <i>P. sulcatifrons</i>
680917, Darwin Guyot	2	IKMWT	171° 36.8' E	22° 03.0' N	NR	<i>A. curtirostris</i> , <i>M. mollis</i> , <i>H. gracilis</i> , <i>N. distirus</i> , <i>S. richardi</i>
680919, unnamed seamount	1	IKMWT	178° 07.3' E	25° 37.9' N	NR	<i>A. smithi</i> , <i>A. curtirostris</i> , <i>A. quadrispinosa</i> , <i>O. spinosus</i> , <i>J. spinicauda</i> , <i>M. vesca</i> , <i>H. gracilis</i> , <i>S. richardi</i> , <i>P. sulcatifrons</i> , <i>P. acutifrons</i>

TABLE 1 (continued)

STATION	HAUL NO.	GEAR ^a	LONGITUDE	LATITUDE	DEPTH ^b	SPECIES
680921, Nero Bank	1	IKMWT	177° 53.4' W	27° 56.9' N	NR	<i>A. quadrispinosa</i> , <i>A. curtirostris</i> , <i>A. eximica</i> , <i>O. spinosus</i> , <i>H. frontalis</i> , <i>H. gracilis</i> , <i>S. braueri</i> , <i>S. richardi</i> , <i>P. kensleyi</i> , <i>P. brevis</i> , <i>P. sulcatifrons</i>
680922, Palmer Seamount	2	IKMWT	178° 05.0' W	29° 06.8' N	NR	<i>A. quadrispinosa</i> , <i>A. curtirostris</i> , <i>O. spinosus</i> , <i>H. frontalis</i> , <i>H. gracilis</i> , <i>S. braueri</i> , <i>N. gibbosus</i> , <i>S. richardi</i> , <i>P. sulcatifrons</i>
680923, Wentworth Seamount	1	IKMWT	177° 52.5' W	28° 43.0' N	NR	<i>A. quadrispinosa</i> , <i>A. acutifrons</i> , <i>A. curtirostris</i> , <i>A. prionota</i> , <i>H. gracilis</i> , <i>S. richardi</i> , <i>P. sulcatifrons</i>
680923, Wentworth Seamount	2	IKMWT	177° 44.0' W	28° 47.1' N	NR	<i>A. smithi</i> , <i>A. quadrispinosa</i> , <i>A. prionota</i> , <i>A. curtirostris</i> , <i>A. sibogae</i> , <i>J. spinicauda</i> , <i>H. gracilis</i> , <i>H. frontalis</i> , <i>E. benedicti</i> , <i>M. vesca</i> , <i>S. braueri</i> , <i>N. elegans</i> , <i>P. kaiwiensis</i> , <i>P. sulcatifrons</i>

^aOT, Otter trawl; IKMWT, Issacs-Kidd midwater trawl; ST, Sigsbee trawl; FVT, free vehicle trap.

^bNR, not recorded.

collections of the Scripps Institution of Oceanography.

METHODS

Whenever possible the following measurements were taken from each specimen: carapace length (CL), measured from the posterior rim of the eye socket to the mid-dorsal posterior edge of the carapace; total length (TL), measured from the tip of the rostrum to the tip of the telson. When several specimens of a species are present in the collections, the ratio CL/TL is given. Egg number, size, and stage of development were recorded in the case of ovigerous females. When necessary, spine counts, measurements of dimensions of parts, and detailed morphological drawings were made. The detailed synonymy of each species is not given, but the descriptive works that include details of synonymy are listed.

DESCRIPTIONS OF THE COLLECTED SPECIES

Family PASIPHAEIDAE Dana, 1852

Pasiphaea acutifrons Bate, 1888

Pasiphaea acutifrons Bate, 1888:871, fig. CXLI, 32. Type locality: off Port Churraca, Patagonia, sta. 31, 73° 46.0' W, 52° 45.5' S, 446 m (Challenger Expedition).

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680919, haul 1), 178° 07.3' E, 25° 37.9' N; depth not recorded, 1 female. Specimen taken with an Issacs-Kidd trawl. CL 21.0 mm, TL 66.5 mm.

PREVIOUS RECORDS. South of Japan, 139° 29.0' E, 34° 58.0' N, 775 fm [1417 m] (1 specimen); off Port Churraca, Patagonia, 73° 46.0' W, 52° 45.5' S, 245 fm [446 m] (1 specimen) (Bate 1888).

The collected specimen was compared with the holotype by T.H.B. It is only the

third specimen to be recorded and greatly extends the distribution of the species. The collected specimen closely resembles the holotype, with only slight differences in the shape of the gastric and branchiostegal spines.

Carapace slightly carinate on anterior dorsal third only; segments 2–6 of abdomen carinate; telson slightly shorter than sixth abdominal segment, with deep dorsal sulcus and posterior notch, notch not quite as deep as that of holotype; numbers of meral spines in groups on first and second pereopods, (3,4) and (10,10), respectively correspond with holotype. Bate (1888) recorded that these spines are few in number and fewer on the first than on the second pereopod.

Comparison with the holotype shows that the differences in the shape of the gastric and branchiostegal spines are very slight and probably are related to the size of the specimens.

Pasiphaea sivado (Risso, 1816)

Alpheus sivado Risso, 1816:93, fig. 4. Type locality: off Nice, France. Synonymy: *Pasiphaea sivado* Heller, 1863; *P. savignyi* H. Milne-Edwards, 1837; *P. brevisrostris* H. Milne-Edwards, 1837.

MATERIAL EXAMINED. Wake Island (sta. 680912, haul 1), 166° 40.0' E, 19° 12.6' N, depth 1151 m, 1 male, 13 females (2 ovigerous), 1 indeterminate. Specimens taken with an Issacs-Kidd trawl. Male: CL 26.0 mm, TL 77.0 mm; females: CL 6.5–34.0 mm, TL 26.0–102.0 mm; indeterminate: CL 15.5 mm, TL 46.0 mm.

PREVIOUS RECORDS. This is the most widely distributed species of *Pasiphaea*. It occurs in the Mediterranean, the Bay of Biscay, off the west coast of Europe, the Red Sea, the Indian Ocean, and off Japan (De Man 1920, Sivertsen and Holthuis 1956, Zariquiey Alvarez 1968).

The collected specimens appear to be the first records of the species in the Mid-Pacific region and agree well with the descriptions in Bell (1853), Kemp (1910), Sivertsen and Holthuis (1956), and Zariquiey Alvarez (1968). Comparisons were made by T.H.B. with specimens from the Mediterranean in

the Nationaal Natuurhistorisch Museum, Leiden (nos. 2472 and 6740).

Gastric spines of collected specimens somewhat more pronounced than those from Mediterranean specimens, but latter are smaller; "platform" anterior and lateral to spines is similar; carapace not carinate dorsally.

Yaldwyn (1962) referred to a small, distinct posterior dorsal spine on the sixth abdominal segment, which is present in Mediterranean specimens. In collected specimens this is at best blunt, otherwise suggestive. A feature not previously noted but present in both Pacific and Mediterranean specimens is a small posterolateral spine on the sixth abdominal segment. Differences are very small and are not sufficient to warrant separation from *P. sivado*. There is no other species to which these specimens might be referred.

Of the two ovigerous specimens in the sample (CL 34 mm), both were releasing larvae. The egg envelope measures 2.7 by 2.0 mm, and there are ca. 130 eggs in each specimen. Both specimens had only three eggs attached to the fourth pleopods.

Pasiphaea kaiwiensis Rathbun, 1906
Figure 2

Pasiphaea kaiwiensis Rathbun, 1906: 927, pl. xxiii, fig. 4. Type locality: Kaiwi Channel, Hawaii, U.S. Fish Commission station 3470, 613–624 m (USNM No. 30557).

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680923, haul 2), Palmer Seamount, 178° 05.0' W, 29° 06.08' N, depth not recorded, 1 female. Specimen taken with an Issacs-Kidd trawl. CL 13.3 mm, TL 47.9 mm.

PREVIOUS RECORDS. Kaiwi Channel, Hawaii, 337–343 fm [613–624 m] (8 specimens); Bali Sea, 538 m (Rathbun 1906, De Man 1920).

The collected specimen is similar in all but two respects to the descriptions given by Rathbun (1906) and De Man (1920): the collected specimen is without spines on merus of first pereopod, and the telson is more deeply notched than in specimens described by Rathbun (1906) (Figure 2).

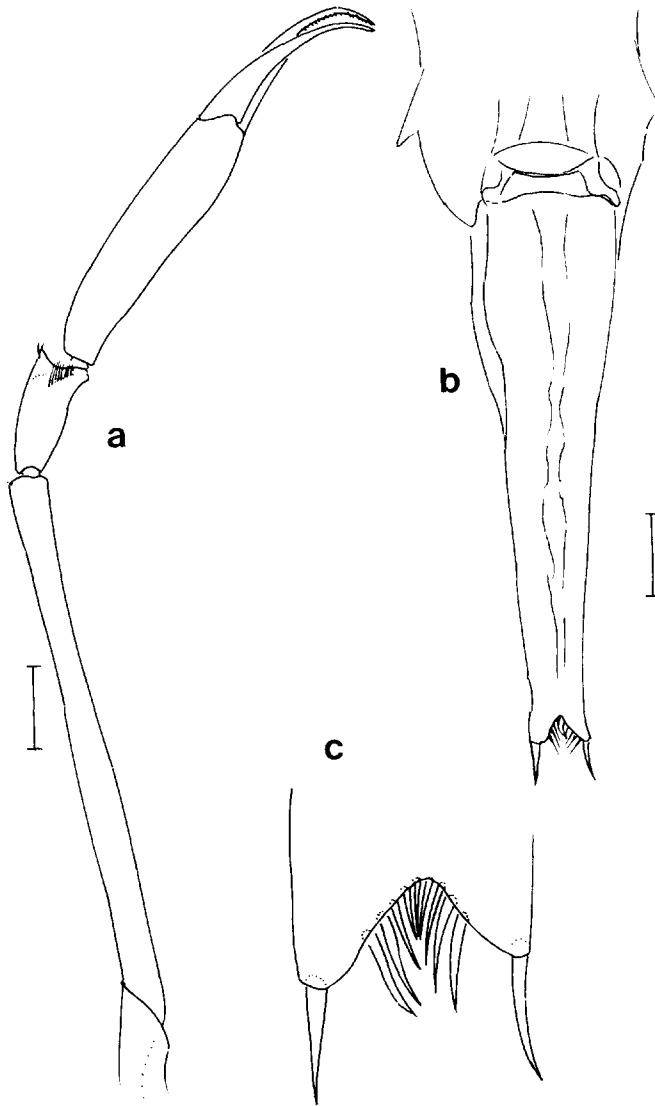


FIGURE 2. *Pasiphaea kaiwiensis*: a, first pereiopod of female; b, dorsal view of telson of female; c, enlarged detail of tip of telson. Scales = 1.0 mm.

Frontal margin of carapace dorsal to eyes, somewhat pointed; carapace emarginate posteriorly, anterior dorsal spine curved, extends slightly beyond frontal margin; telson deeply notched; endopodite of uropod projects about one-sixth and exopodite about one-third of lengths beyond tip of rostrum; distal part of blade of scaphocerite not as narrow as that drawn by De Man (1920); carpus of

first pereiopod ca. one-fifth length of merus, chela shorter than merus by about one-sixth; merus of second pereiopod bears two spines, one each on proximal and distal fifths, otherwise similar to that of first pereiopod; dactyl about same length as palm of chela, exopodite extends to about three-sevenths of length of merus; dactyl of third pereiopod about one-eighth length of merus, exopodite

reaches about an eighth along merus; dactyl of fourth pereopod about one-fourth length of propus and about as half as wide as long, setae on dactylus two or three times as long as joint; exopodite of fifth pereopod extends to one-third of merus.

Parapasiphaea sulcatifrons Smith, 1884

Parapasiphaea sulcatifrons Smith, 1884: 384, pl. 5, fig. 4; pl. 6, figs. 1–7. Type locality: not specified but recorded from 10 stations (depth range 939–5367 m) off east coast of the United States, from U.S. Fish Commission stations between 35° 12' 10" N, 74° 57' 15" W–41° 53' N, 65° 35' W (pl. 5 female from sta. 2099 and pl. 6 female from sta. 2034).

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680922), Palmer Seamount, 178° 05.0' W, 29° 06.8' N, depth not recorded, 3 males; (sta. 680923, haul 1), Wentworth Seamount, 177° 52.5' W, 28° 43.0' N, depth not recorded, 20 males; (sta. 680923, haul 2), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 20 males, 2 females, 1 ovigerous female; (sta. 680921, haul 1), Nero Bank, 177° 54.4' W, 27° 56.9' N, depth not recorded, 1 male, 1 female, 5 indeterminate; (sta. 680916, haul 1), Darwin Guyot, 171° 36.0' E, 22° 09.5' N, 0–1252 m, 1 female; (sta. 680919, haul 1), 178° 53.4' W, 27° 56.9' N, depth not recorded, 1 female. All samples were taken with an Issacs-Kidd trawl. Males: CL 15.5–24.1 mm, TL/CL 3.2; females: CL 11.6–24.1 mm, TL/CL 3.3; indeterminates: CL 5.7–10.4 mm, TL/CL 3.3.

PREVIOUS RECORDS. There are now sufficient records to indicate that the species has a cosmopolitan distribution with a wide depth range (500–5370 m) (see Squires [1990] and Kensley et al. [1987] for most recent records).

The collected specimens correspond with the detailed descriptions of Chace (1940), Barnard (1956), and Crosnier and Forest (1973).

Dorsal carina of carapace unarmed, but anterior quarter broad with central groove in

adult; rostrum extends to level of middle of eyestalk; no spine on anterior edge of lateral part of carapace; small median spine at end of fourth abdominal somite; dactyl of chela of third pereopod not longer than palm; telson dorsally sulcate, tip broadly rounded with eight spines, outermost largest.

The developing eggs vary in size: 4.50–4.72 by 3.39–3.61 mm. Thirteen eggs were carried by a specimen with CL of 24.1 mm.

Family OPHOPHORIDAE Dana, 1852

Janicella spinicauda (A. Milne-Edwards, 1883)

Oplophorus spinicauda A. Milne-Edwards, 1883. Type locality: off Casablanca, Morocco, Travailleur sta. 65, 34° 1313.5' N, 7° 43.0' W, 636 m, muddy sand. Synonymy: *O. foliaceus* Rathbun, 1906; *Acanthephyra anomala* Boone, 1927.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680912, haul 1), Wake Island, 166° 42.9' E, 19° 06.5' N, depth 1151 m, 7 males, 8 ovigerous females; (sta. 680912/680913, haul 3), Wake Island, 166° 42.9' E, 19° 06.5' N, depth not recorded, 1 male, 2 indeterminate; (sta. 680831, haul 1), Hess Guyot, 174° 24.1' W, 17° 59.0' N, depth 0–1252 m, 1 male, 1 ovigerous female; (sta. 680923, haul 2), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 1 female; (sta. 680919, haul 1), Mid-Pacific Ocean, 178° 07.3' E, 25° 37.9' N, depth not recorded, 2 males. All specimens taken with an Issacs-Kidd trawl. Males: CL 6.4–9.4 mm, TL/CL 5.3; females: CL 7.2–9.1 mm, TL/CL 6.0; ovigerous females: CL 8.2–9.1 mm; indeterminates: CL 4.6–4.7 mm.

PREVIOUS RECORDS. This is a widely distributed species, reported from the tropical Atlantic, the Indian Ocean off Madagascar and south of India, and the western Pacific at mesopelagic depths down to 1900 m (Chace 1940, 1986, Kensley et al. 1987).

The species is well described by Chace (1940, 1986). It is separated from species of *Oplophorus* by presence of long spines on second, third, and fourth abdominal somites;

lack of spine at posterolateral angle of carapace; and serrated outer margin of antennal scale.

The distinction between *Janicella* and *Oplophorus* is detailed by Chace (1986). The collected specimens conform to the latter description. Oviparous females (CL 7.9 mm) bear 9 or 10 eggs. At an early stage in development these measure 2.47–2.56 mm total length and 1.11–1.17 mm maximum width. Eyed late stages measure 2.83–3.44 mm total length and 1.89–2.00 mm maximum width.

Oplophorus spinosus (Brullé, 1839)

Palaemon spinosus Brullé, 1839 (in Barker-Webb and Bertholet): 18, 1 fig. Type locality: off Grand Canary Island. Synonymy: *Hoplophorus grimaldii* Coutière, 1905; *O. grimaldii* Chace, 1940.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680915, haul 2), Darwin Guyot, 171° 40.1' E, 22° 00.0' N, depth 0–1252 m, 1 male; (sta. 680916, haul 1), Darwin Guyot, 171° 36.0' E, 22° 09.5' N, 1 female; (sta. 680922, haul 2), Palmer Seamount, 178° 05.0' W, 29° 06.8' N, depth not recorded, 2 oviparous females; (sta. 680919, haul 1), 178° 07.3' E, 25° 37.9' N, depth not recorded, 1 oviparous female; (sta. 680912, haul 1), Wake Island, 166° 40.0' E, 19° 120.6' N, depth not recorded, 1 oviparous female; (sta. 680921, haul 1), Nero Bank, 177° 53.4' W, 27° 56.9' N, depth not recorded, 1 male, 1 female, 5 indeterminate. All specimens taken with an Issacs-Kidd trawl. Males: CL 12.2–19.4 mm, TL/CL 4.7; females: CL 3.8–15.6 mm, TL/CL 6.6; indeterminates: CL 5.2–6.2 mm, TL/CL 5.4.

PREVIOUS RECORDS. This is a widely distributed species, reported from the North and South Atlantic, Indo-West Pacific, West Australia, South Japan, and Easter Island, 75–1800 m (Chace 1940, 1986, Holthuis 1949, Crosnier and Forest 1973, Baba et al. 1986).

Holthuis (1949) gave a detailed account of the description by Brullé (1839), and Chace (1940), who listed the species as *O. grimaldii* Coutière, 1905, also gave a good description

and figures. Likewise, Sivertsen and Holthuis (1956) gave descriptions and illustrations of specimens of different sizes (CL 2.5–13.0 mm) to show changes in morphology with growth. Other recent descriptions were provided by Hayashi and Miyake (1969), Baba et al. (1986), and Kensley et al. (1987), and

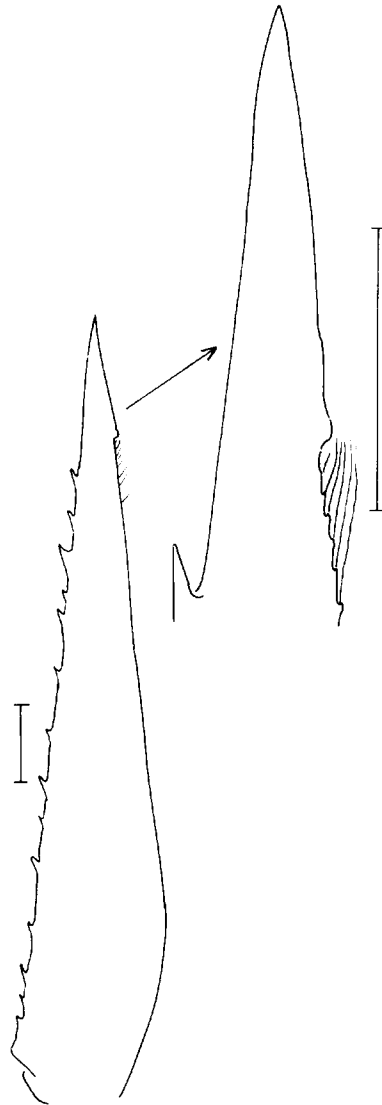
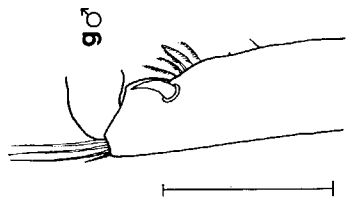
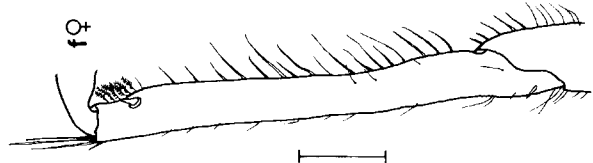
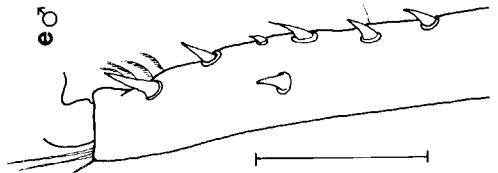
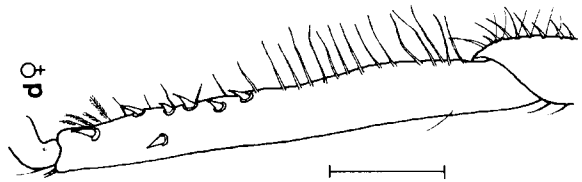
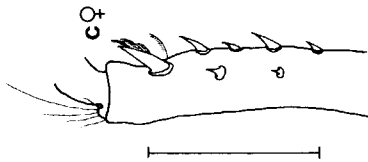
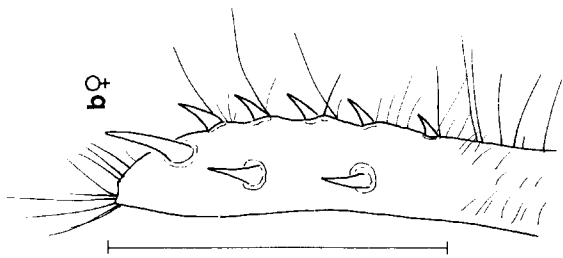
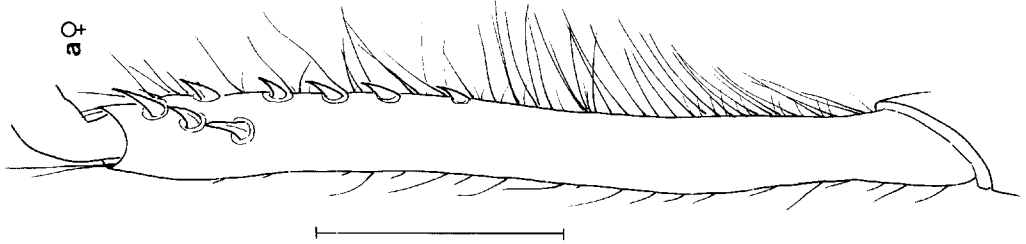


FIGURE 3. *Oplophorus gracilirostris*: antennal scale of female (CL 8.7 mm) and enlarged detail of the tip. Scales = 1.0 mm.



Chace (1986) keyed the species and provided further illustrations.

To briefly summarize the distinguishing characters: third, fourth, and fifth abdominal somites with large dorsal spines; no spine at posterolateral point of carapace; inner margin of antennal scale with distinct barb, outer margin with series of conspicuous spines.

The smallest ovigerous female measures (CL) 11.2 mm, stage A eggs measure 3.06 by 2.06 mm—3.22 by 2.17 mm, with stage D eggs (with eyespots) no larger (3.11 by 2.22 mm). Approximately 20 eggs are carried.

Oplophorus gracilirostris A. Milne-Edwards, 1881

Figures 3, 4

Oplophorus gracilirostris A. Milne-Edwards, 1881: 6. Type locality: U.S. Coast Survey Steamer *Blake*, sta. 177ag, off Dominica, 215 m. Synonymy: *O. longirostris* Bate, 1888; *Hoplophorus Smithii* Wood-Mason, 1891 (in Wood-Mason and Alcock 1891a).

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680901, haul 1), Hess Guyot, 174° 24.1' W, 17° 59.0' N, 0–1252 m, 1 female; (sta. 680912, haul 1), Wake Island, 166° 40.0' E, 19° 12.6' N, 0–2101 m, 2 ovigerous females. All specimens were taken with an Issacs-Kidd trawl. CL 14.9–18.1 mm, TL/CL 4.9.

PREVIOUS RECORDS. This species is recorded from the Bahamas, Gulf of Mexico, Caribbean, off southeast Africa, Indian Ocean, western Pacific from Indonesia to south of Japan, and Hawai'i (Baba et al. 1986, Chace 1986).

Chace (1947, 1986) described specimens from the Caribbean and the Philippines and provided excellent illustrations and keys. Hayashi and Miyake (1969) and Baba et al. (1986) added to the descriptions. Hayashi and Miyake (1969) stated that there is a barb present on the antennal scale of *O. gracili-*

rostris, but Chace (1986) and Hayashi (in Baba et al. 1986) stated that there is no barb. A barb is also *entirely* absent in *O. typus* H. Milne-Edwards, but in *O. typus* the lateral carinae converge posteriorly toward the midline, whereas they are subparallel in *O. gracilirostris*.

Collected specimens possess blunt spine on ventral margin of pleuron of first abdominal somite; hook on posterolateral spine of carapace; contrary to description by Chace (1986), ill-defined barb present near distal end of inner margin of antennal scale, 14 spinules on proximal five-sixths of outer margin (Figure 3); armature of eight spines in wedge-shaped crest on distal end of merus of third pereiopod (Figure 4) (in *O. typus* single spine on merus); lateral carinae diverge slightly from midline.

Of the two ovigerous females the eggs of one have early eyespots and vary in size from 3.17 to 3.39 mm by 2.17 to 2.39 mm; in the other specimen the larvae are on the point of hatching, and the egg cases measure ca. 3.33 by 2.44 mm.

Acanthephyra prionota Foxton, 1971

Acanthephyra prionota Foxton, 1971: 33, figs. 1 and 2A–H. Type locality: off East Africa, *Discovery* sta. 1582, 05° 39' S, 46° 22' E, 1900–1850 m to surface, 4.5-m diameter ring net (holotype, BMNH No. 1970253).

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680923, hauls 1 and 2), Wentworth Seamount, 177° 52.5' W, 28° 43.0' N and 177° 44.0' W, 28° 47.1' N, depths not recorded, 5 males, 7 females (2 ovigerous); (sta. 680829, haul 2), Horizon Guyot, 168° 49.9' W, 19° 07.3' N, 3629–4926 m, 1 female; (sta. 680901, haul 1), Hess Guyot, 174° 24.1' W, 17° 59.2' N, 0–1251 m, 2 females. All specimens taken with an Issacs-Kidd trawl. Males: CL 7.6–17.8 mm, TL/CL 3.3; females:

FIGURE 4. *Oplophorus gracilirostris*: a, left merus of the third pereiopod (CL 14.9 mm); b, enlarged detail of distal end of merus oriented slightly to the right of that drawn in a; c and d, left merus of third pereiopod of two specimens (CL 7.5 and 8.7 mm, respectively) from Japan donated by K.-I. Hayashi for comparison with a and b. *O. typus*: f and g, left merus of third pereiopod of specimens from the eastern Indian Ocean (CL 11.9 and 12.6 mm, respectively). Scales = 1.0 mm.

CL 6.7–15.5 mm, TL/CL 3.5; ovigerous females: CL 15.4–15.5 mm.

PREVIOUS RECORDS. This species is recorded from the tropical Atlantic, off East Africa, and from the eastern Pacific (Foxton 1971).

By separate coincidence, Peter Foxton and John Yaldwyn recognized this species at the same time as we did in 1970. Foxton published details of the species in the following year (Foxton 1971). Stanley Kemp had also described this species, but the manuscript was largely burned in the bombing of the Plymouth Laboratory in 1941 and was never published. Foxton (1971) chose Kemp's proposed specific name; Allen and Butler and Yaldwyn, also coincidentally, had decided to propose the name "serrata."

Foxton (1971) gave a good description with clear figures. Here we add a concise description from our own observations.

Carapace with dorsal median carina that extends posteriorly for two-thirds length and terminates posteriorly at posthepatic groove and anteriorly in short, spinelike rostrum; anterior one-third of carina developed as crest, much of which inclines anteriorly to rostrum, crest bears 5–7 spines, most anterior, may be so close to tip of rostrum as to make latter appear bifid; rostrum terminates immediately posterior to level of cornea, fringe of long hairs on ventral part of rostrum between eyes; laterally carapace with long ridge or rounded carina extending from posterior edge to within one-fourth the distance to antennal spine, ridge with slight inflection where posthepatic groove descends vertically to meet it; anterior to lateral ridge bifid ridge extends from posterior limit of eye socket to position immediately anterior to lateral ridge, where it divides into short branch passing tangentially and ventrally immediately below limit of lateral ridge and longer branch curving dorsally and posteriorly over hepatic region; posterior to branchiostegal spine small groove curves posteriorly and terminates below lower branch of bifid ridge; antennal spine small, obtuse; branchiostegal spine moderately large, without carina; integument relatively soft.

Abdominal segments 2–6 dorsally carinate, carinae of 3–6 terminating in posterior spine, that of last segment relatively larger than those on segments anterior to it, carinae of 2–5, but not 6, obtusely serrate, carina of the fifth segment extends anteriorly as small rounded crest, half may be covered by spine and articulation of fourth segment, serrations on crest extended as 6–9 small teeth; small notch on carina of fourth segment two-thirds back from anterior limit, this appears to relate to tip of extended spine of third segment, the two coincide when abdomen extended; abdominal serrate carinae appear unique to species. No other distinguishing spines occur on abdominal segments.

Telson elongate, fractionally longer than uropods and longer than sixth abdominal segment, bears four small lateral spines on distal one-third, median terminal spine probably flanked by three pairs of spines (only one specimen with relatively undamaged telson with one marginal spine and sockets for two others between it and median spine).

Eyes small, short, cornea smaller than eyestalk, latter with prominent papilla on inner dorsolateral margin with cornea; stylocerite of basal segment of antennular peduncle not very large, ends in sharp spine, relatively narrow ending short of distal end of first segment of peduncle, second and third segments of peduncle, together, about same length as first, second is particularly short; upper flagellum thickened with ca. 25 basal articles; antennal scale about five times as long as broad, lamella extends beyond terminal lateral tooth, with central and lateral ridges; mandible of typical acanthephyran form, incisor process with continuous series of teeth, palp with three segments; maxillae and other mouthparts similar to those of other oplophorids; third maxillipeds extend four-fifths of length of antennal scale, exopod represented by very small lobe; paired epipod present, proximal arm angled, semicircular notch at inflexion, similar notch present on epipod of pereopods. Pereopods not particularly stout, nor elongate; first pair, noticeably setose, do not extend much beyond first half of antennal scale; second pair slightly longer but less robust; third pair longest but,

like fourth and fifth, very slender and reach tip of antennal scale. Endopod of first pleopod of female unusual, bears nonspinose retinaculum at tip, this normally associated with the male; male with enormously inflated tip extending beyond spinose retinaculum; ovigerous female exhibits same feature. It may be that this indicates protandry. Uropods without distinguishing features.

The ovigerous females bear eggs at stage 3 (i.e., before the eyes become pigmented). Egg measurements range from 0.83 by 1.19 mm to 0.89 by 1.22 mm.

The only other feature of note was a space between the crest of the carapace and the dorsal wall of the stomach. This appeared to be filled with oil and is presumably a flotation mechanism.

Acantheephyra quadrispinosa Kemp, 1939

Acantheephyra quadrispinosa Kemp, 1939: 571, 572, 576, and 578. Type locality: not specified (the specimens from which the first description was made were from the *Discovery* and *Dana* collections from the South Atlantic from 32° S to 40° S and from the Indo-Pacific from the coast of East Africa to 163° W and from 25° N to 42° S), mesopelagic, 1500–0 m. Synonymy: *Acantheephyra purpurea* De Man, 1920, Balss, 1925, and Calman, 1939 (all in part); *Acantheephyra batei* Stebbing, 1905, non *A. batei* Faxon, 1895.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680922, haul 2), Palmer Seamount, 178° 05.0' W, 29° 06.8' N, depth not recorded, 4 males, 4 indeterminates; (sta. 680923, hauls 1 and 2), Wentworth Seamount, 177° 52.5' W, 28° 43.0' N and 177° 44.0' W, 28° 47.1' W, depth not recorded, 3 males, 6 females, 7 indeterminates; (sta. 680905, haul 1), Hamilton Guyot, 179° 13.6' W, 18° 31.0' N, depth not recorded, 1 female; (sta. 680919, haul 1), 178° 07.3' E, 25° 37.9' N, depth not recorded, 5 males, 3 females, 6 indeterminates; (sta. 680921, haul 1) Nero Bank, 177° 53.4' W, 27° 56.9' N, depth not recorded, 3 males, 12 indeterminates; (sta. 680916, haul 1), Darwin Guyot, 171° 36.0' E, 22° 09.5' N, 0–1402 m, 1 male, 1 female;

(sta. 680915, haul 2), Darwin Guyot, 171° 36.0' E, 22° 07.7' N, 1281 m, 1 male. All samples were taken with an Issacs-Kidd trawl. Males: CL 7.6–13.8 mm, TL/CL 5.4; females: CL 4.6–14.7 mm, TL/CL 5.2; indeterminates: CL 3.8–6.0 mm, TL/CL 5.0.

PREVIOUS RECORDS. This species is widespread in the South Atlantic and Indo-Pacific, including off East Africa, the Philippines, Indonesia, Sulu Sea, Celebes, and New Caledonia and off the coast of Oregon and the Northwest Pacific at depths varying from 27 m to at least 1463 m (Kemp 1939, Krygier and Percy 1981, Chace 1986).

Acantheephyra quadrispinosa is almost certainly a diurnal migratory species (Chace 1986). It closely resembles *A. purpurea* (Kemp 1939), but can be distinguished from that species by presence of a tooth at the distal end of the dorsal carina of the fourth abdominal somite, the tooth slightly smaller than that on the fifth somite.

Numbers of rostral teeth vary, in collected specimens dorsal series 7–10 (most commonly 9 or 10), ventral series 5 or 6; carapace not dorsally carinate posteriorly, dorsal profile not indented, branchiostegal spine strong, flared outward, buttressed with conspicuous keel; eyes small; telson bears four pairs of spinules. None of the present specimens was ovigerous; however, one female, with very setose pleopods and presumed to be in breeding dress, was taken on 23 September. The ova of this specimen did not appear to be completely mature.

Acantheephyra sanguinea Wood-Mason & Alcock, 1892, which has been reported as commonly occurring with *A. quadrispinosa* (Kemp, 1939), was not recorded in our samples. It can be distinguished from *A. quadrispinosa* by the form of the branchiostegal spine, which is little more than a small projection of the frontal margin and is not flared outward and flanked by a short carina.

Acantheephyra curtirostris Wood-Mason, 1891

Acantheephyra curtirostris Wood-Mason (in Wood-Mason and Alcock 1891a): 195. Type locality: not specified (three males

from which the first description was made came from two H.M. Indian Marine Survey Steamer *Investigator* stations [100 and 104], in the Bay of Bengal, 16° 55' 41" N, 83° 21' 18" E, 1529 m, and in the Laccadive Sea, 11° 12' 47" N, 74° 25' 30" E, 1829 m. Synonymy: *A. acutifrons* Bate, 1888 (in part).

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680907, haul 3), Agassiz Guyot, 178° 25.0' W, 18° 08.7' N, 0–1601 m, 1 male; (sta. 680908, haul 2), Agassiz Guyot, 178° 04.2' E, 17° 50.9' N, 0–2002 m, 3 females; (sta. 680921, haul 1), Nero Bank, 177° 53.4' W, 27° 56.9' N, depth not recorded, 1 male, 5 females (1 ovigerous), 1 indeterminate; (sta. 680827, haul 1), Horizon Guyot, 168° 54.0' W, 19° 43.3' N, 1001 m, 5 females; (sta. 680829, haul 2), Horizon Guyot, 168° 49.9' W, 19° 07.3' N, 3629–4926 m, 3 males, 2 females; (sta. 680915, haul 2), Darwin Guyot, 171° 40.1' E, 22° 00.0' N, 0–1252 m, 2 males, 4 females; (sta. 680916, haul 1), Darwin Guyot, 171° 36.0' E, 22° 09.5' N, depth not recorded, 0–1402 m, 3 males, 1 female; (sta. 680917, haul 2), Darwin Guyot, 171° 36.8' E, 22° 03.0' N, 2 males, 2 females; (sta. 680919, haul 1), 178° 07.3' E, 25° 37.9' N, depth not recorded, 3 males, 30 females (2 ovigerous); (sta. 680905, haul 1), Hamilton Guyot, 179° 13.6' W, 18° 20.7' N, depth not recorded, 1 male; (sta. 680912, haul 1), Wake Island, 166° 40.0' E, 19° 12.6' N, 0–1151 m, 1 male, 2 females; (sta. 680922, haul 2), Palmer Seamount, 178° 05.0' W, 29° 06.8' N, depth not recorded, 6 males, 2 females (1 ovigerous); (sta. 680923, haul 1), Wentworth Seamount, 177° 52.5' W, 28° 43.0' N, 2 males; (sta. 680923, haul 2) Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 6 males, 3 females. All samples were taken with an Issacs-Kidd trawl. Males: CL 4.8–19.4 mm, TL/CL 4.6; females: CL 4.3–19.3 mm, TL/CL 4.6; ovigerous females: CL 15.7–17.7 mm; indeterminate: CL 7.4 mm.

PREVIOUS RECORDS. This species has been recorded from the Indian Ocean, the Philippines, South China Sea, Celebes, New Caledonia, New South Wales, Japan, the eastern Pacific from Vancouver to Panama and

Peru, Caribbean, West Africa, and Madeira, bathypelagic, 190–4970 m but usually not deeper than 2500 m (De Man 1920, Chace 1940, 1986, Crosnier and Forest 1973, Butler 1980; Krygier and Percy 1981).

This species was well described and figured by Butler (1980) and Chace (1940, 1986). There is some uncertainty whether the eastern Pacific populations are part of a species complex similar to that of *A. purpurea* (Chace 1986). The collected specimens agree well with the descriptions of *A. curtirostris*. The ovigerous specimens are too damaged to make accurate measurements and to make counts of the eggs.

Acanthephyra stylostratis (Bate, 1888)

Bentheocaris stylostratis Bate, 1888: 726, pl. 123, figs. 4–4a. Type locality: H.M.S. *Challenger* sta. 13, 44° 39' W, 21° 38' N, 3458 m. Synonymy: ?*Bentheocaris exuens* Bate, 1888: 724, pl. 123, figs. 3–3a. Type locality: H.M.S. *Challenger* sta. 285, southern Pacific, 137° 47' W, 32° 36' S, 4290 m (holotype, BMNH No. 1716). [Note: Although synonymized by recent authorities (e.g., Chace 1986), examination of the badly damaged type specimen of *B. exuens* indicates that this is probably not the same species.]

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680912, haul 3), Wake Island, 166° 42.9' E, 19° 06.5' N, 0–2101 m, 1 female. Collected with an Issacs-Kidd trawl. CL 20.5 mm, TL/CL 3.1.

PREVIOUS RECORDS. This species has been reported from the Gulf of Mexico, Caribbean, Gulf Stream off New Jersey, off Bermuda, Azores, Canary Islands, Cape Verde Islands, Gulf of Guinea, off Natal, South Africa, and the South Pacific, 900–1830 m (Chace 1940, 1986, Crosnier and Forest 1973).

This species was both keyed and illustrated by Chace (1940, 1986) and by Crosnier and Forest (1973). The descriptions of Chace (1936, 1940), added to those of Bate (1888) and Calman (1925), show that the species can be distinguished by the form of

the rostrum. This is short, high, and dorsally convex. In the case of the collected specimen, the rostrum is short and high but not quite so broadly convex as in the earlier descriptions.

Rostrum of collected specimen with six dorsal spines disposed as per figure by Crosnier and Forest (1973); branchiostegal spine extends from long carina, latter originates from posterior branchial region; telson with three pairs of spines (specimens with two or four pairs have been recorded). The collected specimen is the first to be recorded from the central Pacific.

Acanthephyra acutifrons Bate, 1888

Acanthephyra acutifrons Bate, 1888: 749, pl. 126, fig. 3, in part. Type locality: H.M.S. *Challenger* sta. 191, off Arro, 134° 04' 30" E, 5° 41' S, 800 m, trawled. Note: Kemp (1906), who reexamined the *Challenger* material, stated that only the type specimen of the three specimens recorded by Bate (1888) can be accepted; the other two, from stations 213 and 214, he referred to *A. curtirostris*.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680827, haul 1), Horizon Guyot, 168° 54.0' W, 19° 43.3' N, 1001 m, 1 male, 1 female; (sta. 680829, haul 2), Horizon Guyot, 168° 49.9' W, 19° 43.3' N, 1701–1706 m, 1 male; (sta. 680901, haul 1), Hess Guyot, 174° 24.1' W, 17° 59.0' N, 0–1252 m, 1 male, 1 female; (sta. 680907, haul 3), Agassiz Guyot, 178° 25.0' W, 18° 08.7' N, 0–1601 m, 2 males; (sta. 680923, haul 1), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 1 male; (sta. 680915, haul 2), Darwin Guyot, 171° 40.1' E, 22° 00.0' N, 0–1252 m, 1 ovigerous female. All samples taken with an Issacs-Kidd trawl. Males: CL 35.2–53.4 mm, TL/CL not determined because in all specimens the rostrum and/or telson was broken; females: CL 5.4–44.4 mm, TL/CL 3.8; ovigerous female: CL 44.4 mm.

PREVIOUS RECORDS. This species has been reported from the tropical and subtropical Atlantic, Gulf of Mexico, off Bermuda, off Liberia and São Tomé, Indian Ocean, off the Philippines, and off New South Wales,

mesopelagic, 650–2400 m (Kemp 1906, Chace 1940, 1986).

Chace (1940, 1986) gave good descriptions and illustrations, and the collected specimens agree well with those. Small specimens of carapace lengths 5.4, 6.9, and 14.6 mm have a large, almost fleshy spine on the third abdominal somite. This is much reduced in the larger specimens. These young specimens have particularly thin exoskeletons. This is possibly an aid to buoyancy and seems to support the suggestion of Chace (1940) that only young specimens are encountered in midwater.

Acanthephyra smithi Kemp, 1939

Acanthephyra smithi Kemp, 1939: 573 and 577. Type locality: not specified, but original specimens from which the first description was made came from the *Discovery* and the *Dana* collections from off eastern Africa to 131° W, latitudinally to 14° S in the west and between 20° N and 24° S in the east.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680923, haul 2), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 1 male; (sta. 680915, haul 2), Darwin Guyot, 171° 40.1' E, 22° 00.0' N, 0–1252 m, 1 male; (sta. 680907, haul 3), Agassiz Guyot, 178° 25.0' W, 18° 08.7' N, 0–1601 m, 1 male; (sta. 680919, haul 1), 178° 07.3' E, 25° 37.9' N, depth not recorded, 1 male. All the specimens were taken with an Issacs-Kidd trawl.

Mid-Pacific Ocean (sta. 680830, haul 2), Horizon Guyot, 168° 56.2' W, 19° 21.3' N, 1446–1521 m, 1 ovigerous female. Specimen taken with an Otter trawl.

Males: CL 9.0–19.2 mm, TL/CL 4.3; ovigerous female: CL 19.6 mm, TL/CL 3.9.

PREVIOUS RECORDS. This species has been reported from the Indian Ocean, western and central Pacific, and off eastern Australia, 216–1521 m (Kemp 1939, Hayashi and Miyake 1969, Chace 1986, Kensley et al. 1987).

Rostrum shorter than carapace; branchiostegal spine supported by very small car-

ina. In collected specimens, rostral spines of males 8–9 dorsally, 5 ventrally, female with 6 dorsal and 2 ventral spines; carinae on second to sixth abdominal segments, third to sixth somites end in large spines; telson with three pairs of dorsolateral spines. Unlike all other records, including the collected specimens, those taken from Australian waters were reported to have four pairs of dorsolateral spines on the telson (Kensley et al. 1987). In other respects the collected specimens agree with the descriptions of the authorities listed above.

The records reported here extend the distribution eastward in the Pacific from 131° W to 171° E.

Acanthephyra eximia Smith, 1884

Acanthephyra eximea Smith, 1884: 376 (*eximia*, p. 377); Smith, 1886b: 667, pl. XIV, fig. 1. Type locality: off Cape Hatteras, U.S. Fish Commission, sta. 2111, 35° 09' 50" N, 74° 57' 40" W, 1707 m, specimen no. 5644. Synonymy: *Acanthephyra eximia* De Man, 1920.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680905, haul 1), Hamilton Guyot, 179° 13.6' W, 18° 20.7' N, depth not recorded, 1 male; (sta. 680921, haul 1), Nero Bank, 177° 53.4' W, 27° 56.9' N, depth not recorded, 1 immature indeterminate. Both specimens were taken with an Issacs-Kidd trawl.

Mid-Pacific Ocean (sta. 680915–16, haul 2), Darwin Guyot, 1281 m, 1 male, 1 female. Specimens taken with a free-fall trap.

Males: CL 15.7 mm and 21.0 mm, TL/CL 4.1; female: CL 13.7 mm, TL/CL 3.9; immature indeterminate: CL 7.9 mm, TL/CL 3.7.

PREVIOUS RECORDS. This species has been recorded from most tropical and temperate seas of the world (De Man 1920, Chace 1940, 1986, Crosnier and Forest 1973, Baba et al. 1986).

This is a much described and discussed species (De Man 1920, Chace 1940, 1986, Holthuis 1947, 1977, Crosnier and Forest 1973). Although there is considerable variation in the size and dentition of the rostrum,

Chace (1940) stated that for the most part specimens with three teeth on the lower margin of the rostrum are more common in the Pacific and those with four in the Atlantic. Of the collected specimens, three have four ventral spines and one, an immature specimen, has three. Other morphological features of note include the telson with four pairs of dorsolateral spines and the appendix masculina very short and reminiscent of species of *Pandalus*.

It should be noted that, apart from the new species of *Heterocarpus* described later in this paper, this was the only species caught in traps on the seabed. This appears to confirm Chace's (1940) observation that "this is another of that group of species which are apparently usually found on or near the bottom as adults."

Acanthephyra sibogae De Man, 1916

Acanthephyra (Meningodora) sibogae De Man, 1916: 149; De Man, 1920: 1, 69, pl. vii, figs. 17–17j. Type locality: *Siboga* sta. 210^a, entrance to the Gulf of Boni, Celebes, Indonesia, 121° 18' E, 05° 26' S, 1944 m.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680923, haul 2), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 1 ovigerous female. Specimen taken with an Issacs-Kidd trawl. CL 32 mm, TL/CL? (specimen damaged).

PREVIOUS RECORDS. This species has been recorded from the Celebes Sea, Banda Sea, Indonesia, and east of the Marquesas Islands; it probably occurs down to 1000 m (De Man 1916, 1920, Hayashi and Miyake 1969, Chace 1986).

De Man (1916), who later gave a detailed description (De Man 1920), originally placed this in the then subgenus *Meningodora*. Chace (1986), although not discussing the point, clearly disagreed, keying it unambiguously within the genus *Acanthephyra*.

Acanthephyra sibogae can be separated from species of *Meningodora* by the following: a pronounced cervical groove; first two abdominal somites without carinae, third

abdominal somite without spine, fifth and sixth carinate, each with spine; obtuse ridge or crest, which in fourth and fifth somites separates pleura from terga, ridge continues on sixth somite; papilla on eyestalk, eyestalk longer than cornea.

In the collected specimen, the antennal spine is as described by Hayashi and Miyake (1969). It has seven rostral spines.

The specimen is an ovigerous female; the eggs had been recently laid. The eggs are almost spherical, measuring 0.78–0.89 by 0.78–0.83 mm.

Ephyrina benedicti Smith, 1885

Ephyrina benedicti Smith, 1885: 506. Type locality: off the northeastern coast of the United States, U.S. Fish Commission, sta. 2083, 40° 26' 40" N, 67° 05' 15" W, no. 7156.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680923, haul 2), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 2 females. Specimens taken with an Issacs-Kidd trawl. CL 15.9 mm and 17.0 mm, TL/CL 4.2.

PREVIOUS RECORDS. This species has a northerly temperate to tropical distribution in both the Pacific and the Atlantic Oceans (Crosnier and Forest 1973).

The species is characterized by a large triangular spine on the third abdominal somite and the telson with 20–25 pairs of dorso-lateral spines (Crosnier and Forest 1973, Chace 1986). Of the collected specimens, one has 25 and the other has 26 pairs of spines. In addition, in one of the two specimens there is a small blunt spine on the fourth abdominal segment.

Hymenodora gracilis Smith, 1886

Figure 5

Hymenodora gracilis Smith, 1886b: 680, pl. 12, fig. 6. Type locality: taken from 10 U.S. Fish Commission stations, but the detailed descriptions were made of a male each from sta. 2182, 71° 44' W, 39° 25' 30" N, 1567 m, no. 7974, and sta. 2036, 69° 24' 40" W, 38° 52' 40" N, 3158 m, no. 7158.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 650921, haul 1), Nero Bank, 177° 53.4' W, 27° 56.9' N, depth not recorded, 3 males, 22 females, 3 indeterminates; (sta. 680901, haul 1), Hess Guyot, 174° 24.1' W, 17° 59.0' N, 0–1252 m, 1 indeterminate; (sta. 680923, haul 1), Wentworth Seamount, 177° 52.5' W, 28° 43.0' N, depth not recorded, 5 females, 1 indeterminate; (sta. 680923, haul 2), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 2 males, 13 females, 5 indeterminates; (sta. 680922, haul 2), Palmer Seamount, 178° 05.0' W, 29° 06.8' N, 1 male, 5 females, 1 indeterminate; (sta. 680827, haul 1), Horizon Guyot, 168° 54.0' W, 19° 43.3' N, 1001 m, 1 female, 1 indeterminate; (sta. 680919, haul 1), 178° 07.3' E, 25° 37.9' N, depth not recorded, 1 female; (sta. 680916, haul 1), Darwin Guyot, 171° 36.0' E, 22° 09.5' N, 0–1402 m, 1 female; (sta. 680917, haul 2), Darwin Guyot, 171° 36.8' E, 22° 03.0' N, depth not recorded, 3 females, 2 indeterminates. All specimens were taken with an Issacs-Kidd trawl. Males: CL 6.0–10.7 mm, TL/CL ?; females: CL 5.1–10.4 mm, TL/CL 3.3 (1 specimen); indeterminates: CL 4.8–9.0 mm, TL/CL ? All but one of the specimens taken were damaged.

PREVIOUS RECORDS. This species is widespread, from the North Atlantic (southwest Greenland, east coast of the United States, Bermuda, West Indies, Eire, Bay of Biscay) to South Africa, Arabian Sea, southern Indian Ocean, and Antarctic, also in the eastern Pacific off Oregon and seamounts west of Mexico, 500–5300 m (Chace 1940, 1986, Sivertsen and Holthuis 1956, Crosnier and Forest 1973).

In the past this species has been confused with *H. glacialis* Buchholz. That they are separate species was confirmed by Chace (1940) and Sivertsen and Holthuis (1956). Because this is the first record of this species from the central Pacific, these specimens were given extensive scrutiny. According to Sivertsen and Holthuis (1956), Crosnier and Forest (1973), and Chace (1986), *H. gracilis* is distinguished from *H. glacialis* by the following: (1) absence of a posterodorsal transverse groove delimiting the hepatic region;

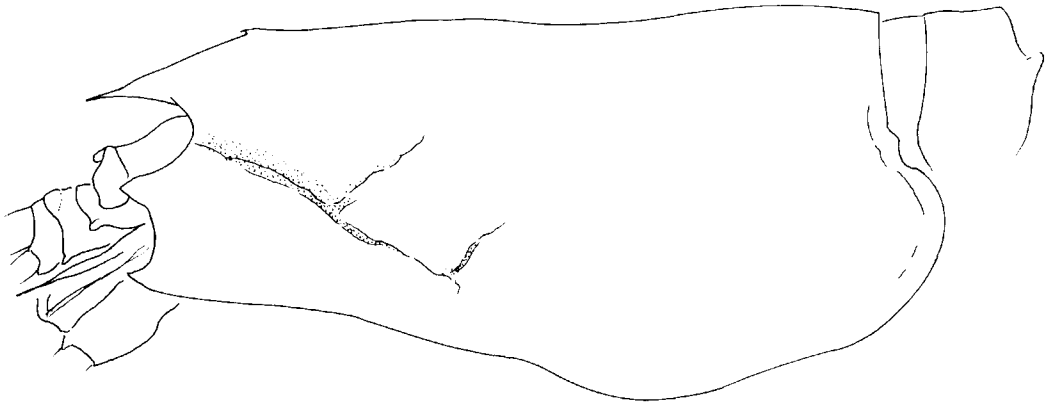


FIGURE 5. *Hymenodora gracilis*: lateral view of carapace of female (CL 8.6 mm).

(2) presence of a podobranch on the second maxilliped; (3) anterior margin of the second segment of the antennal peduncle forms a dorsal lobe and is produced to a blunt point in the outer part, over the outer basal part of the scaphocerite.

The collected specimens agree with (1) and (2) and apparently with (3), although in the case of (3) not as distinctly as shown by Sivertsen & Holthuis (1956) (Figure 5).

The conspicuous difference between the collected specimens and those described earlier is that most have a single dorsal rostral spine, and 5 out of 71 specimens examined had two. Zariquiey Alvarez (1968) stated that there are four to six rostral spines, and the specimen figured in Sivertsen and Holthuis (1956: fig. 13) has four spines. Nevertheless, Crosnier and Forest (1973: fig. 25a) showed one spine in their drawing of the carapace of *H. gracilis*. Examination of material from the *Michael Sars* Expedition (sta. 81, no. 11361–365) in the Nationaal Natuurhistorische Museum, Leiden, by T.H.B. showed that those specimens had six dorsal rostral spines. Close examination of the collected material did not reveal any further differences, and we conclude that this character is variable, as indeed it is in the case of the rostral spines of other species that we discuss in this paper.

Hymenodora frontalis Rathbun, 1902

Hymenodora frontalis Rathbun, 1902:904.

Type locality: west of Umalaska, U.S.
Fish Commission steamer *Albatross*, sta. 3327, 586 m (holotype, USNM No. 25284).

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680922, haul 2), Palmer Seamount, 178° 05.0' W, 29° 06.8' N, depth not recorded, 3 females; (sta. 680923, haul 2), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 1 female; (sta. 680921, haul 1), Nero Bank, 177° 53.4' W, 27° 56.9' N, depth not recorded, 4 females. All specimens were taken with an Issacs-Kidd trawl. CL 3.9–13.4 mm, TL/CL 3.6.

PREVIOUS RECORDS. *Hymenodora frontalis* has been reported from the Sea of Okhotsk, Aleutian Islands, Bering Sea, Kamchatka, west coast of North America south to off Monterey Bay, 586–3223 m (Rathbun 1902, 1910, Chace 1986). This species is reported to be the most common oplophorid shrimp in Canadian waters (Butler 1980).

With the exception that the posterolateral spines on the telson vary from four to seven pairs instead of the reported six to nine pairs, the collected specimens correspond well with the descriptions of Rathbun (1902, 1910) and Butler (1980). The collected specimens are

either fully mature, with the ovary extending into the abdomen, or spent, but without egg remains and breeding dress.

Meningodora vesca (Smith, 1886)

Meningodora vesca Smith, 1886a:189, 192; Smith, 1886b:609, 676. Type locality: Gulf Stream east of Chesapeake Bay, U.S. Fish Commission Steamer *Albatross*, sta. 2099, 69° 39' 00" W, 37° 12' 20" N, 5367 m, Globigerina ooze, beam trawl, no. 5434. Synonymy: *Notostomus viscus* Smith, 1886a; *N. vescus* Smith, 1886b; *Acanthephyra brevisrostris* Bate, 1888; *A. batei* Faxon, 1895; *A. parvirostris* Coutière, 1911.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680912, haul 1), Wake Island, 166° 40.0' E, 19° 12.6' N, 0–2101 m, 1 female; (sta. 680829, haul 2), Horizon Guyot, 168° 49.9' W, 19° 21.3' N, 3629–4926 m, 1 male; (sta. 680923, haul 2), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 1 male; (sta. 680919, haul 1), 178° 07.3' E, 25° 37.9' N, depth not recorded, 1 male, 1 female. All specimens were taken with an Issacs-Kidd trawl.

Males: CL 14.5–15.2 mm, TL/CL 3.2; females: CL 10.0 and 11.4 mm, TL/CL 3.4.

PREVIOUS RECORDS. North Atlantic off the United States; south of Eire; off Portugal, Azores; off Sierra Leone, Canaries; off Gabon to Angola; South Atlantic, Indonesia, Philippines, Sulu Sea, New Caledonia, and New South Wales, 615–5400 m (Chace 1940, 1986, Crosnier and Forest 1973, Kensley et al. 1987).

The collected specimens do not differ in any way from the descriptions of the above authors.

Meningodora mollis Smith, 1882

Meningodora mollis Smith, 1882:74, pl. 11, figs. 8, 8a, 9; pl. 12, figs. 5, 5a, 6–9. Type locality: east of Cape Lookout, North Carolina, U.S. Coast Survey Steamer *Blake*, sta. 328, 75° 22' 50" W, 34° 28' 25" W, 2970 m. Synonymy: *Hymenodora mollis* Bate, 1888; *Notostomus fragilis* Faxon,

1893; *Acanthephyra mollis* De Man, 1920; *Notostomus mollis* Balss, 1925.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680913, haul 3), Wake Island, 166° 42.9' E, 19° 06.5' N, 0–2101 m, 2 females (1 ovigerous); (sta. 680907, haul 3), Agassiz Guyot, 178° 25.0' W, 18° 08.7' N, 0–1601 m, 1 female; (sta. 680915, haul 2), Darwin Guyot, 171° 40.1' E, 22° 00.0' N, 0–1252 m, 1 indeterminate; (sta. 680916, haul 1), Darwin Guyot, 171° 36.0' E, 22° 09.5' N, depth not recorded, 3 males, 1 female; (sta. 680917, haul 2), Darwin Guyot, 171° 36.8' E, 22° 03.0' N, depth not recorded, 1 female, 1 indeterminate. All specimens taken with an Issacs-Kidd trawl. Males: CL 9.8–10.0 mm, TL/CL 3.3; females: CL 7.9–10.3 mm, TL/CL 3.0; ovigerous female: CL 11.6 mm; indeterminate: CL 5.0 and 6.8 mm.

PREVIOUS RECORDS. This species has been recorded off South and East Africa, Somalia, Indian Ocean, Sri Lanka, South China Sea, Philippines, New Caledonia, off western Americas from Oregon to Panama, Galápagos Islands, North and South Atlantic, Bermuda, Bahamas, Gulf of Mexico, off Spain and Portugal, Canaries, off Gabon to Angola, 840–2985 m (Chace 1940, 1986, Crosnier and Forest 1973, Kensley et al. 1987).

Except that in some the number of dorsal rostral teeth are less than the seven to eight recorded in the literature, the collected specimens compare in every respect with the descriptions of the above authors and others such as Bate (1888) and Faxon (1893). The dorsal rostral teeth number four to six.

The eggs of the one ovigerous female taken were on the point of hatching. The egg dimensions varied: length, 0.86–0.92 mm; width, 0.58–0.64 mm.

Meningodora marptocheles (Chace, 1940)

Meningodora marptocheles Chace, 1940:158, figs. 33 and 34. Type locality: Northeast Providence Channel, Bahamas, 77° 18' W, 25° 29' N, mesopelagic. Synonymy: *Notostomus marptocheles* Chace, 1940.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680915, haul 2), Darwin Guyot, 171° 40.1' E, 22° 00.0' N, 0–1252 m, 1 female. Specimen taken with an Issacs-Kidd trawl. CL 11.4 mm, TL/CL 3.7.

PREVIOUS RECORDS. This species has been recorded from the Bahamas, northwest Atlantic, and Banda Sea, Indonesia, mesopelagic and bathypelagic (Chace 1940, 1986).

This species is similar to *M. vesca*, but is distinguished by a triangular posteromesal spine on third abdominal segment; branchiostegal spine supported by very short carina; lateral carina of carapace not horizontal, posterior part slopes dorsally; prominent papilla on inner surface of eye. The collected specimen is without most of its thoracic limbs, but we have little doubt that it is a specimen of *M. marptocheles* corresponding with both descriptions of Chace (1940, 1986).

This is only the second record from the Pacific and is the first record from the Mid-Pacific Ocean.

Notostomus elegans A. Milne-Edwards, 1881

Notostomus elegans A. Milne-Edwards, 1881:

8. Type locality: southeastern Gulf of Mexico, U.S. Coast Survey Steamer *Blake*, sta. 29, 84° 05' W, 24° 36' N, 1738 m. Synonymy: *N. patentissimus* Bate, 1888; *N. longirostris* Bate, 1888; *N. westergreni* Faxon, 1893; *N. atlanticus* Lenz & Strunck, 1914.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680923, haul 2), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 1 female. Specimen taken with an Issacs-Kidd trawl. CL 15.8, TL/CL 4.1.

PREVIOUS RECORDS. This species is widespread in the tropical western and eastern North Atlantic and Pacific from the Philippines and Indonesia to off Ecuador, off New South Wales, mesopelagic, 0–3500 m (Crosnier and Forest 1973, Chace 1986, Kensley et al. 1987).

There has been much debate as to the synonymy of many species of the genus

Notostomus, and *N. elegans* is no exception. Crosnier and Forest (1973) gave a detailed consideration of the problem, and Chace (1986) accepted their conclusions, perhaps with some hesitation. Before the revision, the synonymized species listed above formed a group within the genus having five lateral carinae on the posterior part of the carapace. Originally, we identified the collected specimen as *N. longirostris*, distinguishing it from the other species by its longer and less rapidly narrowing rostrum (rostral teeth 79/12) and a well-marked median carina at the base of the rostrum. We noted that Chace (1940) had figured such a carina on a drawing of *N. westergreni* although he had not mentioned it in his text. Our original determination had been based on the work of Sivertsen and Holthuis (1956), Zariquery Alvarez (1968), and Hayashi & Miyake (1969). We accept that we based our earlier decision on very variable characters, and, because material is so sparse, we here defer to the conclusions of Crosnier and Forest (1973).

Notostomus gibbosus A. Milne-Edwards, 1881

Notostomus gibbosus A. Milne-Edwards, 1881:7. Type locality: off Grenada, Lesser Antilles, U.S. Coast Survey Steamer *Blake*, sta. 267, 61° 51' 25" W, 12° 04' 50" N, 1139 m. Synonymy: *N. perlatus* Bate, 1888; *N. brevirostris* Bate, 1888.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680901, haul 1), Hess Guyot, 174° 24.1' W, 17° 59.0' N, 0–1252 m, 3 females; (sta. 680912, haul 1), Wake Island, 166° 40.0' E, 19° 06.5' N, 0–2101 m, 2 males, 3 females; (sta. 680827, haul 1), Horizon Guyot, 168° 54.0' W, 19° 43.3' N, 1001 m, 2 males; (sta. 680907, haul 3), Agassiz Guyot, 178° 25.0' W, 18° 08.7' N, 0–1601 m, 1 female; (sta. 680915, haul 2), Darwin Guyot, 171° 40.1' E, 22° 00.0' N, 0–1252 m, 1 female; (sta. 680922, haul 2), Palmer Seamount, 178° 05.0' W, 29° 06.8' N, depth not recorded, 1 male. All specimens were taken with an Issacs-Kidd trawl. Males: CL 39.0–45.5

mm, TL/CL 2.5; females: CL 23.3–44.5 mm, TL/CL 3.7.

PREVIOUS RECORDS. This species has been reported from off the east coast of Africa, Indonesia, Marquesas Islands, western and eastern North Atlantic, and equatorial Atlantic off New South Wales, mesopelagic, 850–4000 m (Crosnier and Forest 1973, Chase 1986, Kensley et al. 1987).

Again, there has been debate about the specific identification of this species (Chace 1940, 1986, Crosnier and Forest 1973). Those authors had little doubt in synonymizing *N. perlatus* Bate, 1888 and *N. brevirostris* Bate, 1888 with *N. gibbosus*. The species is characterized by the following: gastro-orbital carina continuous with lower laterorostral carina; rostrum barely or not exceeding antennal scale; well-developed posterior median spines on third, fourth, and fifth (and to lesser extent on sixth) somites. A further character that we find specific is that the ventral and lateral margins of the pleura have carinae and that on the first somite is particularly pronounced. The carinae are illustrated by Crosnier and Forest (1973: fig. 13) but not commented upon in the text.

Notostomus distirus Chace, 1940

Notostomus distirus Chace, 1940: 166, figs. 39 and 40. Type locality: western North Atlantic off Bermuda, 1829 m (holotype, New York Zoological Society No. 311915).

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680917, haul 2), Darwin Guyot, 171° 36.8' E, 22° 03.0' N, depth not recorded, 1 male. Specimen taken with an Issacs-Kidd trawl. CL 27.8 mm, TL/CL ?, rostrum damaged.

PREVIOUS RECORDS. This species has been recorded off Bermuda, west of the Canaries, southwest of the Azores, 1000–2000 m (Chace 1940, Sivertsen & Holthuis 1956).

Notostomus distirus resembles *N. murrayi* Bate, 1888 and *N. japonicus* Bate, 1888, but differs from the former in having fewer ven-

tral spines on the rostrum and shorter post-antennal carina, and from the latter in having postorbital and postantennal carinae positioned very close together and telson shorter than inner uropod (Chace 1940).

This is the first record of this species in the Pacific.

Systellaspis debilis (A. Milne-Edwards, 1881)

Systellaspis debilis A. Milne-Edwards, 1881: 13. Type locality: Old Bahama Channel, U.S. Coast Survey Steamer *Blake*, 910 m. Synonymy: *Acanthephyra debilis* A. Milne-Edwards, 1881; *Miersia gracilis* Smith, 1882; *A. debilis* var. *Europa* A. Milne-Edwards, 1883; *S. Bouvieri* Coutière, 1905; *S. debilis* var. *indica* De Man, 1916.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680915, haul 2), Darwin Guyot, 171° 40.1' E, 22° 00.0' N, 0–1252 m, 1 male; (sta. 680916, haul 1), Darwin Guyot, 171° 36.0' E, 22° 09.5' N, 0–1601 m, 2 males, 6 females; (sta. 680905, haul 1), Hamilton Guyot, 179° 13.6' W, 18° 20.7' N, depth not recorded, 1 female; (sta. 680912, haul 1), Wake Island, 166° 40.0' E, 19° 12.6' N, 0–1151 m, 1 male, 1 female; (sta. 680901, haul 1), Hess Guyot, 174° 24.1' W, 17° 59.0' N, 0–1252 m, 1 female. All specimens taken with an Issacs-Kidd trawl. Males: CL 9.3–11.4 mm, TL/CL 5.1; females: 4.1–10.0 mm, TL/CL 5.6.

PREVIOUS RECORDS. This species has been recorded off South Africa, from the Indian Ocean, western North Atlantic from south of Greenland to the Gulf of Mexico and the Bahamas, eastern Atlantic from the Faeroes to Angola, off the Philippines, Hawai'i, and Indonesia, Kyushu-Palau Ridge, New Caledonia, and New South Wales, 150–4594 m, mesopelagic (De Man 1920, Crosnier and Forest 1973, Baba et al. 1986, Chace 1986, Kensley et al. 1987).

This is one of the most common and widespread of the oplophorids, characterized by conspicuous long rostrum, carinate third and fourth abdominal somites, and crenated posterior margins of fourth and fifth somites.

Systellaspis braueri (Balss, 1914)

Systellaspis braueri Balss, 1914:594. Type locality: Gulf of Guinea, *Valdivia* Expedition, sta. 50 and sta. 52, 06° 32' W, 00° 26' N and 04° 34' W, 00° 56' N, 0–4000 m. Synonymy: *Acanthephyra braueri* Balss, 1914; *S. densispina* Stephensen, 1923.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680923, haul 2), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 1 female; (sta. 680921, haul 1), Nero Bank, 177° 53.4' W, 27° 56.9' N, depth not recorded, 1 female; (sta. 680922, haul 2), Palmer Seamount, 178° 05.0' W, 29° 06.8' N, depth not recorded, 1 female. All specimens taken with an Issacs-Kidd trawl. CL 5.6–14.8 mm, TL/CL 4.1.

PREVIOUS RECORDS. This species has been recorded from the eastern Atlantic southwest of Eire to Congo, western North Atlantic southeast of Newfoundland to the Bahamas, Bay of Bengal, Banda Sea, eastern Pacific off Oregon to off Mexico, 200–4000 m (Chace 1940, 1986, Crosnier and Forest 1973).

This species is well described and documented and the collected specimens conform in all respects. It differs markedly from *S. debilis* in that the triangulate rostrum is less than half the length of the carapace; and the sixth abdominal somite is twice as long as the fifth.

Family NEMATOCARCINIDAE Smith, 1884

Nematocarcinus productus Bate, 1888

Nematocarcinus productus Bate, 1888:810, pl. 132, fig. 5. Type locality: not specified, original specimens came from widely separated stations in the western Pacific: off Luzon, H.M.S. *Challenger*, sta. 205, 119° 22' E, 16° 42' N, trawled, 1911 m; off Banda Island, H.M.S. *Challenger*, sta. 195, 129° 07' E, 04° 21' S, trawled, 2594 m; near Yokohama, H.M.S. *Challenger*, sta. 237, 140° 32' E, 34° 37' N, trawled, 3413 m; off New Hebrides, H.M.S. *Challenger*, sta. 176, 173° 52' E, 18° 30' S, 2639 m. Synonymy: *N. tenuipes* Bate,

1888; *N. intermedius* Bate, 1888; *N. ensifer* var. *producta* De Man, 1920.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680826, haul 2), Horizon Guyot, 168° 46.7' W, 19° 32.1' N, 1701–1706 m, 1 male, 1 female; (sta. 680903, haul 1), Hamilton Guyot, 179° 36.0' W, 18° 31.0' N, 1436–1673 m, 1 female. Specimens taken with a 7.62-m Otter trawl.

Mid-Pacific Ocean (sta. 680905, haul 1), Hamilton Guyot, 179° 13.6' W, 18° 20.7' N, depth not recorded, 6 females (1 ovigerous); (sta. 680916, haul 1), Darwin Guyot, 171° 36.0' E, 22° 09.5' N, 0–1402 m, 1 late larval stage. Specimens taken with an Issacs-Kidd trawl. Male: CL 13.1 mm, TL/CL ?, specimen damaged; females: CL 9.1–19.0 mm, TL/CL 4.4.

PREVIOUS RECORDS. This species has been recorded from the western Pacific from off Japan to New Guinea, 631–3429 m (Chace 1986).

Before the revision of the species of *Nematocarcinus* by Chace (1986), we had identified the collected specimens as *N. ensifer* var. *producta* De Man, 1920. We confirm the descriptions of De Man (1920) and Chace (1986). For example, in an intact female specimen of total length 14.4 mm: 22 dorsal rostral teeth, proximal teeth close together, distal spines spaced farther apart; tip of rostrum level with posterior margin of orbit; antennal scale with somewhat truncate blade, outer margin slightly exceeds spine; telson dorsally sulcate, lateral spines 7 to 8 on each side.

The ovigerous female was carrying eggs at an early stage of development; the length and width measurements varied from 0.61 to 0.69 mm and from 0.47 to 0.56 mm, respectively.

Family HIPPOLYTIDAE Bate, 1888

Lebbeus profundus (Rathbun, 1906)

Lebbeus profundus Rathbun, 1906:914, pl. 24, fig. 10 (1 specimen). Type locality: vicinity of Modu Manu, 1394–1829 m, *Albatross*, sta. 4157 (holotype, USNM No.

30546). Synonymy: *Spirontocaris profunda* Rathbun, 1906.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680905, haul 1), Hamilton Guyot, 179° 13.6' W, 18° 20.7' N, no depth recorded, 1 female. Specimen taken with an Issacs-Kidd trawl. CL 9.3 mm, TL/CL ?, specimen damaged.

PREVIOUS RECORDS. This species was reported off Modu [Moku] Manu, Hawaii, 1394–1829 m (Rathbun 1906).

Rathbun (1906) described this species from one female specimen. We believe that this is only the second specimen to be taken; therefore it is worth recording its salient characteristics and adding our own anatomical observations.

Carapace stout, anterior two-thirds carinate; rostrum, slender horizontal, about one-third length of carapace (original specimen with 2/1 spines [see below]); carapace with supraorbital, antennal, and pterygostomial spines; antennal scale with oblique blade, exceeds spine in length; third maxilliped stout, very long, lacks exopod; first three per-

eiopods stout, long, epipods present; fifth and sixth abdominal somites with posterolateral spine; fifth somite 1.5 times length of sixth; telson with three or, possibly, four pairs of lateral spines.

Rostrum of collected specimen 3.1 mm long, almost horizontal, proximally deep, tapers sharply to tip, 0/1 spines; dorsal carina of carapace very strong, supraorbital spine very strong, antennal spine strong, pterygostomial spine fairly well developed; antennules with three prominent spines on distal part of peduncle, one spine on second segment, two spines on third; antennal scale oblique, blade extending beyond spine; third maxilliped very long, exceeding antennular flagella; distal ends of maxillipeds bear eight black, well-developed spines; first pereiopod long, stout, dactyl with black tip, 2.2 mm long, propus 6.3 mm long; other pereiopods as described by Rathbun (1906); pleopods somewhat elongate; posterolateral spine on fifth abdominal somite; telson broken.

Family PANDALIDAE Haworth, 1825

Heterocarpus agassizi Allen & Butler, n. sp.
 Figures 6–9

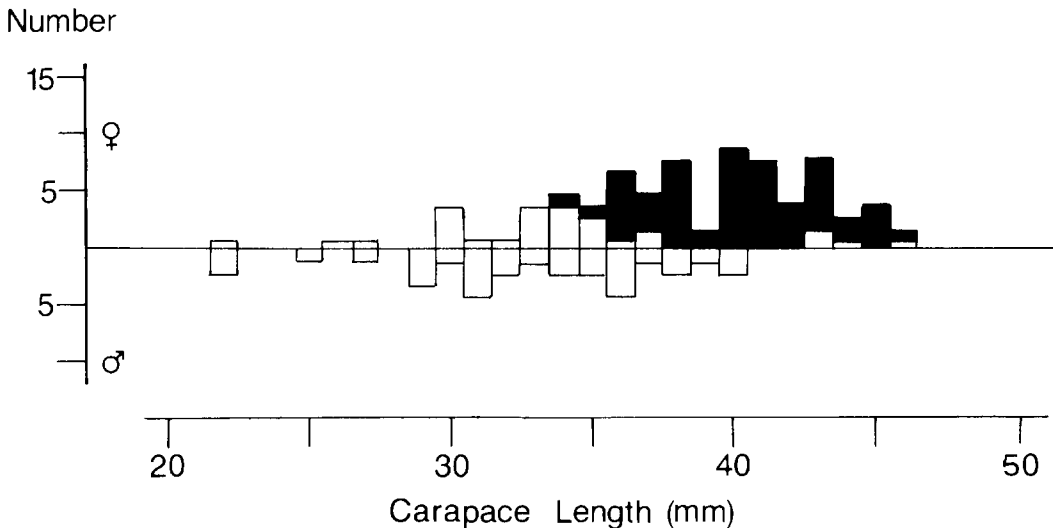


FIGURE 6. Carapace length frequency histogram of sample of *Heterocarpus agassizi* from Darwin Guyot. Ovigerous females indicated in black.

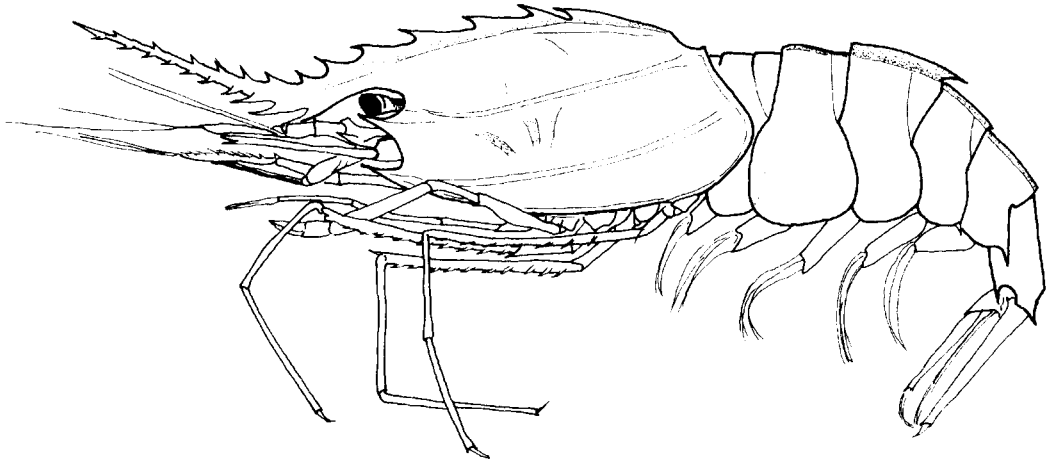


FIGURE 7. *Heterocarpus agassizi*: lateral view of female (CL 40.8 mm).

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680915-16, haul 2), Darwin Guyot, 171° 36.0' E, 22° 07.7' N, 1281 m, 38 males, 87 females (59 ovigerous). Specimens were taken with a free vehicle trap. Males: CL 21.8-41.4 mm, TL/CL 4.13; females: CL 22.3-46.2 mm, TL/CL 4.00; ovigerous females: CL 33.4-45.5 mm, TL/CL 3.90.

HOLOTYPE. Female bearing eggs, CL 41.4 mm, TL 161.0 mm. Paratypes: 36 males, 27 females, 56 ovigerous females (overall measurements given above).

Of the described species of *Heterocarpus* (De Man 1920, Sivertsen and Holthuis 1956, Crosnier and Forest 1973, Chace 1985), *H. agassizi* (Figure 6) most closely resembles *H. grimaldii* A. Milne-Edwards & Bouvier (1900). The collected specimens were compared by T.H.B. with specimens of *H. grimaldii* from the *Michael Sars* Expedition of 1910, from sta. 41 off the Canary Islands, which are in the Nationaal Natuurhistorische Museum, Leiden (No. 11376).

Rostrum long, slender, directed upward, between one-third and one-half of length extends beyond scaphocerite (Figure 7), little shorter than carapace length; middorsal carina of carapace bears four teeth posterior

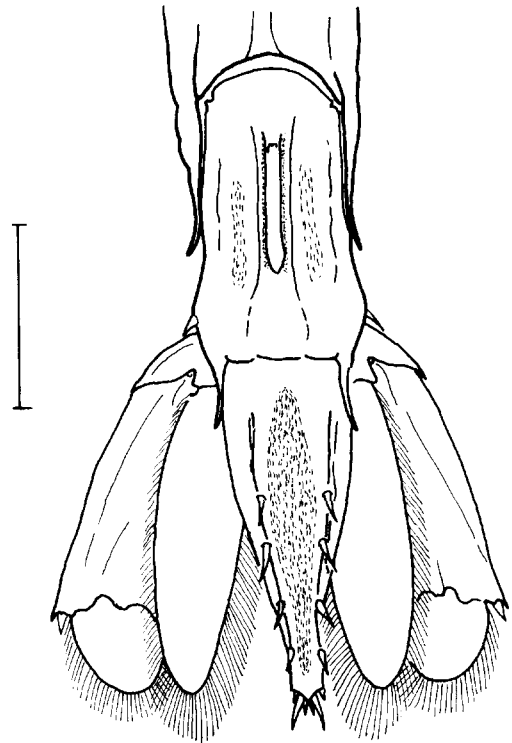


FIGURE 8. *Heterocarpus agassizi*: dorsal view of telson and uropods of female illustrated in Figure 7. Scale = 10.0 mm.

to eye socket; rostrum with nine teeth dorsally and 11 teeth ventrally, two most anterior small, inconspicuous; no middorsal tubercle on dorsal carina of carapace close to posterior margin; carapace with two very strong, lateral carinae, originating close to posterior margin, more dorsal traverses to orbit, more ventral to pterygostomial spine; antennal spine with distinct, short carina; short carina lies close to ventral rim of carapace; ventral rim thickened.

First and second abdominal segments with posterior transverse groove extending to limit of base of pleuron; third segment markedly carinate along whole length, carina continues as posteriorly directed spine (Figure 6), upper surface of carina flattened; fourth and fifth abdominal segments with indistinct rounded carinae, not ending in tooth; median dorsal line of sixth segment flattened; pleurae of first three segments rounded, those of last three

segments with pointed spine on posteroventral corner; upper surface of telson edged with two carinae and five spines (Figure 8), first spine one-third distance from proximal end; posterior tip of telson bears three pairs of spines, each pair of different length.

Abdomen and carapace covered with anteriorly directed scales; photophores present on all abdominal segments, one pair each on second, fourth, fifth, and sixth, and two pairs on first and third. Cornea of the eye well developed, broader than peduncle, latter narrowing strongly to base; stylocerite slender, pointed, not reaching limit of second segment of antennal peduncle, small, blunt, anteriorly directed process at base, first segment of antennal peduncle with small spine; scaphocerite four times as long as wide; tooth not reaching tip of lamella; incisor process of mandible with two large and five small teeth; third maxilliped with exopod (Figure 9a).

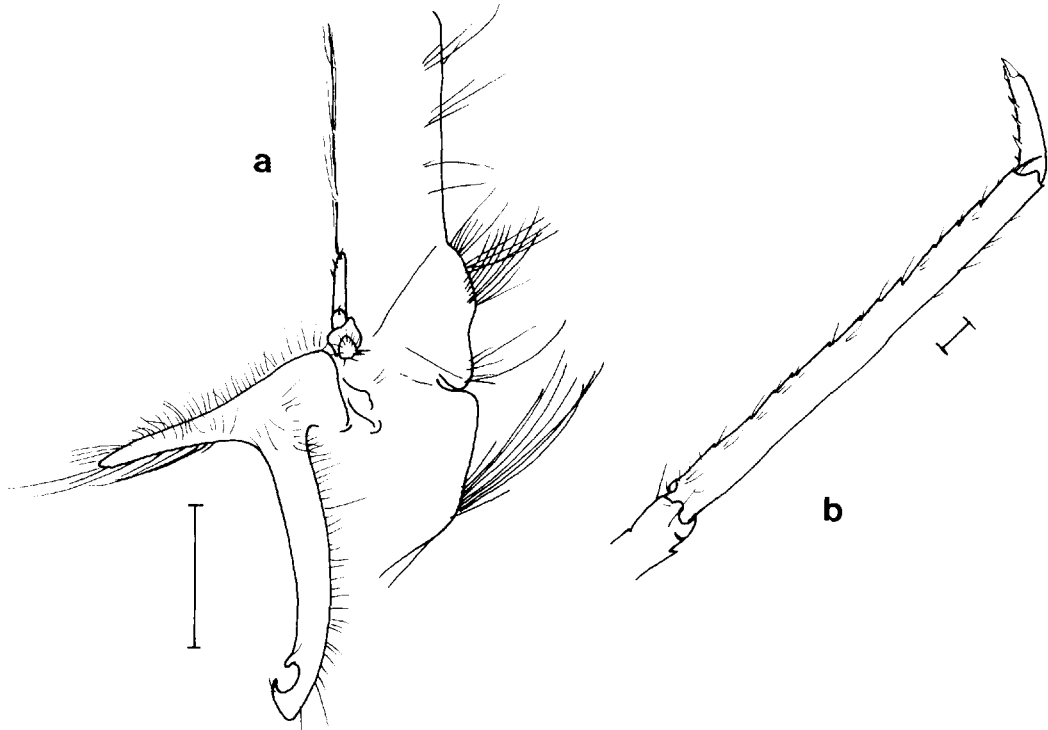


FIGURE 9. *Heterocarpus agassizi*: a, proximal portion of right third maxilliped to show small exopod; b, dactyl and propus of the third right pereopod. Both from specimen illustrated in Figure 7. Scales = 1.0 mm.

Second pereopod of left side with 22 carpel joints, right side with eight joints; third pereopod with four spinules on posterior surface of dactyl, three distal spines; fourth pereopod with two distal spines on dactyl; dactyls of third and fourth pereopods very short, approximately one-sixth length of propus (Figure 9b); first pleopods of male and female with endopod, one-third size of exopod; endopod and exopod relatively slender, end in point; uropods with sharp, stout, movable spine on inner side of tooth of exopod.

Egg size of the early stage (stage a) in development varies: length, 0.69–0.83 mm and width, 0.56–0.61 mm.

Stylopandalus richardi (Coutière, 1905)

Pandalus richardi Coutière, 1905: 1115. Type locality: west of Madeira, 23° 58' W, 32° 18' N, 0–2000 m; and off Canary Islands, 18° 28' W, 27° 43' N, 0–3000 m. Synonymy: *Stylopandalus richardi* Richard, 1905; *Parapandalus zurstrasseni* Balss, 1914; *Pandalus (Plesionika) gracilis* Boradaile, 1915.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680922, haul 2), Palmer Seamount, 178° 05.0' W, 29° 06.8' N, depth not recorded, 1 male; (sta. 680915, haul 2), Darwin Guyot, 171° 40.1' E, 22° 00.0' N, 0–1252 m, 1 male; (sta. 680917, haul 2), Darwin Guyot, depth not recorded, 2 females; (sta. 680919, haul 1), 178° 07.3' E, 25° 37.9' N, depth not recorded, 2 ovigerous females; (sta. 680921, haul 1), Nero Bank, 177° 53.4' W, 27° 56.9' N, depth not recorded, 1 ovigerous female; (sta. 680923, haul 1), Wentworth Seamount, 177° 44.0' W, 28° 47.1' N, depth not recorded, 1 female; (sta. 680905, haul 1), Hamilton Guyot, 179° 13.6' W, 18° 20.7' N, depth not recorded, 1 male. All specimens taken with an Issacs-Kidd trawl. Males: CL 6.5–6.8 mm, TL/CL 8.1; females: CL 4.1–8.7 mm, TL/CL 7.8.

PREVIOUS RECORDS. This species has been recorded from the Indian Ocean, from off Natal to west of Australia, Tasman Sea, off New South Wales, southwestern Pacific Ocean (limits 31° 49' S, 111° 24' E, 0–3600 m), Philippines, Sulu Sea, Banda Sea, west-

ern and eastern Atlantic, Gulf of Mexico, off northern Spain south to Angola (Crosnier and Forest 1973, Chace 1940, 1985, Kensley et al. 1987).

This is a very common species in subtropical, tropical, and southern temperate waters of the world's oceans. The collected specimens confirm its occurrence north of the equator in the Pacific (as per Robert A. Wasmer in Chace [1985]). It has not been recorded off the northeastern coast of America nor off Japan.

Distinguished by extremely long rostrum, ca. three times as long as carapace; upper margin of carapace with two large teeth dorsal to eye and about 10 very small teeth on distal half; sixth somite long, ca. three times as long as fifth somite.

The eggs of some of the collected specimens were close to hatching and measured from 0.72 to 0.78 mm long and 0.56–0.61 mm wide; eggs at an early stage of development (stage a) measured from 0.58 to 0.64 mm long and 0.42–0.44 mm wide. Approximately 120 eggs were carried by each female.

Plesionika kensleyi Chace, 1985

Plesionika kensleyi Chace, 1985: 77, figs. 35 and 36. Type locality: Mindanao Sea, 123° 33' 45" E, 8° 45' 30" N, 309 m. Synonymy: *P. ascanthonotus* Kensley, 1969, non *Pandalus ascanthonotus* Smith, 1882.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680921, haul 1), Nero Bank, 177° 53.4' W, 27° 56.9' N, depth not recorded, 1 female. Specimen collected with an Issacs-Kidd trawl. CL 7.2 mm, TL/CL 3.9.

PREVIOUS RECORDS. This species has been recorded from the Philippines and off Durban, South Africa, 188–333 m (Chace 1985).

Before the elegant work by Chace (1985), we had tentatively placed this specimen close to *Plesionika brevis* Rathbun, 1906. Chace (1985) gave good reasons why the Rathbun species is not a species of *Plesionika*. Although we accept this, we are not yet convinced that *P. brevis* is a species of *Lipkius* Yaldwyn, 1960.

Plesionika kensleyi is characterized by a short rostrum (rostrum of collected specimen very short, barely reaching two-thirds of length of antennal scale); rostrum straight, not particularly deep, with nine dorsal spines, four posterior to orbit, and three ventral spines; laterally rostrum bears ridge that parallels close to rim of orbit with very short postocular branch, posterodorsal to orbit; eye relatively stout, ocellus not as obvious as that described by Chace (1985); two outer segments of antennular peduncle unequal in size, distal segment half that of proximal; antennal peduncle approximately half length of antennal scale; antennal scale much shorter than carapace length (4.1 mm compared with 7.2 mm); third maxilliped with epipod; fifth pereopods without epipods; first pereopods extend beyond antennal scale by distance at least half of carpus; second pereopods subequal, carpus of left limb divided into six segments; no carina or spine on third abdominal segment; posterior limit of fifth abdominal segment dorsally "cut back," with blunt posteroventral lateral spine; sixth abdominal segment twice as long as fifth segment; telson slightly shorter than sixth abdominal segment, with four lateral spines on left side and three on right.

Family GLYPHOCRANGONIDAE Smith, 1884

Glyphocrangon joani Allen & Butler, n. sp.

Figures 10–14

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680910, haul 3), 171° 15.0' E, 18° 14.0' N, 1281–1651 m, 1 male, 5 females, 2 ovigerous females. All specimens were taken with a Sigsbee trawl. Male: CL 14.0 mm, TL/CL 4.0; females: CL 9.0–20.2 mm, TL/CL 4.0.

HOLOTYPE. Female in breeding dress with several newly extruded eggs: CL and TL 19.2 and 79.0 mm, respectively. Paratypes: 6 females, CL 9.0–20.2 mm and TL 36.0–77.0 mm, and 1 male, CL 14.0 mm and TL 56.0 mm.

This species (Figure 10) was first thought to be close to *G. megalopthalma* De Man, 1918 (De Man 1918, 1920, Chace 1984), but examination of specimens from the *Siboga* expedition in the Nationaal Natuurhistorische Museum, Leiden, showed that it differs substantially from the latter species, thus: rostrum transversely septate; antennal scale is not oval and lacks indentations or contusions on margins, spine on outer margin longer than scale; cervical and hepatic grooves of carapace more or less continuous. In general,

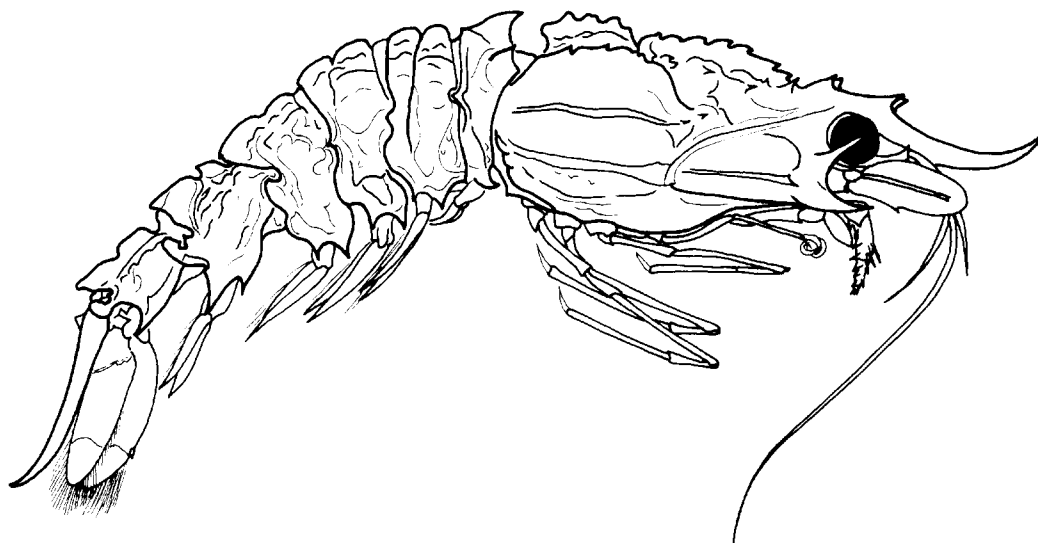


FIGURE 10. *Glyphocrangon joani*: lateral view of female (CL 19.2 mm).

it also resembles the western Atlantic species *G. longirostris* (Smith, 1882) but differs in having a shorter rostrum without dorsal transverse corrugations. It also lacks an entire third ridge anterior to the cervical groove of the carapace. *G. joani* also resembles *G. nobilis* A. Milne-Edwards, 1881; however, the posterior antennal carina does not end anteriorly in a subrectangular tooth (Smith 1882, Bate 1888, Wood-Mason and Alcock 1891*a,b*, Faxon 1893, 1895, Alcock and Anderson 1894, De Man 1918, Barnard 1926, Schmitt 1931, Chace 1939, 1984, Holthuis 1971).

We have much pleasure in naming the species after the wife of one of us (T.H.B.).

Carapace lacks anterior antennal carina anterior to cervical groove (Holthuis 1971, Chace 1984); rostrum shorter than carapace (0.77), but exceeds scaphocerites (Figures 10 and 11), tapered and directed downward for most of length, but sharply upturned at distal end, dorsal surface with moderately deep furrow and faint, but distinct, median carina for most of length, rostrum lacks transverse corrugations but with two pairs of strong, sharply pointed spines, more posterior pair at base of rostrum, anterior pair extend beyond anterior limit of eyes; antennal (suborbital) spines large, directed outward and upward, but barely extend beyond eyes, not continuous with a third anterior ridge of carapace; branchiostegal (pterygostomial) spines larger than antennal, directed inward and downward and extend beyond latter; anterior submedian carinae consist of ca. eight blunt, prominent tubercles that converge toward small, median tubercle near base of rostrum; posterior submedian carinae formed by two small tubercles, with three short, blunt, ridged teeth in between; number of small tubercles between posterior submedian and intermediate carinae; anterior intermediate carinae formed by two or three blunt tubercles and prominent anterior spine, latter larger than rostral spines; posterior intermediate carinae formed by six or seven blunt tubercles; about 10 small tubercles occur between posterior intermediate and posterior antennal carinae; anterior antennal carina not present, but six or seven blunt tubercles

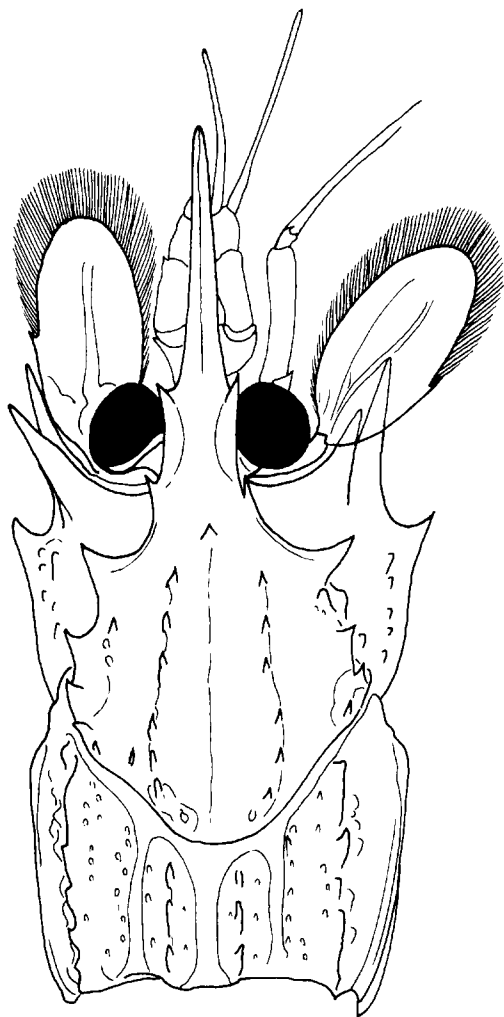


FIGURE 11. *Glyphocrangon joani*: dorsal view of carapace of female illustrated in Figure 10.

scattered on branchiostegal region; anterior and posterior lateral carinae almost entire, conspicuous and blunt-edged, anterior ends in conspicuous spine; posterior sublateral carina formed by tubercles and contusions; anterior sublateral carina entire, lying parallel to lateral carina but not continuous with branchiostegal spine.

Eyes fairly large, not, or barely, extending beyond line from anterior rostral spine and antennal spine; cornea pigmented; scaphocerite broadly oval, less than twice as long as

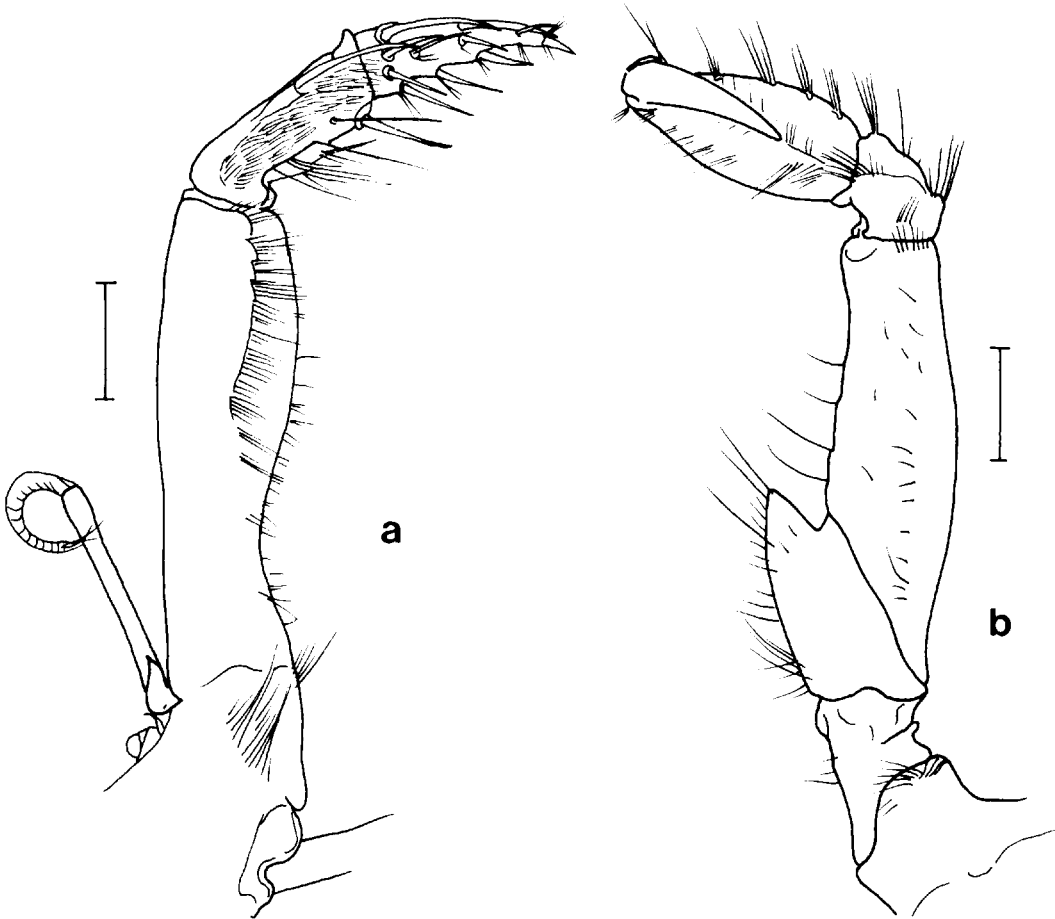


FIGURE 12. *Glyphocrangon joani*: a, right third maxilliped; b, right first pereiopod, both from a female (CL 14.6 mm). Scales = 1.0 mm.

wide, with small spine on outer margin; antennular peduncle not reaching end of scaphocerite, dorsal and transverse ridges of fine spines and setae at distal ends of basal and second segments; antennal peduncle slender and shorter than foregoing.

Third maxilliped stout (Figure 12a), barely reaches end of scaphocerite; dactylus short and spiniform; propus bears ca. 14 strong movable spines on ventral and lateral surfaces; carpus bears three strong spines on outer lateral surface and one on ventral surface; conspicuous line of closely spaced setae on ventral surface of merus, which distally lie transversely, then turn to extend longi-

tudinally and obliquely almost to proximal end; merus with interlocking coxal process and exopod.

First pereiopod stout (Figure 12b), barely reaching beyond merus of third maxilliped; short oblique line of setae at ventral distal end of propus and two converging lines of setae on ventral surface of carpus, short transverse line of setae at distal end of merus; merus and ischium fused though line of separation remains distinct; ischium projected anteriorly as a lamella; coxa with denticle that appears to fit into notch on carapace; second pereiopod slender, reaching about as far as tip of third maxilliped; left carpus with

about 20 segments and right 25 or 26; ischium lamellate and wider at distal end; third pereopod slender, not reaching tip of rostrum; dactylus somewhat flattened, with acute tip; fourth and fifth pereopods similar to third; fourth extends well beyond end of scaphocerite; dactyli show no sexual dimorphism.

Abdomen moderately rugose, with tubercles and carinae on all somites (Figure 10); first somite with median carina that projects anteriorly as strong spine; similar spine occurs on dorsolateral surface of tergum; pleuron tapers to blunt, anteriorly di-

rected spine; second somite with two median well-separated carinae, pleuron tridentate with median and posterior teeth the more prominent; third somite bears median dorsal carina incompletely separated into two parts, pleuron bidentate with anterior tooth the more prominent; fourth somite with median carina extending most of length of tergum, barely separated into two sections, pleuron bidentate, anterior tooth the larger; fifth somite with two keel-like median carinae, posteriorly higher than anteriorly, close to posterior of these, on either side, a low, sharp

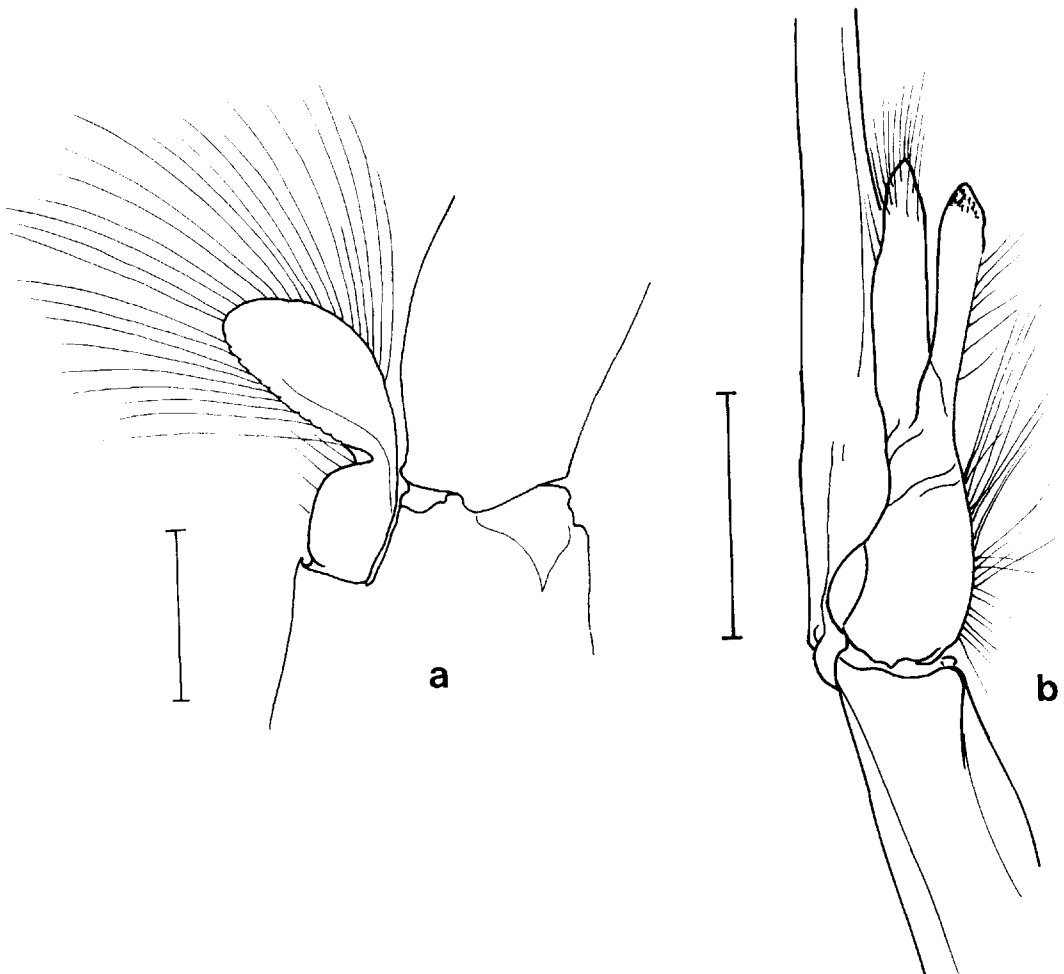


FIGURE 13. *Glyphocrangon joani*: a, endopod of first right pleopod; b, appendix interna of second pleopod, both from a female (CL 14.6 mm). Scales = 1.0 mm.

carina is directed anteriorly toward midline, pleuron bidentate, both teeth pointing posteriorly, posterior the larger; sixth somite with prominent median carina along entire tergal length, divided into two, pleuron with single large posteriorly directed spine. Endopod of first pleopod of female oval and bluntly rounded (Figure 13a); endopod of male with main part of ramus oval, bearing row of setae similar to that described by Barnard (1950) (Figure 14a); copulatory organ elongate with several cinninuli at tip;

endopod of second pleopod of female with appendix interna less than half length of endopod, appendix interna distally bears closely spaced transverse rows of cinninuli on oblique surface of projecting tip (Figure 13b); appendix masculina of male slightly larger than appendix interna, tapers to tip that bears 10 strong spines (Figure 14b); length of uropods similar to that of sixth abdominal segment, inner pair narrower than outer; telson slender, about 1.3 times as long as uropods, horizontal for most part, as-

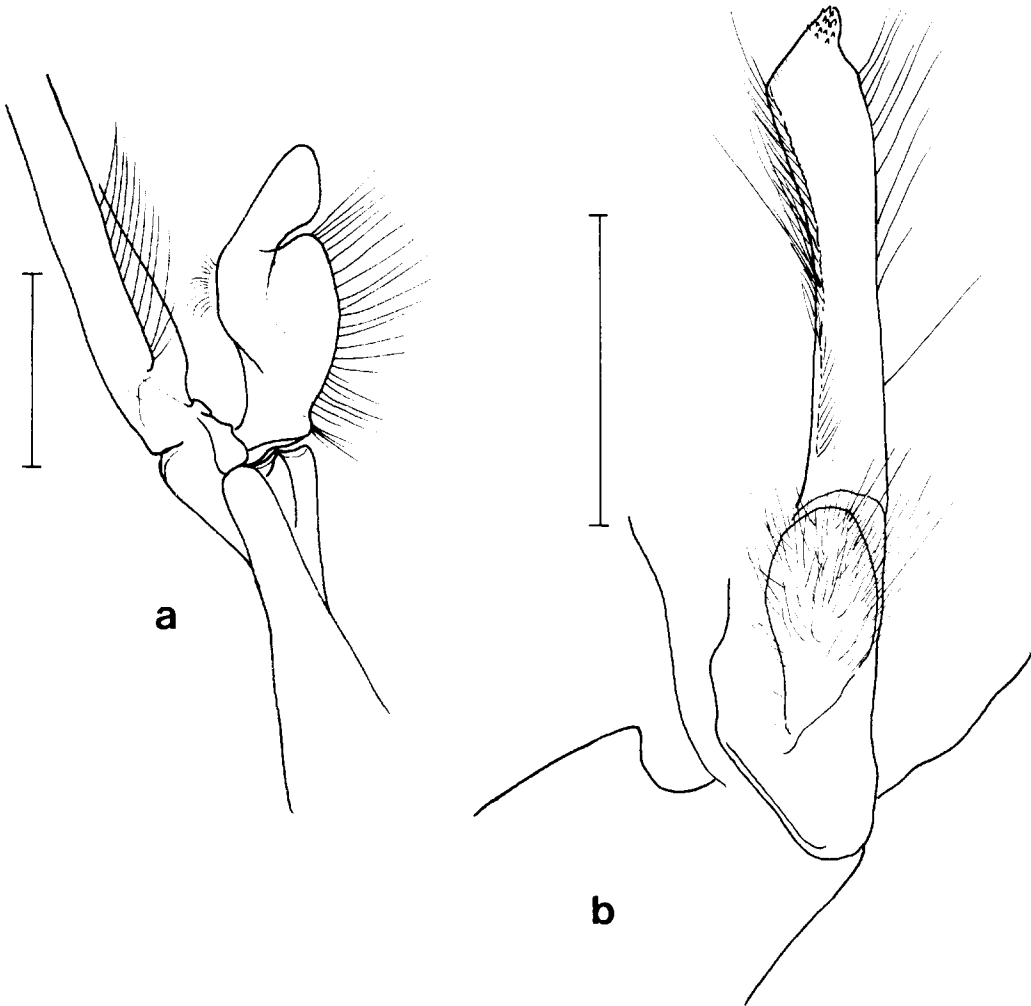


FIGURE 14. *Glyphocrangon joani*: a, endopod of first right pleopod; b, appendix interna and appendix masculina of second left pleopod, both from a male (CL 14.0 mm). Scales = 1.0 mm.

ending distally, but to lesser extent than rostrum, median dorsal tooth at proximal end with some proximal denticles on dorso-lateral and lateral carinae.

The newly laid eggs measure 3.0–3.4 mm long and 2.4–2.7 mm wide.

Family CRANGONIDAE Haworth, 1825

Pontophilus gracilis abyssi Smith, 1884

Pontophilus abyssi Smith, 1884: 363. Type locality: off Chesapeake Bay, 70° 57' 30" W, 37° 56' 20" N and 70° 37' 30" W, 37° 40' 30" N, 3506 and 4060 m. Synonymy: *P. gracilis* Bate, 1888; *P. challengerii* Ortman, 1893; *P. batei* Faxon, 1893, non *Crangon batei* Kingsley, 1882.

MATERIAL EXAMINED. Mid-Pacific Ocean (sta. 680910, haul 3), 171° 15.0' E, 18° 14.0' N, 1281–1651 m, 2 females. Both specimens taken in a Sigsbee trawl. CL 6.2 and 7.1 mm, TL/CL ?, specimens damaged.

PREVIOUS RECORDS. This subspecies has been recorded from Indonesia, Molucca Strait, Atlantic, Gulf of Mexico, possibly in all tropical and temperate seas, 1400–5852 m (Crosnier and Forest 1973, Chace 1984).

This subspecies is one of a complex of subspecies that has been described in considerable detail by a number of authors (De Man 1920, Faxon 1896, Crosnier and Forest 1973, Chace 1984). Our specimens agree with the descriptions of *P. gracilis abyssi*.

The only morphological details that we record include the following: fine fissure extending from immediately above supraorbital spine to close to epibranchial spine; antennal scale two-thirds length of carapace; width of eyes less than 1/10th of carapace length including rostrum.

DISCUSSION

This collection of caridean decapods is important because it originates from a part of the world's oceans that has been very little sampled, and also because it is relatively close to the northwestern boundary of the

East Pacific Province, which has been regarded as faunally distinct from the remainder of the Pacific (Allison et al. 1967). In fact, most of the species recorded here comprise either temperate/tropical or subtropical/tropical species that occur widely in the world's oceans. The former include *Pasiphaea sivado*, *Parapasiphaea sulcatifrons*, *Oplophorus spinosus*, *Acantheephyra quadrispinosa*, *A. curtirostris*, *A. stylostratis*, *Ephyrina benedicti*, *Hymenodora gracilis*, *Meningodora vesca*, *M. mollis*, *Systellaspis debilis*, *S. braueri*, *Stylopandalus richardi*, and *Pontophilus gracilis abyssi*. Of these, only *Pasiphaea sivado*, *Acantheephyra curtirostris*, *Meningodora mollis*, and possibly *Hymenodora gracilis* are present off the west coast of South America. Worldwide subtropical and tropical species include *Janicella spinicauda*, *Oplophorus gracilirostris*, *Acantheephyra prionata*, *A. smithi*, *A. eximia*, *Notostomus elegans*, and *N. gibbosus*, and of these only *A. prionata* and *N. elegans* have been reported from the eastern Pacific. *Notostomus distirus* is recorded from the Pacific for the first time and probably can be added to the list of circumglobal tropical species.

There are also a number of species that are widespread in the Pacific Ocean, including *Pasiphaea acutifrons*, *P. kaiwiensis*, *Acantheephyra sibogae*, *Hymenodora frontalis*, and *Nematocarcinus productus*. Of these only *P. acutifrons* and *H. frontalis* are reported from the eastern Pacific. *Plesionika kensleyi* is an Indopacific species and, as for many of those species listed above, the record of *P. kensleyi* from this expedition greatly extends the distribution of the species east and north within the Pacific.

These widespread species are without exception either mesopelagic or bathypelagic, and the great majority are members of the Oplophoridae. It seems unlikely that the mid-Pacific guyots have had any influence as stepping-stones in the distribution of such widespread midwater swimmers, although the effect of the guyots on water flow and thus on distribution and density of planktonic food organisms may be of influence. Yet, why many of these species are not recorded in the southeastern Pacific remains

unclear, but it may be related to the lack of sampling. Certainly this collection has greatly extended the known distribution of many of the species reported here.

The three species that are restricted to Hawaiian waters and/or the guyots are all epibenthic. These include *Lebbeus profundus*, *Glyphocrangon joani*, and *Heterocarpus agassizi*. In the case of the epibenthic species, the faunas of the central Pacific guyots can be compared with island faunas. In these cases they are acting as centers of speciation rather than as stepping-stones for the spread of a species.

Most of the species collected were in very small numbers; the one notable exception was the new species of *Heterocarpus*. This is likely to be a simple reflection of the oligotrophic condition of this part of the central Pacific. The fact that *H. agassizi* was caught in such large numbers may be a reflection of the method of capture using baited traps. Although pandalids occur in concentrated populations (Butler 1980), a widespread low-density population may have been attracted to the bait in much the same manner as the scavenging deep-sea amphipod *Eurythenes gryllus* (Lichtenstein) (Schulenberg and Barnard 1974), which was also collected in the baited traps. Like *E. gryllus*, *H. agassizi* is, at least in part, a scavenging species.

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Effects of Decreased Salinity on Expulsion of Zooxanthellae in the Symbiotic Sea Anemone *Anthopleura elegantissima*¹

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ABSTRACT: Many natural conditions cause expulsion of zooxanthellae from corals and sea anemones. Recent studies have focused on causes and mechanisms of this release. We examined an incidence of bleaching in a field population of the sea anemone *Anthopleura elegantissima* (Brandt). Our data suggest that expulsion of zooxanthellae was caused by reduced salinity from freshwater runoff after heavy rainfall. In the laboratory, *A. elegantissima* expelled zooxanthellae in quantities directly correlated with strength and duration of exposure to hyposalinity. The mechanism of release appears to be rupture of the host cell, followed by accumulation of clumps of zooxanthellae that are then expelled from the coelenteron. *A. elegantissima* has little or no ability to osmoregulate the water in its coelenteron, and internal salinity drops rapidly with external salinity reduction.

MANY CNIDARIANS RELY on symbiotic zooxanthellae. Much of the carbon photosynthetically fixed by zooxanthellae is translocated to the host, satisfying a large part of the cnidarian's nutritional needs (Fitt and Pardy 1981, Falkowski et al. 1984). However, cnidarians may expell the zooxanthellae in the presence of various environmental stimuli, including changes in water temperature, decreased salinity, and high levels of sunlight (Steen and Muscatine 1987, Muscatine et al. 1991).

The sea anemone *Anthopleura elegantissima* (Brandt), a symbiotic cnidarian, withstands many harsh conditions in the intertidal environment, including sand coverage, prolonged exposure to air, or weeks of starvation (Fitt et al. 1982, Taylor and Littler 1982). However, *A. elegantissima* in the

laboratory expells its zooxanthellae during prolonged darkness, high temperatures (Buchsbbaum 1968), and long-term exposure to bright sunlight (Dykens and Shick 1984). Other sea anemones show similar responses when exposed to high salinity (Reimer 1971), decreased temperatures (Steen and Muscatine 1987), a cold shock (Muscatine et al. 1991), or UV radiation (Lesser and Shick 1989).

Symbiotic *A. elegantissima*, found along the North American Pacific coast from Alaska to southern California, ranges in color from bright green, with zoochlorellae as symbionts, to greenish brown, containing zooxanthellae. Aposymbiotic, algae-free anemones appear white. Aposymbiotic *A. elegantissima* occurs in nature in fully shaded environments such as in caves and under wharves, deep within mussel beds, and occasionally in the high intertidal if continually exposed to direct sunlight (Buchsbbaum 1968). Color is indicative of the anemone's symbiotic state, but it is not a perfect guide to the presence or absence of zooxanthellae, because aposymbiotic anemones may appear green or brown from endogenous animal pigments (Buchsbbaum 1968).

Expulsion of zooxanthellae as a response to decreased salinity has not been observed

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