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CHIROSTYLID AND GALATHEID CRUSTACEAN ASSOCIATES OF COELENTERATES AND ECHINODERMS COLLECTED FROM THE *JOHNSON-SEA-LINK* SUBMERSIBLE, INCLUDING A NEW SPECIES OF *GASTROPTYCHUS*

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Abstract.—A new species of chirostylid decapod crustacean, *Gastroptychus salvadori,* is described from a specimen collected in association with a brisingid starfish by submersible off the Bahamas. A number of other chirostylids and galatheids, collected together with their echinoderm associates in the tropical and sub-tropical western Atlantic, are also reported. Some of these associations were previously unsuspected. The collections suggest that at least some of the decapods live together as mated pairs on their hosts.

Traditional benthic sampling gears such as trawls and dredges disrupt any but the most robust associations between different animal species. Nevertheless, there are numerous reports in the literature of behavioural associations between decapod crustaceans and other benthic organisms, particularly coelenterates, sponges and echinoderms. Moreover, evidence for such associations has been found even in the fossil record (Bishop & Portell 1989). Most of these records are from relatively shallow regions, but the use of manned submersibles permits observations of such associations to be extended to deeper waters, and particularly to areas where the use of more conventional sampling techniques is precluded. Observations, photographs and collections made from the *Johnson-Sea-Link* (JSL) submersibles (Harbor Branch Oceanographic Institution, Inc.) in the tropical and sub-tropical western Atlantic during recent years have already provided data on associations between pontoniine shrimps and deep sea echinoids (Bruce 1986a, 1986b; Berggren & Svane 1989). This paper reports a small collection of galatheoid crustaceans secured along with their associates during these and other dives off the Caribbean islands of Barbados and St. Vincent. Material described herein has been deposited at the National Museum of Natural History, Smithsonian Institution (USNM) and the Harbor Branch Oceanographic Museum (HBOM).

Family Chirostylidae
Gastroptychus salvadori, new species
Figs. 1A–D; 2B, D, F

Material.—1 ovig. female (holotype USNM 239278)JSL-I-2264, off San Salvador Island, Bahamas, 24°03.61′N, 74°33.37′W, 13 Sep 1988, 874 m, associated with the brisingid starfish *Novodinia antillensis* (A. H. Clark).

Description. (Figs. 1, 2)—Carapace length excluding rostrum slightly more than greatest breadth. Branchial regions inflated so that carapace narrows both anteriorly and posteriorly. Rostrum slender, upturned, more than ⅓ length of remainder of carapace.

Linea anomurica distinct, almost straight; beneath it carapace flanks more or less evenly covered with small spines except for a small, naked, depressed area immediately above insertion of cheliped.

Above linea anomurica carapace surface covered with close-set spines, of which about 45 significantly enlarged; spination particularly dense in cardiac and branchial regions.

Regions of carapace rather clearly demarcated by grooves, carrying the following complement of enlarged spines; gastric region with 3 unpaired and about 6 paired spines; small, triangular anterolateral regions each with 1 spine; hepatic regions with 1 spine; epibranchial regions with 2 large spines; metagastric region with 1 pair of large spines and about 5 intermediate spines; branchial regions each with row of 4 or 5 moderately enlarged spines and additional large spine near mid-line; small, median, posterior, triangular "cardiac" region with pair of enlarged spines. Row of curved, dorsally directed spines along posterior carapace border which also carries about 10 small spines directed posteriorly and clearly visible in dorsal view.

Abdominal tergites covered with close-set setae, much more abundant than on carapace. First abdominal tergite narrow; posterior margin a raised, rounded ridge carrying about 30 short spines and ending in two stout, spine-like processes representing reduced pleura. Pleura of somites 2–5 well-developed, those of somite 2 being acutely tipped, with concave anterior margin, remainder becoming successively more rounded posteriorly. Second tergite with raised transverse ridge anteriorly, interrupted in mid-line and carrying spines similar to those on first tergite; this spination continued onto pleura, but becoming sparse towards tip. Third, fourth and fifth tergites with no significant spines, pleura all carrying low, blunt spines becoming more prominent posteriorly. Sixth tergite and pleura with numerous short spines, generally becoming more prominent posteriorly and about 9 projecting from posterior margin of tergite. Telson membranous, carrying setae but no spines, consisting of 2 small proximal and 2 larger distal rounded lobes so that posterior telson margin has shallow median indentation. Telson and uropods folded tightly beneath sixth abdominal somite.

Sternum narrowed anteriorly. Small plates at base of third maxillipeds each carry a single spine; kite-shaped plates between chelipeds each bear 2 prominent acute spines anteriorly and about 9 smaller ones; sternal plates between second pair of legs with blunt tubercles, those between third and fourth legs unarmed. Sternite of fifth legs atrophied.

When extended, antennular peduncle over-reaches rostrum by length of third segment; basal segment with blunt outer lobe armed with setae but no spines.

Antennal peduncle short, extending just beyond eye; basal segment with short outer spine; terminal peduncular segment with slender distoventral spine.

Coxa of third maxilliped with strong, curved spine on lower external angle; basis with short spine on inner distal margin; ischium with row of 11–12 subequal teeth on inner margin; merus with very short, slightly hooked spine on outer distal margin; carpus with blunt projection basally on outer margin; propodus and dactyl without spines.

Chelipeds and ambulatory legs long, slender, very spinous; propodus, carpus, merus and ischium each with 6 longitudinal rows of principal spines and several subsidiary rows of smaller spines.

Chelipeds about 6 times as long as carapace and rostrum. Basis with single strong ventrodistal spine. Dactyl more than $\frac{1}{3}$ length of propodus, biting edge carrying large proximal truncated spine with denticulate summit closing between two similar spines on propodus; otherwise biting edges of both propodus and dactyl armed with series of small spines which are particularly close-set distally, beyond gape.

Legs 2–4 subequal, reaching about $\frac{4}{5}$ length of carpus of chelipeds. Ratio of dactyl length to propodus length decreasing from ca. 0.3 in leg 2 to ca. 0.2 in leg 4; ratio of propodus length to carpus length increasing from ca. 1.2 in leg 2 to ca. 1.33 in leg 4. Dac-

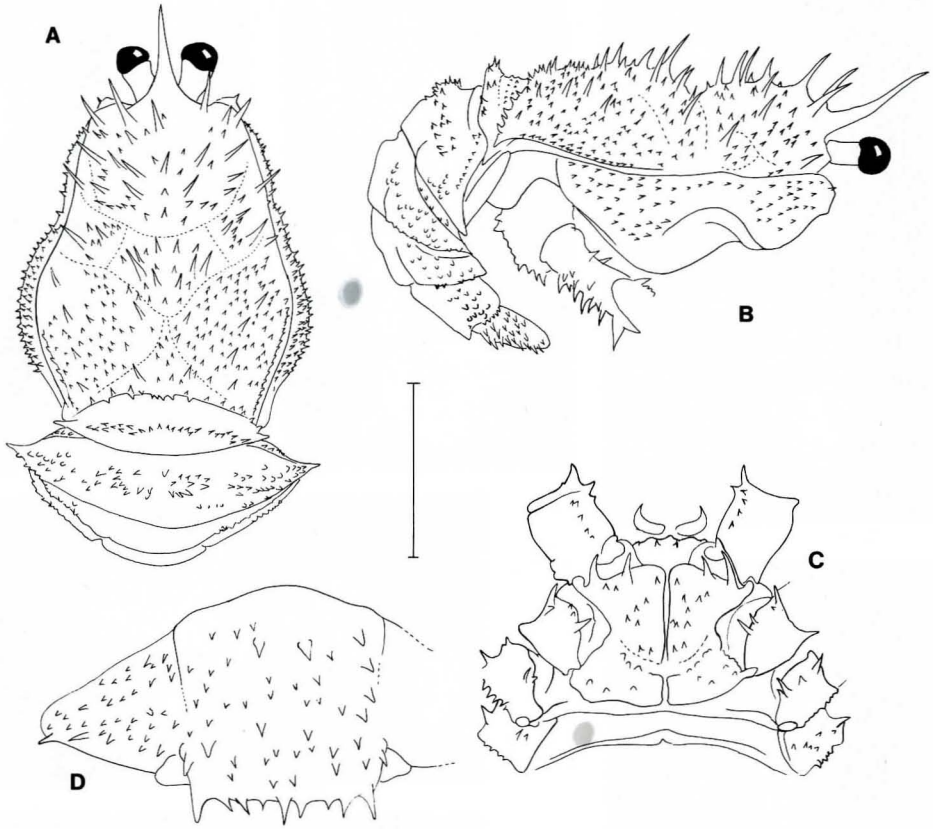

Fig. 1. *Gastroptychus salvadori,* new species. Holotype: A, dorsal view of carapace and first two abdominal tergites; B, lateral view; C, sternal plates; D, dorsal view of sixth abdominal somite. Scale equals 10 mm (A, B), and 5 mm (C, D).

tyls each with single row of 8 or 9 ventral spines regularly increasing in length distally. Propodus of each leg with 6 longitudinal spine rows of which only the ventral extends along whole length of segment: ventral rows with 20–23 spines, including distal pair between which dactyl bites; dorsal rows with 20–23 spines; ventro-lateral and ventro-mesial rows with 9–14 spines; dorso-lateral and dorso-mesial rows with 18–21 spines. Coxo-basal joints each with prominent distal and proximal ventral spines and several smaller spines.

Fifth legs greatly reduced, without spines; dactyl, propodus and carpus with long setae. Chelate, with dactyl about $\frac{1}{5}$ length of propodus.

Abdomen of holotype female carrying about 50 eggs, 1.5–2.2 mm in diameter.

Measurements of holotype.—Carapace length 22.6 mm (including rostrum), 17.5 mm (excluding rostrum), maximum carapace width 15.9 mm, total length of chelipeds ca. 135 m, left dactyl length 17.7 mm, left propodus length 45.6 mm.

Color.—In life the holotype was generally orange-red, with starkly contrasting white patches, particularly on the carapace and abdomen. The orange coloration on the legs was most intense on and at the bases of the main spine rows, with rather paler areas between the rows, giving the general impression of longitudinal stripes along the limbs. On the carapace the color was most intense

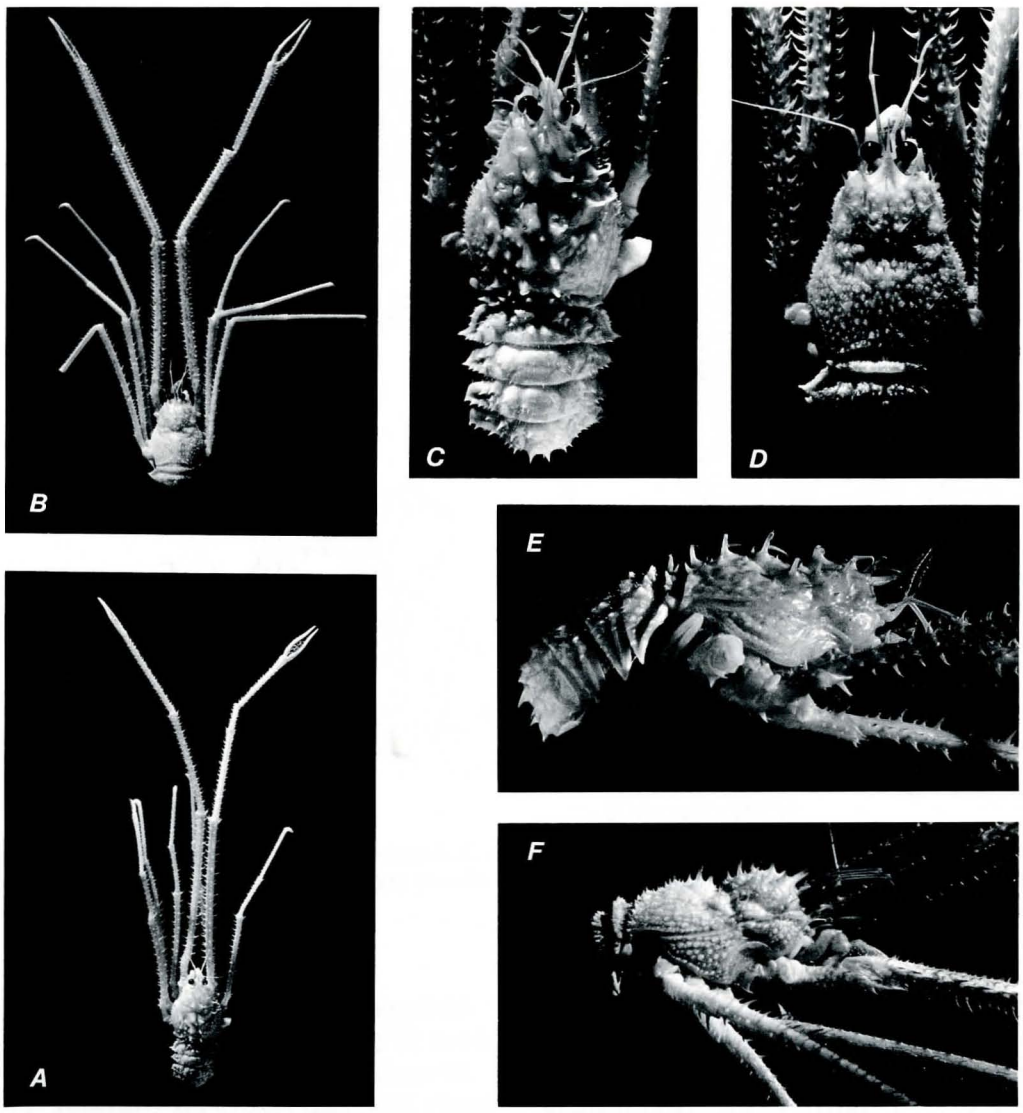

Fig. 2. Comparison of a specimen of *Gastroptychus formosus* (Filhol, 1885) (A, C, E) with the holotype of *G. salvadori* new species (B, D, F). A, B dorsal view; C, D dorsal view; E, F lateral view. A, C, E: female (carapace length including rostrum, 20 mm) collected off north-west Spain, 42°15'N, 11°22'W, Discovery Stn. 9042, 1541–1662 m, Discovery Collections, Institute of Oceanographic Sciences Deacon Laboratory, Wormley, U.K.

on the anterior half of the rostrum, on the gastric and hepatic regions and on the cardiac region. The coloration was much less intense on the branchial regions, while pure white areas were present at the base of the rostrum, across the frontal region, on the antero-lateral regions, across the region of the cervical groove and the epibranchial regions, and along the posterior carapace margin. The anterior part of each abdominal tergite was also white.

Remarks.—The chirostylid species traditionally placed in the genus *Chirostylus* Ortmann, 1892 (e.g., Van Dam 1933, Chace 1942) were separated into two genera by Miyake & Baba (1968); three species lacking

Table 1.—Comparison of *Gastroptychus salvadori,* new species, with Atlantic congeners.

	G. spinifer	*G. affinis*	*G. formosus*	*G. salvadori*
Carapace				
Max. length	30+ mm	11 mm	25+ mm	23 mm
Spination	dense	sparse	sparse	dense
Enlarged spines	ca. 20	<20	ca. 25	>40
Chelipeds				
Total length	4.4–7.1 × CL	3.5–5.6 × CL	5–6 × CL	ca. 6 × CL
Merus L/W ratio	?	?	ca. 21	ca. 14
Dactyl/propodus length	?	?	ca. 0.3	ca. 0.4
Abdominal tergites				
1	unarmed	unarmed	ca. 10 spines	>20 spines
2	unarmed	unarmed	ca. 15 spines	>25 spines
3	unarmed	unarmed	ca. 10 spines	ca. 10 spines
4	unarmed	unarmed	ca. 10 spines	ca. 50 spines
Sternal plates	1–2 large spines	1 large spine	2–3 large spines	2 large + ca. 10 small spines
3rd maxillipeds				
Merus outer spine	prominent	prominent	prominent	very small
Carpus outer spine	prominent	prominent	prominent	absent

a distinct rostrum were retained in the genus *Chirostylus,* while those species with a distinct spiniform rostrum were transferred to the genus *Gastroptychus* Caullery, 1896. The latter genus, as it is now constituted (Baba 1988, Baba & Haig 1990), contains 17 species, three of which are reported from the Atlantic: *G. spinifer* (Milne Edwards, 1880) and *G. affinis* (Chace, 1942) being restricted to the West Indian region (Chace 1942, Springer & Bullis 1956), while *G. formosus* (Filhol, 1885) is reported from the Eastern Atlantic in the Bay of Biscay and off the coast of Ireland and the Canaries (Selbie 1914). These species can be distinguished from one another, and from *G. salvadori,* by a combination of overall size, spination of the carapace, abdominal tergites, sternum and third maxillipeds, and the relative length and robustness of the chelipeds (Table 1).

Of the three previously described *Gastroptychus* species, *G. salvadori* is most similar to *G. formosus,* both species having some of the abdominal tergites armed with spines, whereas these tergites are totally unarmed in *G. affinis* and *G. spinifer.* Moreover, while *G. affinis* and *G. spinifer* both have a row of enlarged spines along the mid-dorsal line of the carapace, such a median row is not a feature of either *G. formosus* or *G. salvadori.*

G. salvadori differs from *G. formosus* in having rather more robust chelipeds and in being generally much more spinous (Fig. 2). Thus, the dorsal and lateral surfaces of the carapace in *G. salvadori* are everywhere covered with rather close-set spines of which about 40 are significantly enlarged; in *G. formosus* only about 25 of the carapace spines are significantly enlarged, while the smaller subsidiary spines are sparse on the branchial region and virtually absent from the gastric, hepatic and epibranchial regions. Similarly, while the first and second abdominal tergites in both *G. salvadori* and *G. formosus* each carry a transverse irregular series of spines, these are much smaller and more numerous in *G. salvadori.* The pleural plates of the third to sixth abdominal somites are armed with a series of spines, becoming more pronounced posteriorly in both species; again, these are much smaller, but

more abundant in *G. salvadori* than in *G. formosus.* The only exception is the tergite of the fifth abdominal somite which carries 4 pairs of prominent spines close to the mid-line in *G. formosus* [not unarmed as Selbie (1914:63) suggests], whereas this tergite is furnished only with setae in *G. salvadori.* The tergite of the sixth abdominal somite carries about 12 large spines in *G. formosus,* including three on the posterior margin, while this tergite in the holotype of *G. salvadori* carries about 50 small spines, of which nine are ranged along the posterior margin.

The sternal plates between the chelipeds are also quite different in the two species. In both cases the anterior border, close to the insertion of the cheliped, carries two very prominent spines on each side. However, whereas in *G. formosus* there is an additional large spine posteriorly near the mid-line, this spine is replaced by a series of about 10 smaller spines in *G. salvadori.*

Finally, the meral and carpal joints of the third maxillipeds each carry a prominent spine distally on the outer margin in *G. formosus,* as in *G. spinifer* and *G. affinis,* but in *G. salvadori* the carpus is unarmed, while the merus has only an extremely small hooked spine in this position.

Etymology.—Named for the type locality, San Salvador Island, Bahama Islands.

Habitat notes.—When first sighted from the submersible, the chirostylid was sheltering on the sediment surface at the base of a large mass of the oculinid coral, *Madrepora carolina* (Pourtalès). On the surface of the coral there were a number of large (ca. 70 cm diameter) specimens of the brisingid seastar *Novodina antillensis,* several of which were collected. As one of the brisingids was being lifted from the coral with the submersible's manipulator arm, the chirostylid 'leapt' onto the starfish and was collected along with it.

The general orange-red color of the chirostylid, traces of which remain on the spine tips in the preserved specimen, closely matched that of the brisingid but contrasted starkly with the very pale, almost white, coloration of the coral. This color match, along with the spinous morphology and the curious behaviour of the chirostylid, suggests that *G. salvadori,* and perhaps other *Gastroptychus* species, may live in close association with brisingids or similar organisms. The abundant spination of the body, and particularly the limbs, in the genera *Chirostylus* and *Gastroptychus,* on the other hand, would seem to be disadvantageous if they lived on finely branching organisms such as gorgonians. Such organisms are known to be frequented by relatively smooth-bodied chirostylids such as *Uroptychus* (e.g., Pequegnat & Pequegnat 1970: 161). However, an uncollected chirostylid which appears to belong to *G. salvadori* was photographed from the *Johnson-Sea-Link* on a species of the arborescent gorgonian genus *Keratoisis* (family Isididae) some 40 nautical miles east of Fort Pierce, Florida at a depth of 731 m. Clearly, *Gastroptychus* species also crawl over such branching organisms, through the color match in this case between the galatheid and the gorgonian was much less close than that between the holotype and the brisingid.

Uroptychus capillatus Benedict, 1902

Material.—1 male, 1 ovig. female (USNM 252390), 1 male, 1 ovig. female (HBOM 089:6819), JSL-I-2260, off Conception Island, Bahamas, 23°48.8′N, 75°08.1′W, 11 Sep 1988, 573 m; associated with the comatulid crinoid *Crinometra brevipinna* (Pourtalès) (see Discussion).

Remarks.—*U. capillatus* has been reported previously only twice in the literature, originally by Benedict (1902) from an *Albatross* station near Arrowsmith Bank off the east coast of Yucatan, and subsequently by Chace (1942) from an *Atlantis* station off the north coast of Cuba. Although Benedict mentioned two specimens in his rather inadequate original account, one of these seems to have disappeared by the 1940s

since Chace refers only to "Benedict's type" (a female in rather poor condition) in addition to his own single specimen, an ovigerous female, pointing out that both individuals lack chelipeds. The specimens reported here agree closely with Benedict's type (USNM 20565) and, together with the type, will be used as the basis for a redescription of the species, including the male (Rice, in prep.).

The morphologically similar congener, *Uroptychus rugosus* (A. Milne Edwards, 1880), also from the Caribbean region, is reported to live commensally with a crinoid, probably *Stylometra spinifera* (Chace, 1942).

Family Galatheidae
Munidopsis abdominalis
(A. Milne Edwards, 1880)
Fig. 3A, B, C

Material.—1 male, 1 ovig. female (USNM 239277), JSL-I-2269, off Crooked Island, Bahamas, 22°41.5'N, 74°20.8'W, 16 Sep 1988, 569 m, on a specimen of the echinoid *Cidaris blakei* (A. Agassiz) (see Fig. 3A). 1 male (USNM 239273), JSL-I-2269, as above, 543 m, on *Cidaris blakei* (Fig. 3B). 1 male (USNM 239276), JSL-II-1733, off Bridgetown, Barbados, 13°00.70'N, 59°39.53'W, 18 Apr 1989, 417 m, on *Cidaris blakei.* 1 male, 1 ovig. female (HBOM 089:06820), JSL-II-1743, off York Bay, St. Vincent, 13°07.2'N, 61°17.04'W, 23 Apr 1989, 408 m, on *Cidaris rugosa* (H. L. Clark) (Fig. 3C).

Remarks.—Both *M. abdominalis* and *C. blakei* were originally described from material collected during the three cruises of the *Blake* in 1877–1880, the decapods having been taken at a station off Barbados (Milne Edwards 1880) and the echinoid at several localities off the coast of Cuba (Agassiz 1878). *Cidaris blakei* has been taken subsequently at a number of localities in the Florida-West Indian region at depths from 150 and 790 m (Serafy 1979), while *M. abdominalis* has been reported from off Cuba, St. Kitts and from the Straits of Florida at depths from 366 to 622 m (Chace 1942, Mayo 1974). Moreover, Mayo reported that one of the stations at which *M. abdominalis* was collected was "characterized by sea urchins," though she did not identify the species. Thus, although a behavioral association between *M. abdominalis* and *C. blakei* has not been referred to previously, it may be common, if not usual.

Munidopsis alaminos
Pequegnat & Pequegnat, 1970
Fig. 3D

Material.—1 male, 1 ovig. female (HBOM 089:06821), JSL-II-1735, off Speightstown, Barbados, 13°14.9'N, 59°45.2'W, 19 Apr 1989, 722 m, associated with the holothurian *Mesothuria gargantua* Diechmann (Fig. 3D).

Remarks.—*Munidopsis alaminos* is recorded at depths ranging from about 500 m to more than 800 m in the western Atlantic and Caribbean region, from the coast of French Guiana to the northern Gulf of Mexico (Pequegnat & Pequegnat 1970, 1971; Mayo 1974). It has not been previously reported in association with any other organism.

Munidopsis spinifer
(A. Milne Edwards, 1880)
Fig. 3E, F

Material.—1 ovig. female (USNM 239275), JSL-I-2261, off Conception Island, 23°50.8'N, 75°09.6'W, 12 Sep 1988, 741 m, on the crinoid *Crinometra brevipinna* (Fig. 3E). 1 male (HBOM 089:06822); JSL-I-2269, off Crooked Island, 22°41.5'N, 74°20.8'W, 16 Sep 1988, 594 m, on *Crinometra brevipinna* (Fig. 3F). 1 juv. female (USNM 239274), JSL-II-1747, off York Bay, St. Vincent, 13°07.2'N, 61°16.8'W, 25 Apr 1989, 415 m, on *Crinometra brevipinna.*

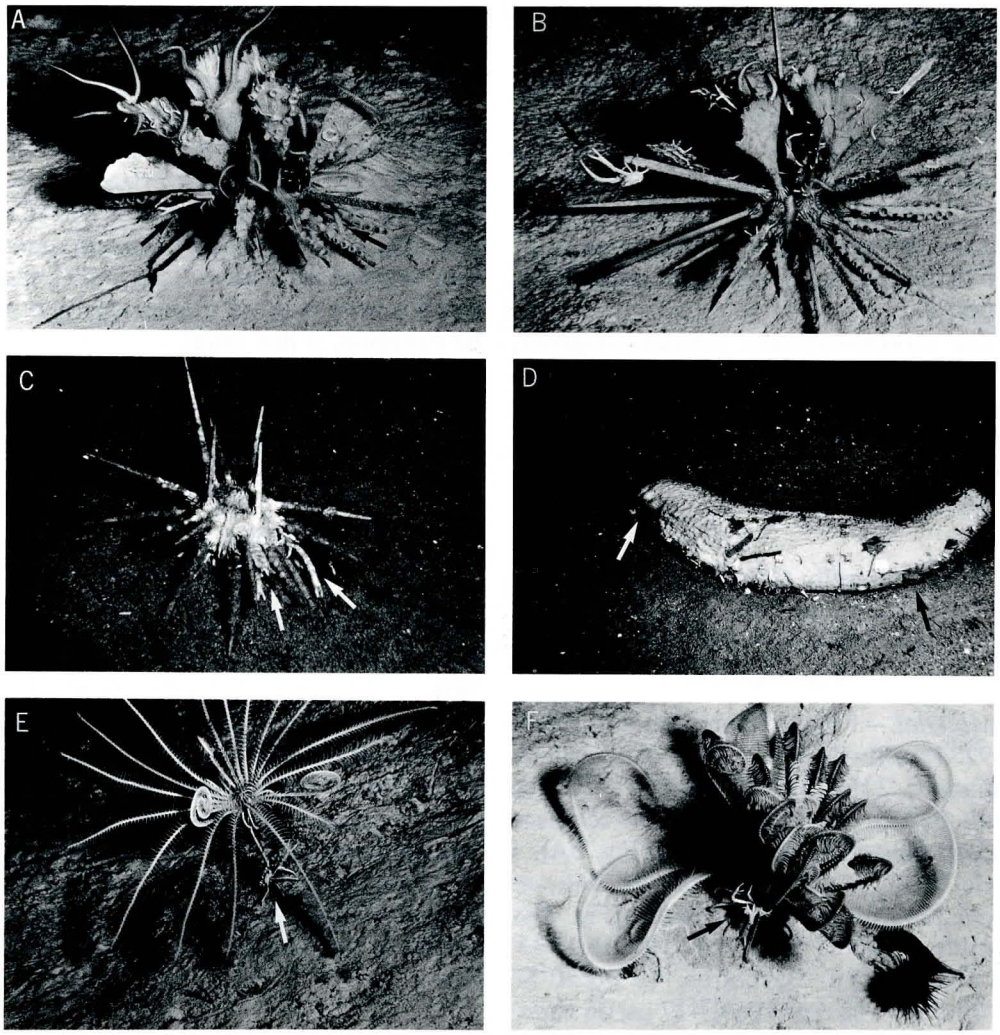

Fig. 3. Photographs of decapods (arrowed) and their echinoderm hosts, taken from the *Johnson-Sea-Link* submersible: A, *Munidopsis abdominalis* wth *Cidaris blakei,* JSL-I-2269, 569 m; B, same as A, 543 m; C, *Munidopsis abdominalis* on *Cidaris rugosa,* JSL-II-1743, 408 m; D, *Munidopsis alaminos* on *Mesothuria gargantua,* JSL-II-1735; E, *Munidopsis spinifer* on *Crinometra brevipinna,* JSL-II-2261, 741 m; F, *Munidopsis spinifer* on *Crinometra brevipinna,* JSL-I-2269, 594 m.

Remarks.—*Munidopsia spinifer* is recorded in the western Atlantic from the Bahamas and the Straits of Florida, and off the Greater and Lesser Antilles from Cuba to Barbados in depths ranging from 275 m to 880 m (Milne Edwards & Bouvier 1897, Chace 1942, Mayo 1974).

Mayo reports the species as being strikingly pigmented orange-red contrasting with white. The contrast appears as longitudinal banding on the chelipeds and ambulatory legs, as in *Chirostylus salvadori,* but whereas the banding on the carapace and abdomen in *C. salvadori* is transverse, it is longitudinal in *M. spinifer.* Thus, the rostrum and frontal region of *M. spinifer* are orange-red, with this pattern extended posteriorly as broad bands on either side of the mid-line.

These bands are continued onto the abdominal somites, with white bands medially and on the lateral margins.

Discussion

There are numerous records in the literature of behavioral associations between galatheoid decapods and other organisms, particularly coelenterates and echinoderms (Milne Edwards 1880; Chace 1942; Baba 1974, 1979, 1988; Pequegnat & Pequegnat 1970). Where the species concerned are littoral or shallow-living, these records are frequently based on direct observations and are therefore unequivocal [e.g., records of *Allogalathea elegans* (Adams & White, 1848), associated with crinoid genera, as cited by Baba (1979, 1988)]. For deeper-living forms, the records are based largely on trawl and dredge hauls and are often less convincing. Thus, although there is rather strong evidence for an association between *Uroptychus nitidus* (A. Milne Edwards, 1880) and the gorgonian coral genus *Chrysogorgia* (see Pequegnat & Pequegnat 1970) and between *Gastroptychus novaezelandiae* Baba, 1974 and the pennatulid *Balticina willemoesii* (see Baba 1974), the evidence for a similar association between *Uroptychus rugosus* (A. Milne Edwards, 1880) and crinoid species, as reported by Chace (1942), is largely circumstantial. Nevertheless, the direct observations reported here, along with the indirect evidence, suggest that some form of commensalism is characteristic of many if not most species of galatheid and chirostylid decapods. This may even be true of the smaller species of genera such as *Munidopsis,* in which commensalism has never been reported before, though this life-style is, perhaps, not to be expected of the deeper-living and larger representatives of the genus.

Moreover, three of the five decapod species reported here were collected in pairs, in each case consisting of a male and an ovigerous female, apparently monopolizing a single host specimen. This raises the intriguing possibility that the animals may form permanent or semi-permanent breeding relationships, a situation never described before in this group.

Acknowledgments

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