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AXIORYGMA NETHERTONI, A NEW GENUS AND SPECIES OF THALASSINIDEAN SHRIMP FROM FLORIDA (DECAPODA: AXIIDAE)

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ABSTRACT

Axiorygma nethertoni is described from material collected in about 30 m of water off the Key Largo area of the Florida Keys, and from 52–58 m in the Gulf of Mexico off the west coast of Florida. The genus is characterized by the possession of sexually dimorphic chelipeds, and by the absence of an appendix masculina in the male. The species burrows in sand flat areas around coral heads, with densities of up to 80/m². The burrows, usually about 15 cm long, are often blocked by debris such as calcareous algal fragments. The species is considered to play an important role in the transfer of material across the sediment-water interface.

The second author discovered the species described here while conducting a sabbatical research project on benthic microbial mats and submarine ground-water discharge off Key Largo, Florida (Fig. 1) (Simmons *et al.,* 1985; Simmons and Love, 1987). Numerous pencil-sized holes, ringed by a cone of sediment, were observed and originally believed to be associated with the submarine ground-water discharge phenomenon. Sagittal core sections showed the holes to be unlined, to have extremely jagged and irregular walls, and to have the opening often occluded with flakes of *Halimeda* and/or other bits of sedimentary material (Fig. 2). The core sections suggested small dissolution channels rather than the work of an invertebrate.

At the suggestion of Mr. Joe Dobarro (New Jersey Bureau of Shellfisheries, Bivalve, New Jersey), the second author injected a mixture of ink and sea water into the holes, and eventually demonstrated that the holes were clustered, even though generally abundant across the bottom where they occurred. The first suggestion that the holes were made by animals came from Mr. Guy Snyder. The second author then began covering the holes in 1-m quadrate areas with sediment, and observed their reappearance through time. A series of attempts was then made to obtain resin casts of the burrows, two of the more successful of which are illustrated (Fig. 3).

Numerous attempts were made to collect the animals, with little success, until, on the last day and last dive of the sabbatical, 11 specimens were found beneath one of the instruments being used to collect submarine ground-water discharge.

This paper had already been submitted for publication when Dr. Richard Heard (head of the Gulf Coast Research Laboratory, Ocean Springs, Mississippi) drew the first author's attention to some axiids from the Gulf of Mexico, during a joint study of thalassinideans. These specimens, taken during the Bureau of Land Management's MAFLA (Mississippi-Alabama-northern Florida) and SOFLA (southern Florida) programs in the Gulf of Mexico off Florida, also proved to be the species described below.

Method for Obtaining Resin Casts

While several types of resins were tried, the best casts were obtained with polyester resin such as is used for Fiberglas® repair. The resin and hardener were carried underwater in separate bags. Collapsible and disposable hospital intravenous bags were suitable. Once the diver was ready, a predetermined amount of hardener was withdrawn with a 30-ml syringe and 14–16 gauge hypodermic needle and injected into the resin bag. The resin and hardener mixture were kneaded quickly for several seconds, and the mixture then withdrawn with a 60-cc syringe and 15-cm spinal tap needle. The mixture was forced into a burrow until resistance was encountered, or until resin began to flow back out of the hole.

Family Axiidae Huxley, 1879

Axiorygma, new genus

Diagnosis.—Carapace not carinate posterior to cervical groove. Eyestalks elongate, subequal to rostrum in length. Antennal acicle elongate. Pereiopod 1: male having robust chelipeds subequal in length, chela differing on left and right sides, proximodorsal propodus of left and right chela bearing 2

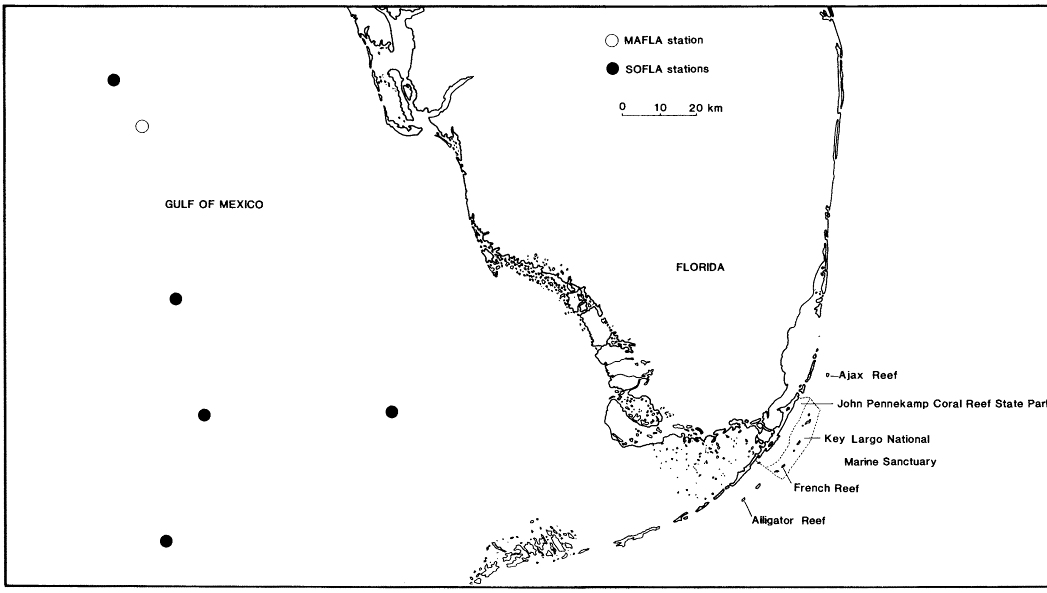

Fig. 1. Study area off Key Largo, Florida, and collection sites in the Gulf of Mexico.

clusters of slender distally feathered setae, merus distally inflated; female having slender nonrobust chelipeds subequal in length and similar. Pleopod 1 in male absent; consisting of single slender article in female. Pleopod 2 similar in male and female, having appendix interna, lacking appendix masculina in male. Outer uropodal ramus having suture in distal half.

Type species.—*Axiorygma nethertoni*, new species, by present designation.

Etymology.—The generic name is a combination of the prefix Axi-, derived from the family name Axiidae, plus *orygma*, from Greek meaning a tunnel or mine. Gender feminine.

Remarks.—Generic definitions in the family Axiidae continue to be unclear or vague, even while new genera are described. A phylogenetic reassessment of the family is obviously needed, along with a reexamination of the characters having value in defining the genera. Nevertheless, a consensus concerning these supposed generic characters is emerging (see Kensley and Gore, 1981, Table 1).

Four species of axiids have been recorded from Florida (Abele and Kim, 1986): *Axiopsis hirsutimana* (Boesch and Smalley), *A. oxypleura* (Williams), *A. serratifrons* (A. Milne Edwards), and *Coralaxius abelei* Kensley and Gore. None of these bears much resemblance to the present species.

Of the 17 or so genera and subgenera of the Axiidae, the present material seems most similar to *Axiopsis* Borradaile, 1903. This similarity is seen in the distribution of exopods, epipods, and branchiae, in the absence of pleopod 1 in the male, in the elongate antennal acicle, in the presence of a uropodal suture, and in the keeled and spinose telson. Two features, however, separate *Axiorygma* not only from *Axiopsis*, but from all the other axiid genera. These features are the sexually dimorphic chelipeds, and the absence of an appendix masculina in the male.

Axiorygma nethertoni, new species
Figs. 4–7

Type Material.—Holotype USNM 211440, ♂ CL 5.8 mm; allotype USNM 211441, ovigerous ♀ CL 6.0 mm; paratypes USNM 221442, 4 ♂♂ CL 5.1, 5.1, 5.6, 5.8 mm, 4 ovigerous ♀♀ CL 5.0, 6.1, 6.2, 6.6, nonovigerous ♀ CL 5.6 mm; Key Largo National Marine Sanctuary, Florida, in 30 m.

Additional Material.—Southwest Florida (Gulf of Mexico), BLM-SOFLA Stations: station 4B, ♂ CL 3.8 mm; 26°46′N, 83°32′W, 55 m, medium sand, 5 April 1981.—Station 16C, D, 3 ♂♂ CL 3.3 mm, 4.1 mm, 4.5 mm; 25°45′N, 83°11′W, 53.7 m, fine sand, 9 November 1980.—Station 16D, ♂ damaged, ♀ CL 5.6 mm; 25°45′N, 83°11′W, 53.7 m, fine sand, 28 April 1981.—Station 20A, 2 ♂♂ CL 4.0 mm, 4.0 mm; 25°17′N, 82°09′W,

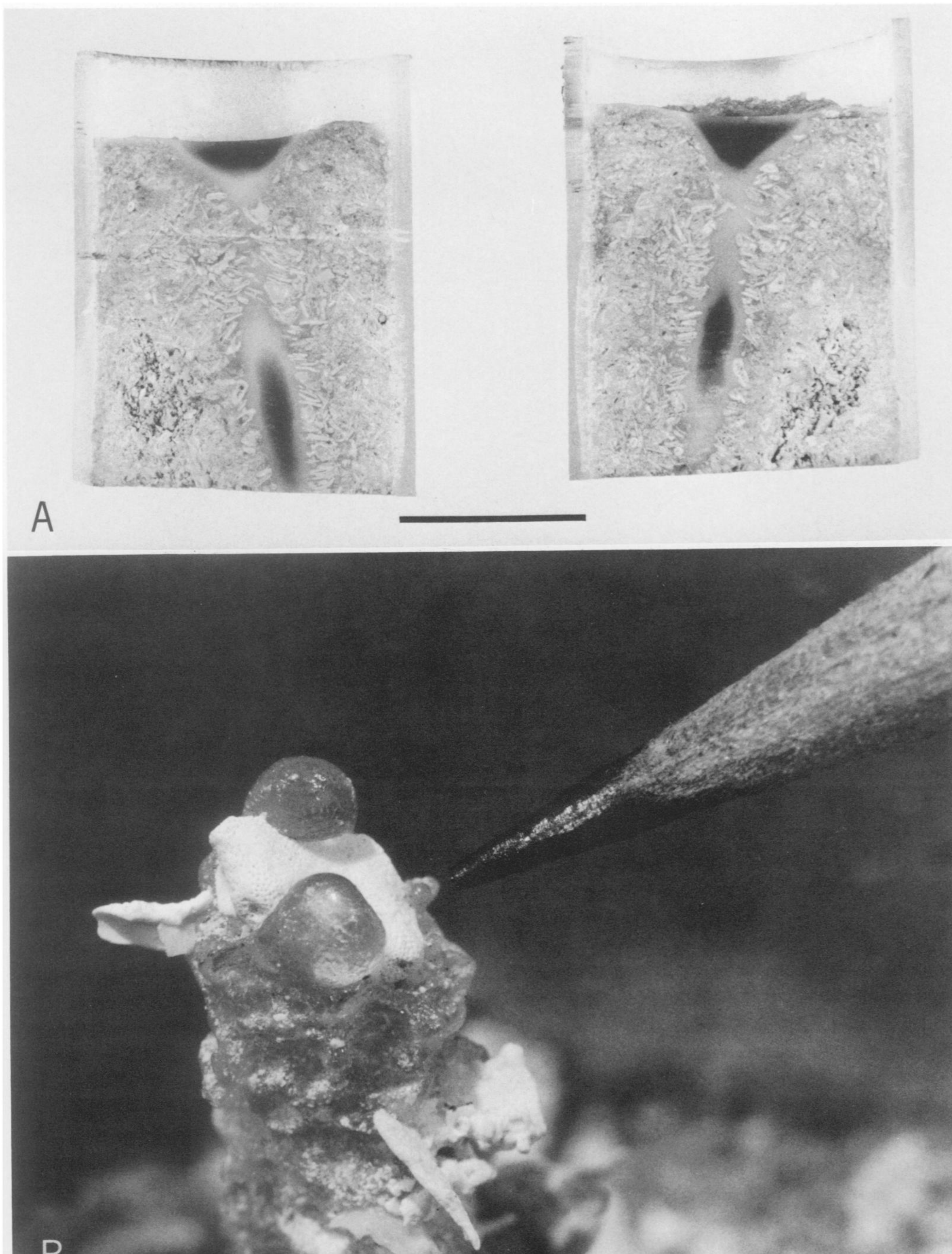

Fig. 2. A, sagittal section of resin-impregnated top of core, showing debris blocking entrance to burrow, scale = 30 mm; B, close-up of carbonate material (possibly fragment of *Halimeda*) blocking resin flow into burrow. Total resin penetration in this burrow was ~2 cm. Pointer is pencil tip.

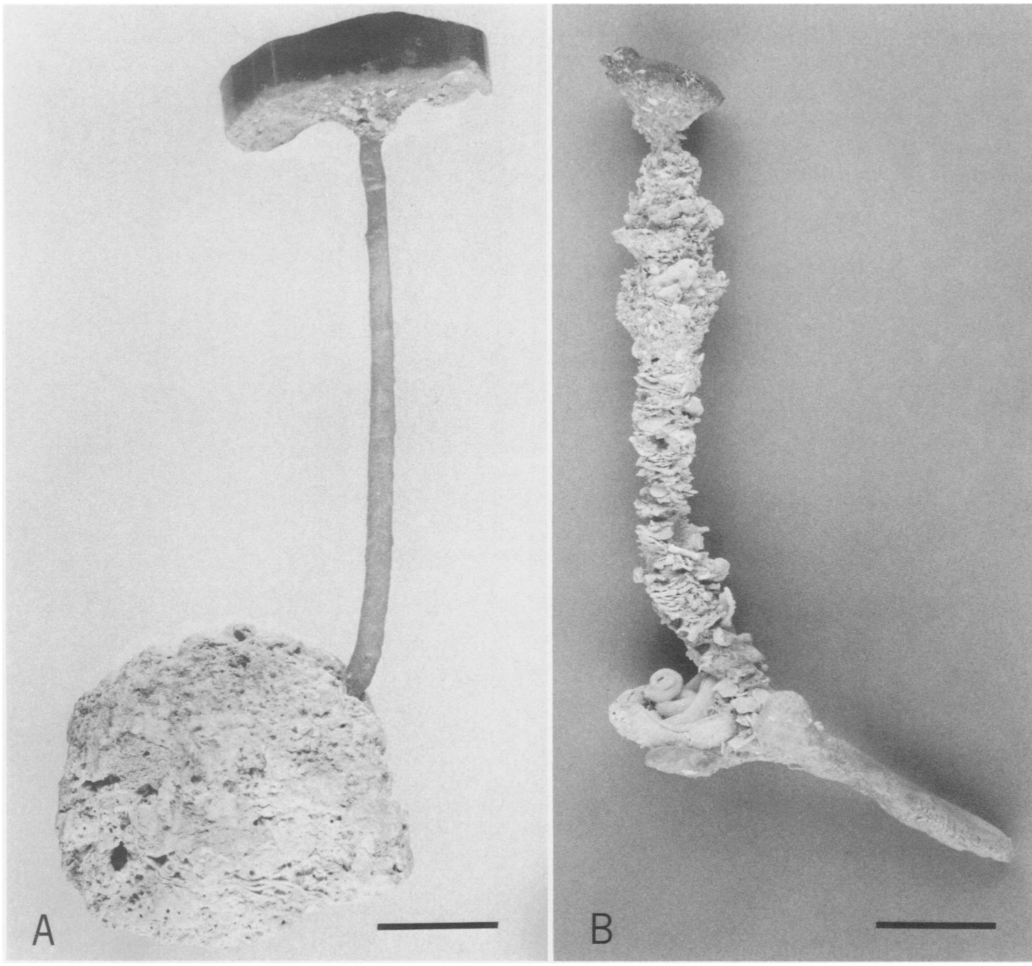

Fig. 3. Resin casts of burrows of *Axiorygma nethertoni,* new genus, new species. A, 15-cm cast of burrow ending in old coral fragment; B, 15-cm cast of burrow with possible side burrows near vermetid and other shell fragments. Scales = 30 mm.

22.7 m, coarse sand, 27 April 1981.—Station 22E, ♂ CL 4.9 mm, ♀ CL 5.0 mm; 25°17′N, 83°02′W, 52.2 m, fine sand, 26 April 1981.—Station 28E, 1 ♂ CL 5.3 mm, 1 ovigerous ♀ CL 5.9 mm; 24°47′N, 83°13′W, 58.6 m, fine sand, 4 August 1981.

BLM MAFLA Stations: station 2104, 2 ♂♂ CL 4.9 mm, 5.3 mm, ♀ CL 5.0 mm; 26°25′N, 83°23′W, 53 m, coarse sand, 29 May 1975.

Description.—Male: carapace smooth, rostrum narrowly triangular, apex very slightly upturned, with 5 pairs of lateral teeth, lateral margins extending onto carapace as distinct entire carina, reaching midway to cervical groove; median carina entire, reaching anteriorly to about midlength of rostrum; submedian carinae entire, starting well posterior of level of anterior carapace margin; cervical groove well defined; outer orbital angle rounded; anterior margin with antennal emargination, then sloping posteroventrally to cervical groove; small branchiostegal tooth present; ventral margin entire; posterior submarginal carina terminating at dorsolateral notch. Middorsal length of abdominal somites 2–6 subequal, all somites smooth; somite 1 shorter, ventrally produced into acute forwardly directed tooth, anterolateral margin with flange articulating with posterolateral carapace extension; pleural ventral margins of somites 2–5 evenly convex; somite 6 with small tooth at posteroventral angle, posterolateral margin concave to accommodate uropodal base.

Eyestalk relatively elongate, reaching to apex of rostrum; cornea well pigmented, barely wider than eyestalk.

Antennular peduncle of 3 articles, basal

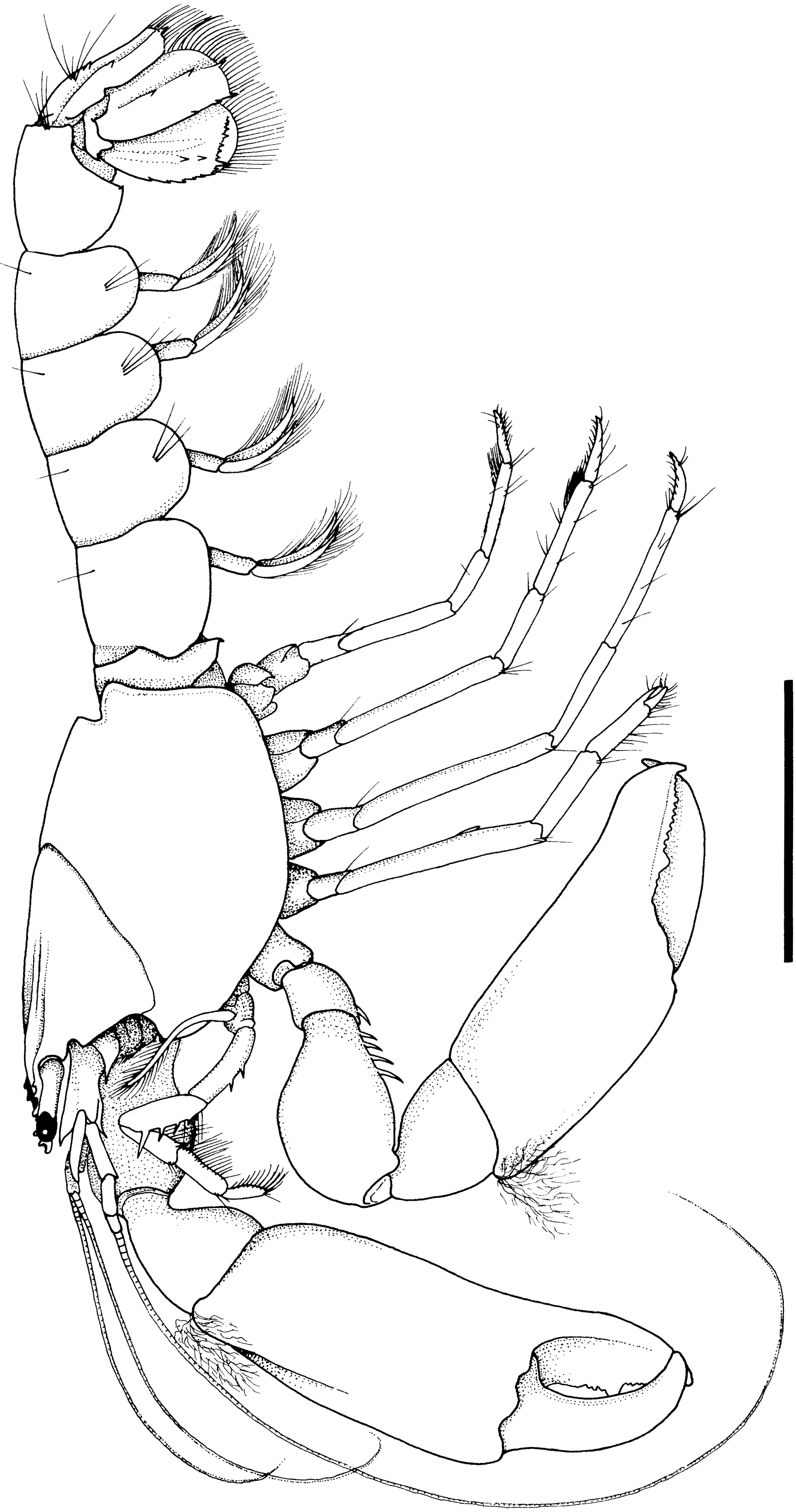

Fig. 4. *Axiorygma nethertoni*, new genus, new species, male in lateral view. Scale = 5 mm.

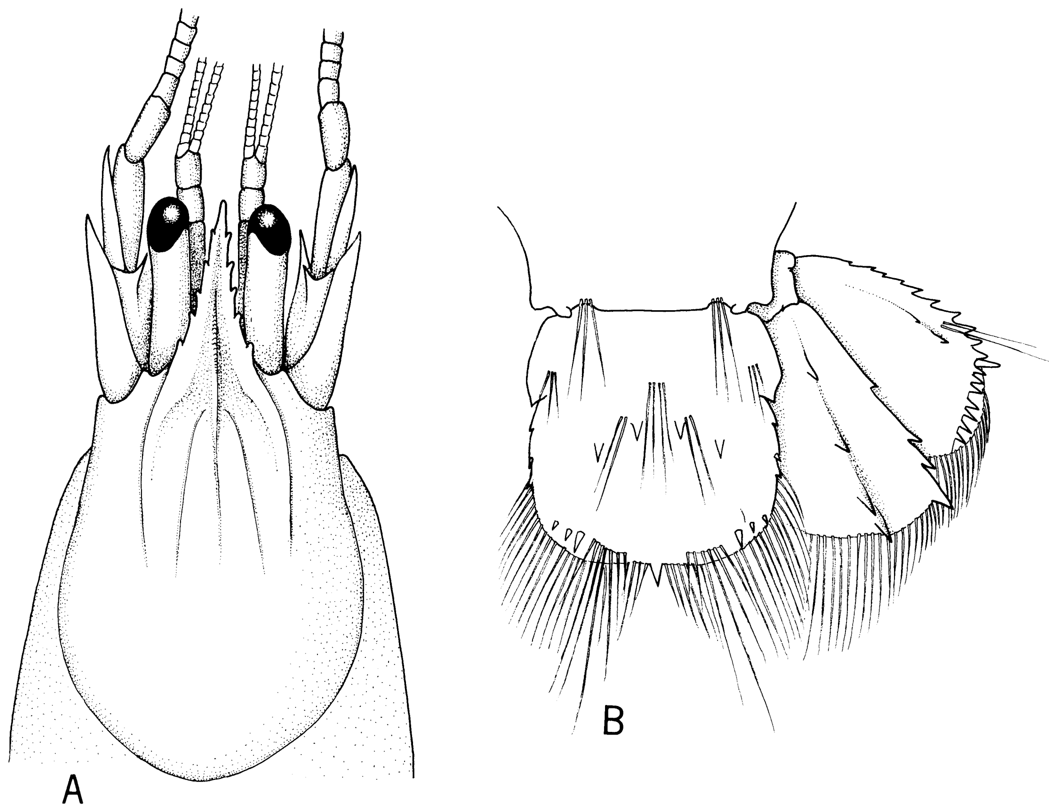

Fig. 5. *Axiorygma nethertoni,* new genus, new species: A, anterior carapace of female; B, telson and right uropod.

article reaching to cornea of eye, with distal spine on outer margin; articles 2 and 3 subequal in length; flagella subequal to carapace in length, inner slightly longer than outer.

Antennal peduncle of 5 articles, article 1 short, with ventrodistal tooth; article 2 distolaterally produced into elongate tooth, with elongate acicle between it and article 3; latter articulating obliquely on article 2, with slender distal tooth; article 5 about half length of article 4, both unarmed; flagellum more than twice length of antennular flagella.

Mouthparts as illustrated.

Distribution of epipods, exopod, and branchiae: maxilliped 1 with broad bilobed epipod; maxilliped 2, exopod, epipod plus reduced podobranch; maxilliped 3, exopod, epipod plus reduced podobranch, 2 arthrobranchs; pereiopod 1 with epipod plus reduced podobranch, 2 arthrobranchs; pereiopod 2 with epipod plus reduced podobranch, 2 arthrobranchs; pereiopod 3 with epipod plus reduced podobranch, 2 arthrobranchs; pereiopod 4 with epipod, 2 arthrobranchs; pereiopod 5 with setobranch.

Maxilliped 3, basis articulating obliquely on coxa, with slender mediodistal tooth; ischium with 2 or 3 teeth on mesial margin, strongly dentate crest on inner surface reaching beyond distal articulation of article; mesial margin of merus bearing 5 teeth, 2 distal teeth longest; carpus subequal to propodus in length, with small mesiodistal tooth and row of elongate setae on mesial margin; both propodus and dactylus bearing dense fringe of elongate setae.

Pereiopod 1, chelae unequal, smaller chela subequal to carapace plus rostrum in length, larger chela about 1.5 times carapace plus rostrum length; ischium with 1 or 2 distal teeth on posterior margin; merus distally inflated, with 3 or 4 teeth on proximal half of posterior margin; carpus half length of merus, unarmed; propodus of both chelae with 2 tufts of 40–50 fine very slender non-

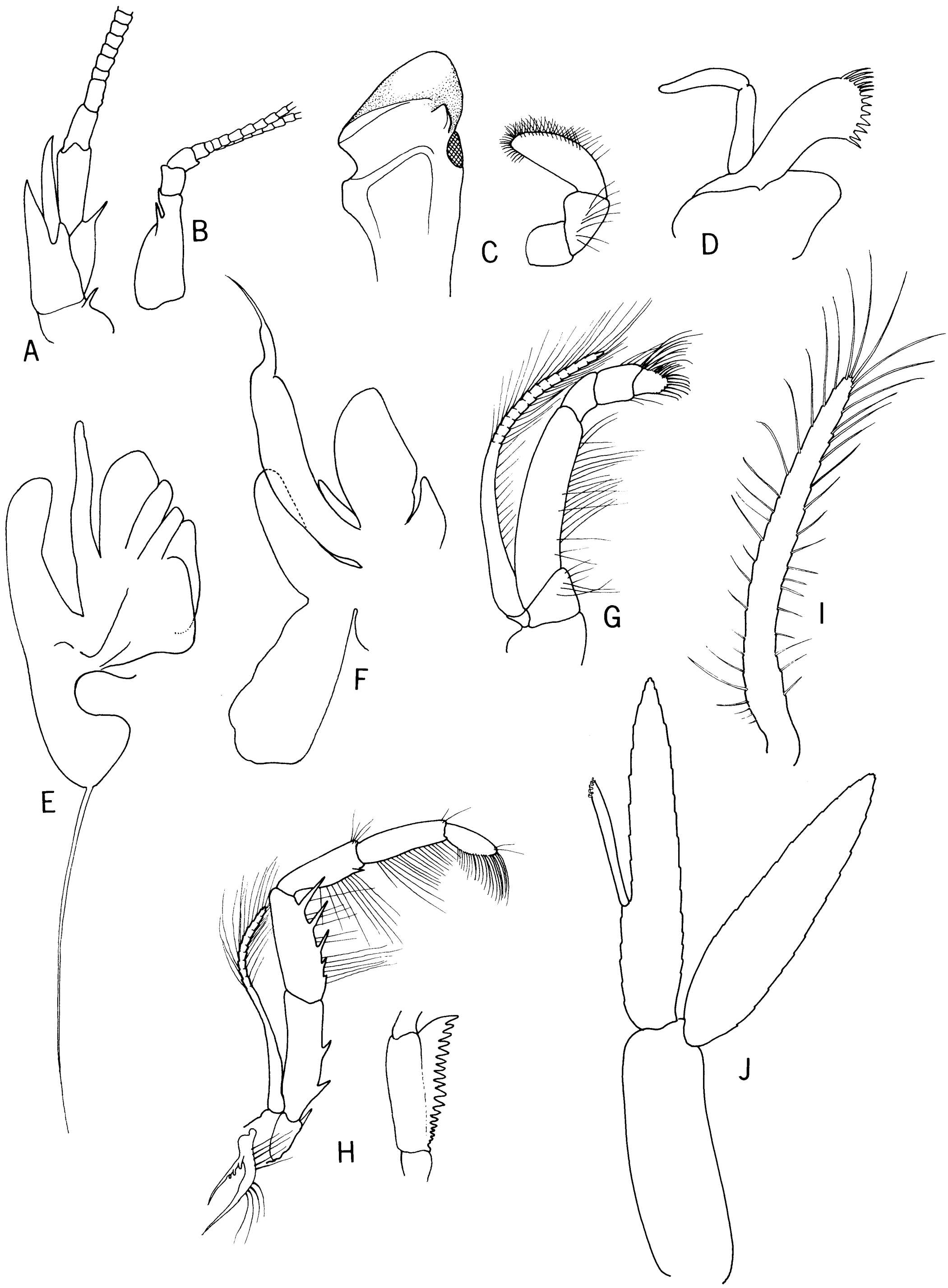

Fig. 6. *Axiorygma nethertoni,* new genus, new species: A, antenna; B, antennule; C, mandible, with palp detached; D, maxilla 1; E, maxilla 2; F, maxilliped 1; G, maxilliped 2; H, maxilliped 3, with dentate crest on inner surface of ischium; I, pleopod 1, ♀; J, pleopod 2, ♂.

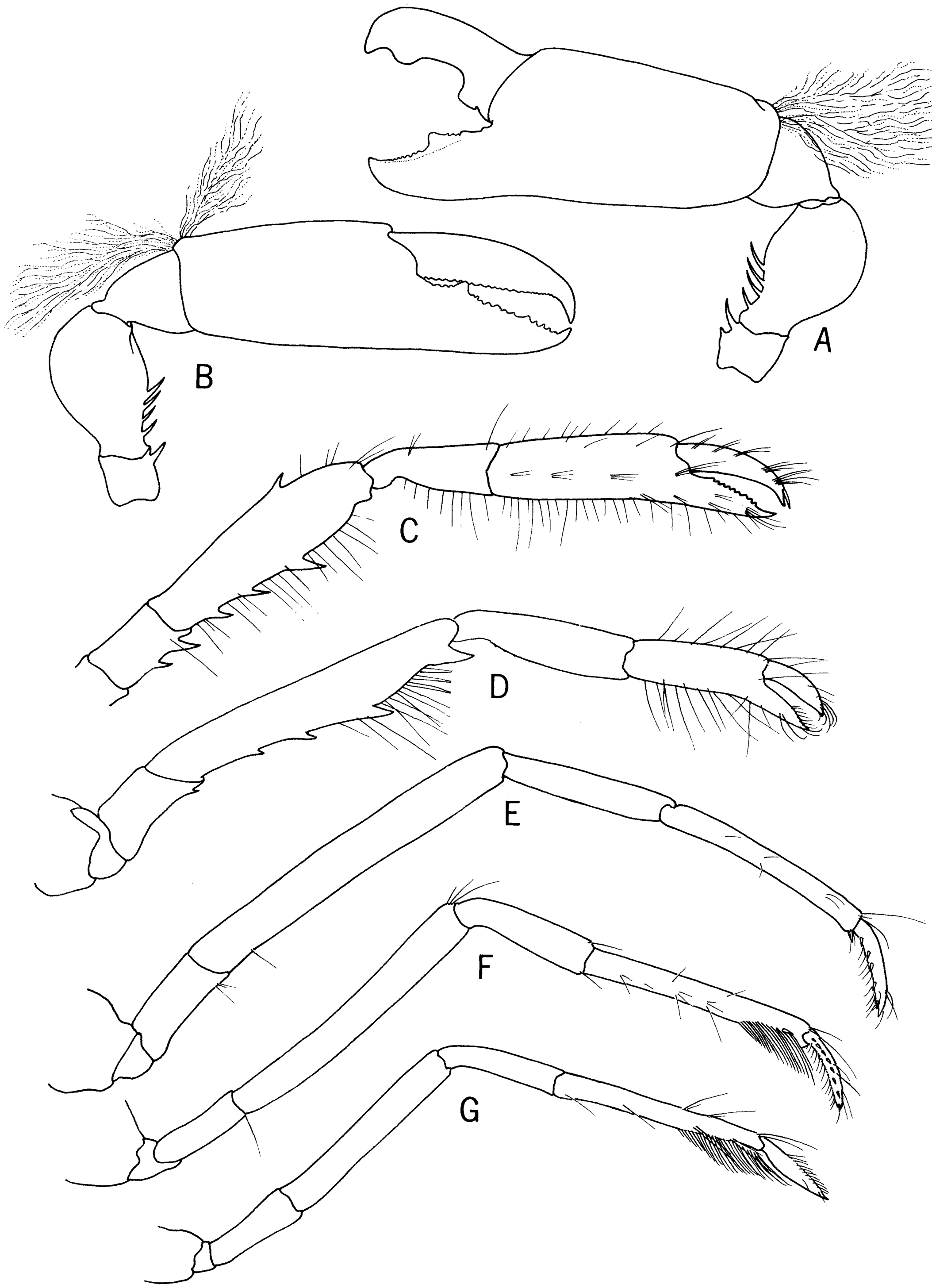

Fig. 7. *Axiorygma nethertoni,* new genus, new species: A, right pereiopod 1 ♂; B, left pereiopod 1 ♂; C, left pereiopod 1 ♀; D, pereiopod 2; E, pereiopod 3; F, pereiopod 4; G, pereiopod 5.

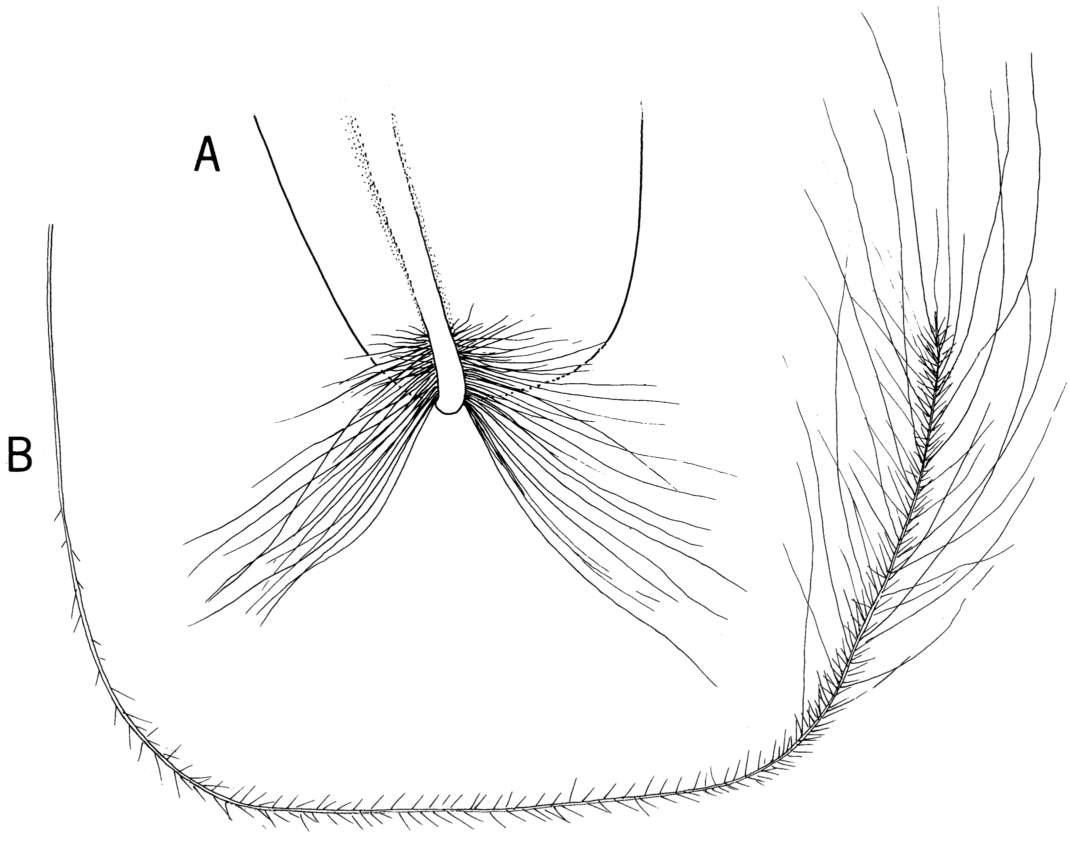

Fig 8. *Axiorygma nethertoni,* new genus, new species: A, posterodorsal part of propodus of ♂ pereiopod 1, showing position of setal tufts; B, single propodal seta. Scale = 0.2 mm.

branching setae of varying length on rounded proximal shoulder, setae proximally smooth, becoming distally setulose, setules longest distally; larger chela, dactylus more than half length of propodal palm; cutting edge of propodal fixed finger with flattened proximal area, large tooth at about mid-length followed by several small teeth, becoming crenulations distally; dactylar cutting edge bearing flattened basal tooth, broad concavity followed by rounded tooth in distal third, remainder of cutting edge finely crenulate. Smaller chela, dactylus subequal to propodal palm; cutting edge of propodal fixed finger with large tooth in proximal third, bounded by smaller teeth or finer crenulations; dactylus with three-fourths of cutting edge straight, finely crenulate, distal fourth formed by flexed apically acute tip.

Pereiopod 2 extending anteriorly to mid-length of chela of pereiopod 1; ischium with small subdistal tooth; merus with 3 or 4 spines on posterior margin becoming distally progressively larger, bearing numerous elongate ventrodistal setae; carpus unarmed, slightly shorter than chela; fingers of chela slightly more than half length of propodal palm, cutting edges finely spinulose, with tufts of distal setae.

Pereiopod 3, ischium about one-fourth length of merus; carpus half length of merus; propodus 1.5 times length of carpus, with single posterodistal spine; dactylus with 5 small spines near posterior margin.

Pereiopod 4 slightly shorter than pereiopod 3, propodus with posterodistal cluster of stiff grooming setae and single subdistal spine; dactylus with 7 small spines on mesial surface. Pereiopod 5 shorter than pereiopod 4; propodus with dense cluster of stiff grooming setae on posterodistal surface; dactylus with posterior margin twisted into almost dorsal position, bearing numerous setae.

Pleopod 1 absent. Pleopods 2–5 biramous, endopod bearing appendix interna.

Outer margin of outer uropodal ramus with 7–10 teeth, ending at larger articulating spine at start of distal suture; 6 or 7 teeth along suture; distal margin bearing elongate fringed setae. Inner uropodal ramus with 4 teeth along outer margin, distal tooth extending beyond distal margin of ramus; 4 teeth on low longitudinal middorsal ridge; distal margin bearing elongate fringed setae.

Telson with lateral margin bearing 3 teeth and small articulating spine between second and third teeth; posterolateral margin evenly convex, bearing elongate fringed setae; 3 submarginal spines at about posterolateral angle; posterior margin with single median tooth; dorsal surface with arc of 4 teeth at about midlength.

Female: similar to male, with following exceptions: median carina of carapace finely crenulate in anterior half. Pereiopod 1, chelipeds subequal, similar, slender, hardly more robust than pereiopod 2; lacking tufts of fine setae on propodi; ischium with 2 teeth on posterior margin; merus not inflated, with single tooth on anterior margin in distal half, 3 teeth on posterior margin; carpus unarmed; fingers of chela about two-thirds length of propodal palm, latter parallel-sided, fixed finger with about 9 low teeth on cutting edge; dactylus with cutting edge entire to very finely crenulate, with transparent subapical spine on outer margin reaching just beyond dactylar apex. Pleopod 1 consisting of single slender article bearing setae along both margins.

Etymology.—The species is named for Mr. John Netherton, diver extraordinary, who has contributed in many significant ways to the collection of this new species, as well as to the measurement and understanding of submarine ground-water discharge in deep coral reef ecosystems.

Ecological Notes.—Burrows of *Axiorygma nethertoni* were observed in the Florida Keys from Elliott Key in Biscayne National Park to Alligator Reef south of Key Largo National Marine Sanctuary. Based on the density and distribution of burrows, it would seem that this species is very abundant in the sand flat areas around coral heads at depths of >27 m off the Florida Keys. The distribution of holes has an unusual pattern: hole-density generally ranged between ~50–80/m^2 in depths between 30.3–37.9 m (100–125 ft), between ~20–40/m^2 in depths between 25.8–30.3 m (85–100 ft), and then ended abruptly at 25.8–27.3 m (85–90 ft). In one survey off Conch Reef (17 July 1985), hole-density averaged 52 $\pm$ 15/m^2 at 30.3 m, 27 $\pm$ 9 at 28.8 m, 4 $\pm$ 4 at 27.3 m, and no holes at 25.8 m. Measurements off French Reef and Ajax Reef showed similar distributions.

In depths of ~30 m, the holes were more dense around coral heads, but became less dense and finally disappeared, as one moved onto open sandy areas. However, at depths of ~38 m, this latter type of distribution was not as marked and holes were more evenly distributed across the bottom. The holes of this species were not found under coral heads.

The material from the west coast of Florida in the Gulf of Mexico was collected with a modified Reineck box core (0.09 m^2) and was taken in a depth range of 52.2–58.6 m, deeper than the SCUBA-collected material from the Florida Keys. The substrate varied from coarse to fine sand.

The geographic range, and the maximum depth at which this species occurs, are at present unknown. The density of holes off the keys suggests that this species is important in the transfer of material across sediment-water interfaces in coral reef ecosystems.

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ANNOUNCEMENT

"Aspects of decapod crustacean biology," A. A. Fincham and P. S. Rainbow, eds., has been published (1988) in the Symposia of the Zoological Society of London 59: i–xv, 1–375. This work contains the proceedings of a symposium held at the Zoological Society of London on 8th and 9th April 1987.

Among the subjects included in the 16 chapters are: life history strategies, evolution in larval forms, the megalopa in majid crabs, hormones in larvae, phylogeny of the brachyuran megalopa, larval sensory biology, ontogeny of anomuran eyes, stock size estimation using larvae, rhythmic behavior, physiological ecology of burrowing decapods, ecophysiology in rock pools, photoecology of pelagic decapods, trace metals, ecophysiology in mangrove swamps, environmental influences on *Nephrops* and fishery management, and lobster population biology.

Copies of this work, at approximately US$100.00, may be obtained from Oxford University Press, Walton Street, Oxford OX2 6DP, England, or Oxford University Press, 16-00 Pollitt Drive, Fair Lawn, New Jersey 07410.