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NOTES ON THE DISTRIBUTION AND BIOLOGY OF GALATHEIDAE AND CHIROSTYLIDAE (DECAPODA: ANOMURA) FROM THE MIDDLE ATLANTIC BIGHT

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ABSTRACT

Twelve species of Galatheidae and one species of Chirostylidae numbering 6,928 individuals were retrieved from trawl collections made on the continental shelf, slope, and rise in the Middle Atlantic Bight. The most abundant species collected was *Munida iris iris* which constituted >90% of the total catch of galatheoidean anomurans. Three other species (*Munidopsis rostrata, Munida valida,* and *Munida longipes*) comprised >1% of the total number of Galatheoidea. The bathymetric distribution of *Munidopsis* spp. was confined to depths >500 m, whereas all except two *Munida* spp. were collected from the continental shelf and upper slope.

Munida spp. and *Eumunida picta* produced large numbers of small eggs, whereas eggs from *Munidopsis* spp. were large and few in number. Ovigerous females of all species examined, except *Munida microphthalma* and *Eumunida picta*, had larger carapace lengths than males and other females. For most species, there was little evidence of reproductive seasonality since ovigerous females were collected throughout the year; however, ovigerous females of *Munida longipes, Munidopsis bairdii,* and *Eumunida picta* were collected only in fall or winter.

Parasites of Galatheoidea were mainly bopyrid isopods and rhizocephalan barnacles. The incidence of parasitism was low for all species examined.

Galatheoidean crustaceans (excluding Aeglidae and Porcellanidae) in the Middle Atlantic Bight constitute a major portion of the decapod fauna from the outer continental shelf out to the continental rise. However, much of the literature available on the Galatheoidea entails records of geographic occurrences and descriptions of species. Early descriptions of Galatheoidea from the Western Atlantic, Caribbean Sea, and Gulf of Mexico, based on specimens from the "*Blake*" and "*Albatross*" collections, were made by Milne Edwards (1880), Milne Edwards and Bouvier (1897), and Smith (1882, 1883, 1884, 1885, 1886). Other major systematic works on Galatheoidea that included species from the Western Atlantic are those by Benedict (1902), Chace (1942), Pequegnat and Pequegnat (1970, 1971), and Mayo (1974).

Although the systematic coverage of the Galatheoidea has been extensive, information on the biology of the group is limited and has been mainly concerned with their parasitization by bopyrid isopods and rhizocephalan barnacles (e.g., Markham, 1973, 1975; Reinhard, 1950, 1958; Williams and Brown, 1972; Wenner and Windsor, 1979). This paper provides information on the geographic and bathymetric distribution, reproduction, and parasites of the Galatheidae and Chirostylidae collected between Cape Cod and Cape Hatteras. For completeness, I have included information on species found within the study area but not collected or examined by me.

MATERIALS AND METHODS

Specimens were retrieved from 280 trawl collections made at randomly selected locations within depth strata bounded by the 75 m, 150 m, 400 m, 1,000 m, 2,000 m, and 3,000 m isobaths. Most (180) collections were made on the continental shelf, slope, and rise in the immediate vicinity of Norfolk

Canyon (36°56.0'–37°09.0'N) and from an area south of the canyon (36°32.4'–36°38.7'N) during June 1973, November 1974, September 1975, and January 1976. Additional collections were made near Tom's Canyon (38°18.0'–39°10.0'N) in May 1974 and in an area extending from 33°40.5'–38°59.0'N during April 1973 and 1974, and July 1975. Trawl tows were made with a 13.7-m or 9.1-m (head-rope) semiballoon, four-seam otter trawl. Tow duration was 0.5 h in depths <2,000 m. Bottom temperatures were recorded by bathythermograph, expendable bathythermograph, reversing thermometer, or a salinity-temperature-depth unit.

Sex of specimens was determined by examining the second pleopods (Williams and Brown, 1972) and the gonads. Ovaries were classified into the following developmental stages: *immature*-ovary thin, threadlike and nearly transparent, consisting of a thin strip of tissue dorsal to the digestive gland; *intermediate*-ovary thicker, enlarged, and opaque with distinct ova visible and containing some yolk; *advanced*-ovary greatly enlarged, nearly covering the dorsal surface of the digestive gland, filled with vitellogenic oocytes whose outlines are distinct and with small developing oocytes located on the dorsal surface of the ovary; *spent*-ovary flaccid and reduced, filled with many developing previtellogenic oocytes as well as a few large atretic ova.

Fecundity was determined by total counts of eggs from the pleopods of species with a few large eggs or by a volumetric estimate (Wenner, 1978) for species with many small eggs. Fifteen eggs from each ovigerous female were measured with an ocular micrometer. The presence of sperm in each male was determined from squash mounts of histological sections of testes preserved in Davidson's fixative. Males were frequently found with spermatophore masses extruding from the gonopore or present on the spoon-shaped first pleopods. This condition is probably indicative of sexual maturity as well as the "ripe" condition in males.

Carapace length (CL), defined as the distance from the posterior orbital margin to the posterior carapace margin at the dorsal midline, was measured on all individuals. Significant differences of sex ratios from unity were determined by Chi-square analysis using Yates correction for continuity (Woolf, 1968). Analysis of variance and Scheffé's multiple mean comparison test (Guenther, 1964) were used to determine significant size differences between male, female, and ovigerous females, as well as to determine significant differences between transformed [$\log_{10}(x + 1)$] mean abundance for designated depth intervals.

Results and Discussion

Twelve species of Galatheidae and one species of Chirostylidae constituting 6,928 individuals were collected in this study. Five additional species not collected by me have been reported from the area between Cape Cod and Cape Hatteras. Among all Galatheoidea collected, *Munida iris iris* was by far the most abundant species with 6,483 individuals. Only three other species constituted >1.0% of the total number of Galatheoidea collected: *Munidopsis rostrata* (2.2%), *Munida longipes* (1.3%), and *Munida valida* (1.3%). Detailed information on depth distribution and biology of all Galatheidae and Chirostylidae collected is presented in the following species accounts.

Family Galatheidae

Galathea rostrata A. Milne Edwards, 1880

Galathea rostrata has been reported at depths of 18–92 m from the continental shelf off Cape Hatteras, North Carolina, to southeastern Florida, and in the Gulf of Mexico from western Florida, the Mississippi Delta, and off Yucatan, Mexico. A questionable record of *G. rostrata* off Rhode Island at 2,156 m was mentioned by Williams (1965). It is evidently very rare within the Middle Atlantic Bight, and none were collected during my study.

Gore (1979) provided the first description of complete larval development in *G. rostrata*.

Munida forceps A. Milne Edwards, 1880

Only a single male specimen of *Munida forceps* was collected at 252 m. The occurrence of this specimen south of Norfolk Canyon (36°43.2'N, 74°38.0'W) extended the geographic range of the species northward from the southwestern Atlantic by 10° latitude (Laird *et al.*, 1976). *M. forceps* has previously been reported from the Gulf of Mexico at depths of 80–338 m and in the southwestern Atlantic between 22°46.5′ and 26°37.0′N (Chace, 1940, 1942; Springer and Bullis, 1956; Bullis and Thompson, 1965). Roberts (1977) reported *M. forceps* as a member of the upper continental slope community within the northeastern Gulf of Mexico at depths of 203–476 m. He estimated the abundance of the species to be 29 individuals per hectare at these depths.

Munida iris iris A. Milne Edwards, 1880

The most abundant galatheid, *Munida iris iris*, has been collected between 86 and 549 m. Its geographic range extends as far north as Martha's Vineyard, as far south as the mouth of the Amazon River, throughout the Caribbean Sea, and in the SE Gulf of Mexico (Chace, 1942; Pequegnat and Pequegnat, 1970). Although *M. i. iris* was collected from depths of 45–932 m in the Middle Atlantic Bight, 58% of the individuals were collected from 200–399 m. A detailed study on the distribution, size, sex composition, and reproduction of *M. i. iris* is currently being completed and will be discussed elsewhere.

The frequency of parasitization of *M. i. iris* by bopyrid isopods was first documented by Williams and Brown (1972), who reported a 10% incidence of infestation by *Anuropodione* sp. Based on specimens from the present study the incidence of parasitization by *Anuropodione carolinensis* was found to be markedly lower (2.2–5.0%) (Wenner and Windsor, 1979). Bursey (1978) also found a low incidence of infestation (2%) by *Munidion irritans* for *M. i. iris* collected between Hudson and Norfolk Canyons.

Additional parasites found on *Munida i. iris* included *Fecampia* sp. (Rhabdocoela: Turbellaria) which was found on four individuals, and the undescribed rhizocephalan barnacles *Lernaeodiscus* spp. (A) and (B) and *Cyphosaccus* sp. (A) (A. Veillet, Université de Nancy, personal communication). *Cyphosaccus* sp. (A) and *Lernaeodiscus* sp. (B) were each found on one individual while *Lernaeodiscus* sp. (A) occurred on eight individuals.

Munida i. iris has been reported as a host for *Lernaeodiscus schmitti* by Reinhard (1950); however, no reports of infestation of *M. i. iris* by *Cyphosaccus* have been published. The only other species of *Munida* from the western North Atlantic known to be a host for this genus of rhizocephalan parasite is *Munida irrasa* infested by *Cyphosaccus chacei* (Reinhard, 1958).

Munida irrasa A. Milne Edwards, 1880

Although *Munida irrasa* was not present in any collection made within the study area, it has been reported from North Carolina by Hay and Shore (1918) and Williams (1965). Its geographic range extends in the western Atlantic from North Carolina (Hay and Shore, 1918) through the West Indies to Barbados and Grenada (Chace, 1942). It also has been reported in the SE Gulf of Mexico and Caribbean from Cuba to Colombia and Venezuela. Reported depths of collection for *M. irrasa* extend from 54–468 m (Pequegnat and Pequegnat, 1970).

Ovigerous females were collected off southeastern Florida in July and off North Carolina in September (Williams, 1965). Pequegnat and Pequegnat (1970) reported that one ovigerous female was taken during July in the southeastern Gulf of Mexico.

Munida irrasa is parasitized by the rhizocephalans *Cyphosaccus chacei* and *Boschmaia munidicola* (Reinhard, 1958). Markham (1975) reported the bopyrid

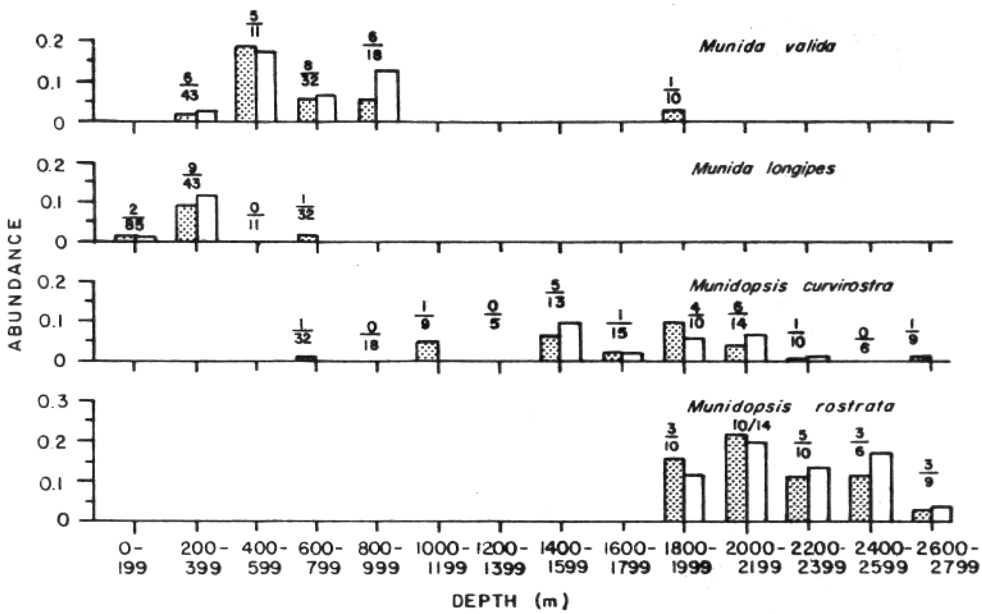

Fig. 1. Abundance, expressed as $\log_{10}(x + 1)/0.5$ h tow, by depth of capture for dominant galatheids from the Middle Atlantic Bight. Fraction above each bar indicates number of tows in which the species was captured (numerator) and total number of tows within a given depth range (denominator).

isopod *Munidion irritans* from *M. irrasa* off the Atlantic coast of Florida and near British Honduras.

Munida longipes A. Milne Edwards, 1880

Within the Middle Atlantic Bight, 92 *Munida longipes* were collected at depths from 175 m (12.6°C) to 613 m (5.0°C) (Fig. 1) between 36°37.6′N, 74°41.2′W and 37°08.5′N, 74°32.8′W. A statistically significant increase in abundance occured at 200–399 m ($F = 6.297$; $df = 3, 167$; $p < 0.05$). Similar findings were reported by Roberts (1977) who found *M. longipes* to be abundant within depths of 203–476 m on the upper continental slope within the northeastern Gulf of Mexico.

Chace (1942) reported *M. longipes* to be one of the commonest species of *Munida* from the western Atlantic where it has been collected from off Beaufort, North Carolina (Hay and Shore, 1918), to the Bahamas and Lesser Antilles (Chace, 1942). It has also been found throughout the Gulf of Mexico and in the Caribbean off British Honduras. The reported depth range for this species is 270–729 m (Pequegnat and Pequegnat, 1970).

Males, females, and ovigerous females were found to differ significantly in size from each other (Fig. 2, Table 1). The overall sex ratio of males to females was significantly different from unity (Table 1).

A total of 54 ovigerous females were collected in January, September, and November, although most (83%) were taken in January. Egg development was also most advanced (eye and abdomen discernible) in individuals collected during January. Examination of gonads from ovigerous females revealed that 41% were spent in January. The smallest ovigerous female collected was 11 mm CL. Fecundity of *M. longipes* ranged from 2,693 eggs on a 15 mm CL female to 9,327 eggs

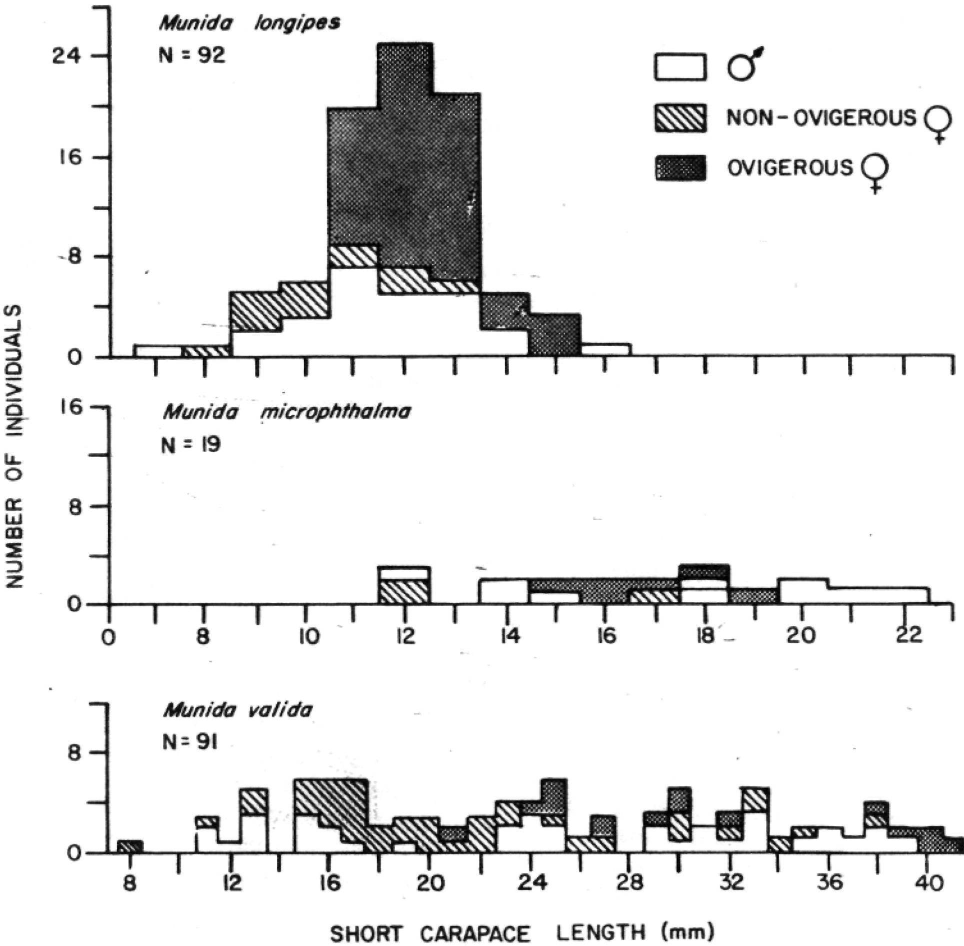

Fig. 2. Length frequency distribution of the most common *Munida* spp. collected by otter trawl survey in the Middle Atlantic Bight.

on a 14 mm CL individual. Egg diameters ranged from 0.49–0.68 mm. The most advanced ovarian condition of nonovigerous females was observed in November in a 12 mm CL female.

Spermatophores were present in the vasa deferentia of males ranging from 9.4–14.0 mm. One male, 7.5 mm CL, had sperm present in the testes but no spermatophores were seen in the vasa deferentia. Males which were observed with spermatophores extruding from the gonopores were 10.7–14.0 mm CL.

A male *Munida longipes*, 13.2 mm, was infested with the bopyrid *Munidion longipedis*. *Munida longipes* is also the host for another bopyrid, an undescribed species of *Pseudione* which occurs throughout the range of *Munidion longipedis* (Markham, 1975). Chace (1942) mentions the occurrence of "branchial parasites" on specimens of *M. longipes* from the West Indies, but Markham (1975) does not mention what species of bopyrid these might be.

A rhizocephalan parasite was also noted on a 14.5 mm male *M. longipes*. The parasite has been tentatively identified as either *Lernaeodiscus* sp. (C) or *Trian-*

gulus sp. (A. Veillet, Université de Nancy, personal communication). Chace (1942) mentioned the presence of "abdominal parasites" on individuals from the West Indies, but I could find no further mention of this species as a host for Rhizocephala. Although Chace (1942) noted that the male pleopods had become feminized due to parasitization, no such morphological alteration was noted in the parasitized male from this study.

Munida microphthalma A. Milne Edwards, 1880

In the Middle Atlantic Bight, individuals were collected between 36°40.6′N, 74°37.4′W and 37°05.5′N, 74°31.5′W at depths of 750 m (4.7°C) to 1,698 m (3.8°C). Fourteen of the 19 individuals collected were taken at 1,440 m (3.9°C). *Munida microphthalma* has previously been reported from the West Indies off Martinique and St. Vincent to the Gulf of Mexico at depths of 666–1,854 m (Chace, 1942). Pequegnat and Pequegnat (1970) noted its occurrence in the western Gulf of Mexico at 1,463 m. Chace (1942) stated the probable occurrence of the species from south of Iceland (194–2,059 m) and in the eastern Atlantic from the Bay of Biscay to Cape Verde Islands and Ascension Island (617–2,129 m).

Males, females, and ovigerous females did not differ significantly from each other in CL (Fig. 2, Table 1). The sex ratio did not differ significantly from 1.1 (Table 1).

Nonovigerous females with advanced stage ovaries were present in September and November collections. Advanced ovaries occurred in females as small as 12 mm and the length at which individuals became ovigerous was 15 mm. Ovigerous females were present in May and November. The fecundity of *M. microphthalma* ranged from 1,210–3,085 eggs for 16.0 and 16.7 mm individuals, respectively. The high variability in number of eggs between individuals of similar size is probably due to loss of eggs during capture. Egg diameters were 0.58–0.67 mm. The smallest male examined contained spermatophores in the vasa deferentia.

One male *Munida microphthalma,* 14.7 mm, was parasitized with *Bonnieria americana*. Infestation of this galatheid by *B. americana* is not uncommon, since the species was reported as a host by Markham (1973, 1975). Alteration of the male secondary sexual characters by the bopyrid was evident, because the first and second pleopods were feminized. Nevertheless, microscopic examination of contents within the vasa deferentia revealed the presence of spermatophores.

Munida valida Smith, 1883

Ninety-two *Munida valida* were collected between 34°05.5′N, 75°52.3′W and 39°09.0′N, 72°19.5′W at depths from 313 m (8.0°C) to 1,823 m (2.4°C) (Fig. 1). Analysis of variance indicated no significant difference in transformed mean abundance among depth intervals ($F = 2.662$; $df = 8, 146$; $p > 0.05$). The greatest number of *M. valida* were caught south of Cape Hatteras near 34°N. Rowe (1971) mentioned that *M. valida* is one of the most common epifaunal invertebrates of the Hatteras continental slope but is usually rare or absent in the Hatteras submarine canyon. The species is generally confined to a narrow bathymetric zone along the continental slope (Rowe and Menzies, 1969) where individuals are oriented into the current (Rowe, 1971). The species also occurs in considerable numbers off New England where Haedrich, Rowe, and Polloni (personal communication) collected 175 *M. valida* at 10 stations between 121 and 2,297 m.

The distribution of *Munida valida* extends from Georges Bank (41°20′N,

Table 1. Results of statistical tests to determine whether mean carapace lengths of Galatheoidea in samples differed significantly between males, females, and ovigerous females, and whether the sex ratio significantly differed from unity. The F statistic and degrees of freedom (df) for Model I single classification analysis of variance are shown, as well as the chi-square (χ^2) statistic for analysis of frequencies.

Species	Mean size (mm)			F	df	Sex ratio (M:F)	χ^2
	♂	♀	Ovig. ♀				
Munida longipes	11.9	10.7	12.9	13.60*	2/89	1:2.5	16.53*
Munida microphthalma	17.4	15.8	17.3	0.38	2/16	1:1.1	<0.01
Munida valida	25.1	21.7	31.0	7.90*	2/88	1:1.6	3.9*
Munidopsis bairdii	23.6	22.3	30.7	6.28*	2/22	1:0.9	0.04
Munidopsis curvirostra	10.6	10.9	12.3	4.82*	2/33	1:1.3	0.43
Munidopsis rostrata	24.8	22.8	30.6	19.35*	2/149	1:1.1	0.06
Eumunida picta	33.1	29.2	39.5	1.68	2/37	1:1.2	0.05

* $p < 0.05$.

66°05′W) to Golfo de Morrosquillo, Colombia, and Curaçao at depths of 90–825 m (Williams, 1974, after Chace, 1942). It is reported to be the largest species of *Munida* in the Gulf of Mexico, where it occurs from 275–824 m (Springer and Bullis, 1956; Pequegnat and Pequegnat, 1970). Roberts (1977) reported abundance of 3 individuals/hectare within the middle continental slope community at 203–476 m in the NE Gulf of Mexico.

Ovigerous females were significantly larger than other females, but males were not significantly different from either (Table 1). The male : female ratio was significantly different from unity (Table 1). Ovigerous females ≥21 mm (Fig. 2) occurred in September, November, April, and May–June collections. Fecundity ranged from 3,157 for a 21 mm CL female to 32,333 for a 40 mm CL individual. The average egg diameter was 0.56 mm.

Nonovigerous females with advanced ovaries were present in May–June, November, and April. The advanced gonadal condition was found in females ≥22 mm CL.

Males (n = 4) with spermatophore masses present on pleopods and gonopores were 31.6–39.4 mm CL. The smallest male examined which had spermatophores present in the vasa deferentia was 11.3 mm CL.

The rhizocephalan *Galatheascus* sp. was found on the abdomen of one male (12.4 mm CL) and four female (11.0–19.0 mm CL) *M. valida*. Two *Galatheascus* sp. were found infesting a 13.8 mm CL female. There were six females (13–33 mm CL) and two males (29, 33 mm CL) with abdominal scars indicative of recent parasitization by a rhizocephalan. The two males had feminized first and second pleopods. All *M. valida* with Rhizocephala or rhizocephalan scars had no visible sign of gonad development. Moreover, in several individuals, rhizoidlike extensions of the parasite were present in the body cavity.

One male, 11.3 mm CL, was parasitized by *Danalia* sp., a cryptoniscid isopod. Spermatophores were present within the vasa deferentia of the male, and the pleopods were normal.

Munida valida is also a host for the bopyrid *Aporobopyrina anomala* (Markham, 1973), but none from the present collection were parasitized by bopyrids.

The mollusk *Anomia* sp. and the barnacle *Trilasmis* (*Poecilasma*) *kaempferi inaequilaterale* were present on the pereopods and carapace of two males (32, 39 mm CL).

Munidopsis aries A. Milne Edwards, 1880

Although no *Munidopsis aries* were collected during the present study, this species has been reported from the West Indies at 2,912 m and has been collected off New England at depths between 3,605 m and 3,642 m (Haedrich, Rowe, and Polloni, personal communication).

Munidopsis bairdii Smith, 1884

Munidopsis bairdii were collected at depths of 2,125 m (3.2°C) to 2,933 m (2.3°C) between 36°33.2′N, 74°01.7′W and 37°08.6′N, 73°57.6′W. Thirteen of the 25 individuals were collected at 2,933 m. This species has been previously reported off Virginia at 2,695 m (Smith, 1884). It has been collected off New England at depths of 1,919–2,626 m (Haedrich, Rowe, and Polloni, personal communication).

Ovigerous females were significantly larger than males and other females (Table 1). The sex ratio of male : female was not significantly different from 1:1 (Table 1).

Ovigerous females were first measured at 25 mm CL (Fig. 3) and were collected in September and November only. Two individuals had spent gonads in November. The fecundity of eight ovigerous females ranged from 71 eggs in a 32.5 mm CL individual to 90 in another 32.5 mm CL individual. The average diameter of the eggs was 2.84 mm. The gravid ovary of an ovigerous female (34.8 mm CL) contained 130 ova, with an average diameter of 2.65 mm. No nonovigerous females with advanced development of ovaries were collected.

Spermatophores were present in the vasa deferentia of males as small as 12.8 mm CL. Males with sperm extruding from gonopores ranged in size from 12.8–27.4 mm CL.

Munidopsis bermudezi Chace, 1939

Based on collections from the Middle Atlantic Bight, Laird *et al.* (1976) noted two *Munidopsis bermudezi* at 2,620 m and 2,955 m south of Norfolk Canyon off the coast of Virginia. An additional ovigerous female was collected at 2,575 m at 36°36.5′N and 73°58.0′W. This species has been reported off the coast of Cuba (Chace, 1939), south of the Azores (Sivertsen and Holthuis, 1956), in the NW and NE Gulf of Mexico (Pequegnat and Pequegnat, 1970), from the Bahamas and north of the Virgin Islands at depths of 2,750 and 5,180 m (Mayo, 1974).

Chace reported a fecundity of 75 eggs for a 27.5 mm CL ovigerous female and Laird *et al.* (1976) found eggs averaged 2.8 mm in diameter.

Mayo (1974) reported a female *M. bermudezi* collected north of the Virgin Islands was parasitized by peltogastrid rhizocephalans, probably an undescribed species of *Cyphosaccus*.

Munidopsis crassa Smith, 1885

Only one specimen of *Munidopsis crassa* was collected at 2,679 m (36°59.2′N, 73°43.4′W) despite its distribution which extends from off the east coast of the United States between 36°N and 41°N (Smith, 1885) to the Colombian and Yucatan Basins (Pequegnat and Pequegnat, 1971), the Bay of Biscay (Sivertsen and Holthuis, 1956), off the Azores (Milne Edwards and Bouvier, 1897), off the Canary Islands (Gordon, 1955), and from the Iberian deep-sea basin (Türkay, 1975). The reported depths for *M. crassa* are from 2,532–5,315 m. A comparison of the ovigerous female collected during this study with the holotype of *M. crassa*

(USNM No. 8563, National Museum of Natural History, Washington, D.C.) revealed some morphological differences.

Specific differences noted were that: 1) the rostrum of the ovigerous specimen is more upturned and narrower, and bears minute spines along the lateral ventral edges, whereas the rostrum of the *M. crassa* holotype is smooth and broad at the base with a stronger rostral carina; 2) the specimen lacks a postantennal spine on the anterior margin of the carapace, whereas the *M. crassa* holotype has a postantennal spine; 3) the posterior margin of the carapace is nearly straight in the ovigerous specimen, whereas that of the *M. crassa* holotype is sinuous and, furthermore, the double-crested edges of the posterior margin of the carapace in the ovigerous specimen are not sharply crenulated as in the *M. crassa* holotype; 4) the carapace of the ovigerous specimen is less spinose but has more nearly parallel transverse ridges than the *M. crassa* holotype; and 5) the ovigerous specimen lacks an outer eye spine on the cornea, whereas a minute spine is present on the outer side of the cornea of the *M. crassa* holotype. The presence of this spine on *M. crassa* appears to be a variable character as noted by Sivertsen and Holthuis (1956). The ratio of the corneal diameter to the inner eye spine length is 1 : 1 for the *M. crassa* holotype but is 1 : 1.3 in the ovigerous specimen.

A specimen labeled *M. crassa* (USNM No. 10803, ovigerous female, National Museum of Natural History, Washington, D.C.) also differs morphologically from the holotype and the ovigerous female from the present collection. The USNM specimen differs from the holotype of *M. crassa* by having: 1) a narrow only slightly carinate rostrum lacking spines, 2) no postantennal spines, and 3) a carapace less spinose than that of the holotype. Specimen No. 10803 also differs from the ovigerous female in the present collection by having: 1) a nearly horizontal rostrum without lateral rostral spinules, 2) a carapace that is less spinose and lacking setation, 3) a single anterolateral spine without accessory spinules, and 4) an outer eye tubercle.

I do not feel these differences are distinct enough to merit a new species designation based on one specimen, and I discuss them here as variations within the species, *M. crassa*. Gordon (1955) also examined several specimens of *M. crassa* and noted differences in the curvature of the rostrum, presence or absence of a supra-antennal spine, and armature of the carapace. The only other mention of variations in curvature of the rostrum and ocular spination of *M. crassa* was by Bouvier (1922).

Mayo (1974) reported that a female specimen from southern Bahama Islands was parasitized by peltogastrid rhizocephalans of the genus *Cyphosaccus*, which may be undescribed.

Munidopsis curvirostra Whiteaves, 1874

Thirty-six *Munidopsis curvirostra* were collected between 36°09.2′N, 74°18.9′W and 38°50.5′N, 72°32.5′W at depths of 636 m (4.8°C) to 2,200 m (3.1° C). Abundance did not differ significantly among depth intervals ($F = 2.763$; $df = 12, 130$; $p > 0.05$) (Fig. 1). *M. curvirostra* has been reported off the east coast of the United States between 35°45.23′N, 74°31.25′W and 41°53′N, 65°35′W at depths of 135–2,322 m. Squires (1965) noted occurrence of *M. curvirostra* off Newfoundland at depths of 245–770 m and temperatures of 1.5°C to 3.6°C.

Ovigerous females were significantly larger than males; however, other females did not differ significantly in size from males and ovigerous females (Table 1). The sex ratio was not significantly different from unity (Table 1). One nonovigerous female (13.0 mm) had advanced ovaries in November. Females were ovi-

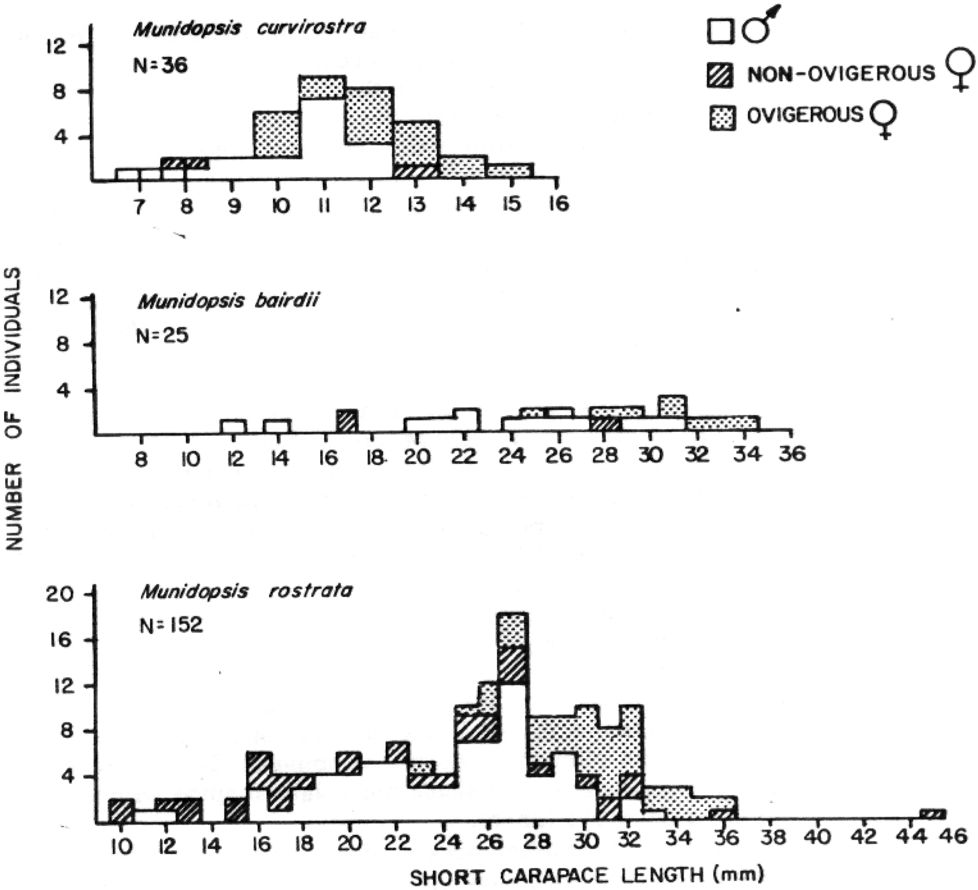

Fig. 3. Length frequency distribution of the most common *Munidopsis* spp. collected by otter trawl survey in the Middle Atlantic Bight.

gerous at 10 mm (Fig. 3) and were present in samples from January, April, May, September, and November. Based on eight females, Squires (1965) found most females were ovigerous in March. He also noted that all ovigerous and large nonovigerous females had ovaries that contained large ova.

Fecundity ranged from 5 eggs in a 10.5 mm CL ovigerous female to 52 in a 13.0 mm CL ovigerous female. The average diameter of eggs was 1.4 mm.

Males with spermatophores extruding from gonopores ranged in size from 9.2–12.5 mm CL. Spermatophores were present in the vasa deferentia of the smallest male collected (7.8 mm CL), agreeing with Squires' (1965) observations of male maturation at 8 mm CL.

Munidopsis polita Smith, 1883

Although no *Munidopsis polita* were collected, this species has been reported from the east coast of the United States off Martha's Vineyard (Smith, 1883), from the Straits of Florida (Mayo, 1974), and the NW Gulf of Mexico between 25°–27°N (Pequegnat and Pequegnat, 1970), in the Caribbean from east of Nicaragua at 15°02′N, 81°05′W (Pequegnat and Pequegnat, 1971), along the northern

Table 2. Percent *Munidopsis rostrata* by sex for each month of collection.

	September	November	January	April	May–June	July
Number of individuals	16	52	24	33	4	21
% Male	25	46	58	61	75	38
% Male with spermatophores extruding	0	4	79	55	33	0
% Ovigerous	31	37	17	24	0	24
% Other Female	44	17	25	15	25	38

coast of South America off Colombia, and off Guadeloupe in the Lesser Antilles (Mayo, 1974). The known depth range for the species is 129–860 m (Mayo, 1974).

Munidopsis rostrata A. Milne Edwards, 1880

Munidopsis rostrata was the second most abundant galatheid (n = 150) collected. Individuals were taken between 35°17.5′N, 74°45.8′W and 39°10.0′N, 71°50.5′W at depths from 1,876 m (3.5°C) to 2,767 m (2.5°C). There was no significant difference in abundance among depth intervals ($F = 2.329$; $df = 5, 42$; $p > 0.05$) (Fig. 1).

Munidopsis rostrata occurs in the western Atlantic from off New Jersey (Smith, 1882, 1884, 1886) to Bequia in the Lesser Antilles (Milne Edwards, 1880), off the coast of Colombia and Tobago (Mayo, 1974), in the SE Gulf of Mexico, off Cuba (Chace, 1942); in the eastern Atlantic off Morocco and off South Africa (Stebbing, 1908; Barnard, 1950; Kensley, 1968); from the Arabian Sea, Gulf of Aden, and Zanzibar Area (Tirmizi, 1966); Bay of Bengal (Wood-Mason and Alcock, 1891); off the Banda Islands in the Moluccas (Henderson, 1888); in the eastern Pacific off the Galapagos Islands (Faxon, 1895) and off Valparaiso, Chile (Henderson, 1885). The reported bathymetric range of the species is 1,620–3,240 m. Haedrich, Rowe, and Polloni (personal communication) found it to be the most abundant *Munidopsis* on the slope off New England and reported captures of 35 individuals in 11 trawls between 1,919 and 3,934 m.

Ovigerous females were significantly larger than other females and males (Table 1), but there was no size difference between females and males. The overall sex ratio for male : female was not different from unity (Table 1).

Ovigerous females were noted at sizes ≥23 mm (Fig. 3) and occurred every month of collection except May and June (Table 2). Spent gonads containing atretic ova were evident among ovigerous females in April (n = 5) and November (n = 1). Nonovigerous females had advanced ovaries in January (n = 1) and November (n = 1).

The smallest nonovigerous female in which advanced stage ovaries occurred was 20 mm. The fecundity of *M. rostrata* ranged from 23 eggs in a 26.5 mm CL individual to 156 in a 33.5 mm CL individual, with an average egg diameter of 2.85 mm.

Spermatophores were observed in the vasa deferentia of male *M. rostrata* as small as 12.8 mm CL. Males with spermatophores extruding from the gonopores ranged from 16–29 mm CL and were present during November, January, April, and May and June samples (Table 2). These spermatophore masses were frequently present on the modified first and second pleopods of the male, as well as extruding from the gonopores.

A male and female epibranchial bopyrid, thought to be an undescribed genus (J. Markham, personal communication), were found on a 36.8 mm CL female

Munidopsis rostrata. The ovary of the female appeared to be spent. This represents the first record of *M. rostrata* as a host for bopyrids.

The rhizocephalan parasites *Lernaeodiscus* sp. (C) and *Cyphosaccus* sp. (B) were also noted on *M. rostrata*. *Lernaeodiscus* sp. (C) occurred on the abdomens of two males (27.3 and 25.5 mm CL). The pleopods of these males were normal, and the vasa deferentia of both individuals contained spermatophores. Six females (25.5–32.3 mm CL) were parasitized by *Lernaeodiscus* sp. (C). The gonads of the females were immature. *Cyphosaccus* sp. (B) occurred on a 30.0 mm CL female. There was no gonad visible in this female.

A male (29.0 mm CL) and a female (31.3 mm CL) were also noted with abdominal scars indicating previous attachment by rhizocephalan barnacles. The gonad of the male was well developed while that of the female was immature. Mayo (1974) reported a small rhizocephalan, tentatively identified as *Sacculina* sp., attached to the second abdominal segment of a male specimen from off Tobago.

Munidopsis serratifrons A. Milne Edwards, 1880

No *Munidopsis serratifrons* were collected from the Middle Atlantic Bight, but the species does occur off Bermuda (Henderson, 1888) to Dominica, from the Bahamas (Mayo, 1974) and Cuba (Benedict, 1902; Chace, 1942), and off Yucatan (Mayo, 1974) from about 604–1,908 m (Mayo, 1974).

Munidopsis similis Smith, 1885

Two male specimens were collected at 37°17.9′N, 73°53.2′W in 2,291 m (3.2°C). *Munidopsis similis* has been previously reported off the eastern U.S. (Smith 1885, 1886) and in the Caribbean Sea off St. Vincent and south of Hispaniola (Mayo, 1974). Haedrich, Rowe, and Polloni (personal communication) collected 11 specimens off New England at depths between 1,919 m and 2,614 m. The reported depth range for the species is 1,885–2,628 m (Mayo, 1974).

The only information on fecundity was given by Smith (1885) who reported 24 eggs with an average size of 2.7 by 2.9 mm from the 16.7 mm CL holotype.

Munidopsis sundi Sivertsen and Holthuis, 1956

A female specimen measuring 23.0 mm CL was collected from 2,933 m at 36°57.9′N, 73°31.5′W. *Munidopsis sundi* has been collected south of the Azores in 2,615 m (Sivertsen and Holthuis, 1956), in the Caribbean Sea (Colombian Basin) at 4,151 m, and in the NW Gulf of Mexico at 3,254 m (Pequegnat and Pequegnat, 1971).

Family Chirostylidae

Eumunida picta Smith, 1883

Eumunida picta were collected between 36°40.4′N, 74°40.0′W and 37°05.0′N, 74°39.5′W at depths of 248 m (9.8°C) to 613 m (5.0°C). The range of *E. picta* extends along the east coast of the United States from Massachusetts to Florida and off the north coast of Cuba (Chace, 1942). The depth range reported for this species is 234–522 m.

Males, females, and ovigerous females did not differ significantly in size (Table 1). The sex ratio was not significantly different from 1:1 (Table 1). Ovigerous females were ≥37 mm (Fig. 4) and were collected only in November.

No gonad was visible in males <34 mm. Larger individuals had the vasa def-

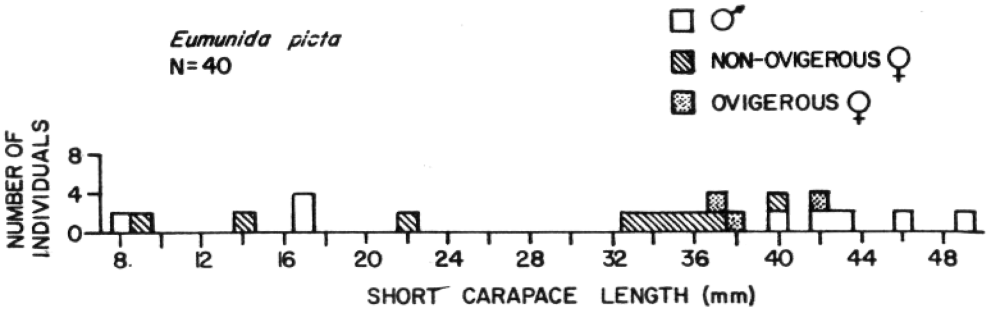

Fig. 4. Length frequency distribution of the chirostylid *Eumunida picta* collected during otter trawl surveys in the Middle Atlantic Bight.

erentia packed with spermatophores. One 49.0 mm CL male had sperm extruding from the gonopores.

Five individuals (3 ♂♂, 2 ♀♀) ranging from 36.4–49.0 mm CL were fouled with *Trilasmis* (*Poecilasma*) *kaempferi inaequilaterale*.

Summary and Conclusions

The galatheid and chirostylid decapod species collected from the Middle Atlantic Bight represent only a portion of the total number of species of these families known from the western North Atlantic. Mayo (1974) reported that 50 species of *Munidopsis* occur within the western North Atlantic, while Chace (1942) listed 30 species of *Munida*. *Eumunida picta* is the only species of that genus which occurs within the study area (Pequegnat and Pequegnat, 1970). Records from Chace (1942), Pequegnat and Pequegnat (1970, 1971) and Mayo (1974) indicate that the Galatheidae are predominantly found in lower latitudes. Thirty-nine species (78%) of *Munidopsis* and 20 species (67%) of *Munida* have been reported solely from deep waters in tropical latitudes (Florida to Rio de Janeiro, the Gulf of Mexico, Caribbean, Bahamas, Straits of Florida, and Bermuda) of the western Atlantic (Table 3). *Munidopsis rostrata* is the only galatheid that has been reported from all oceans. Three galatheids are found in both the Atlantic and Indian Oceans, and there are seven amphi-Atlantic species of *Munida* and *Munidopsis*. The amphi-Atlantic *Munidopsis* represent six of the deepest dwelling species (Mayo, 1974). *Munidopsis bairdii* and *M. curvirostra* are the only species that have been reported exclusively from temperate latitudes of the western Atlantic north of Virginia. Eight galatheids occur in deep water of temperate and tropical latitudes of the western North Atlantic. It is possible that further offshore collecting in waters north of Florida will reveal galatheid species that have previously been reported only in deep-sea depths of tropical latitudes. Laird *et al.* (1976) speculated that rare galatheids may be present within the Chesapeake Bight and that the probability of their detection has been enhanced by increased sampling in that area.

Munidopsis spp. which occur below 500 m are segregated bathymetrically from *Munida* spp. The only species of *Munidopsis* that were abundant enough to be considered dominant within the present study area were *M. curvirostra* and *M. rostrata*. *Munidopsis curvirostra* is a eurybathic species that occurs from 636 to 2,642 m. It is most abundant at depths below 1,400 m. *Munidopsis rostrata* is an exclusively deep-sea species and was collected at depths >1,800 m. The maxi-

Table 3. Zoogeographic distribution of *Munida* and *Munidopsis* species reported from the western North Atlantic. Abbreviations: AO (all oceans), TRWA (Tropical Western Atlantic), TEWA (Temperate Western Atlantic), A-A (amphi-Atlantic), TTA (Tropical and Temperate Atlantic), AIO (Atlantic and Indian Oceans).

Munidopsis species	AO	TRWA	TEWA	A-A	TTA	AIO	*Munida* species	AO	TRWA	TEWA	A-A	TTA	AIO
M. rostrata	+						*M. forceps*					+	
M. spinosa		+					*M. flinti*		+				
M. abbreviata		+					*M. irrasa*					+	
M. gilli		+					*M. longipes*					+	
M. cubensis		+					*M. valida*					+	
M. espinis		+					*M. sculpta*		+				
M. gulfensis		+					*M. microph-thalma*				+		
M. squamosa		+					*M. constricta*		+				
M. barbarae		+					*M. miles*		+				
M. expansa		+					*M. sancti-pauli*				+		
M. bermudezi				+			*M. subcaeca*				+		
M. geyeri		+					*M. nuda*		+				
M. crassa				+			*M. schroederi*		+				
M. sigsbei		+					*M. affinis*		+				
M. serratifrons		+					*M. stimpsoni*		+				
M. reynoldsi		+					*M. striata*		+				
M. sharreri		+					*M. evermanni*		+				
M. aries					+		*M. benedicti*		+				
M. latifrons		+					*M. spinifrons*		+				
M. tenuirostris		+					*M. spinosa*		+				
M. serricornis						+	*M. robusta*		+				
M. bahamensis		+					*M. subrugosa*						+
M. armata		+					*M. gregaria*						+
M. erinaceus		+					*M. media*		+				
M. spinifer		+					*M. iris iris*				+		
M. robusta		+					*M. pusilla*		+				
M. curvirostra			+				*M. elfina*		+				
M. simplex		+					*M. angulata*		+				
M. alaminos		+					*M. simplex*		+				
M. riveroi		+					*M. beanii*		+				
M. longimanus		+											
M. brevimanus		+											
M. platirostris		+											
M. abdominalis		+											
M. polita					+								
M. colombiana		+											
M. bairdii			+										
M. acuminata		+											
M. bradleyi		+											
M. nitida		+											
M. livida				+									
M. subspinoculata		+											
M. spinoculata		+											
M. ramahtaylorae		+											
M. tridens		+											
M. transtridens		+											
M. similis					+								
M. sundi				+									
M. granulens		+											
M. impolita		+											

mum abundances of these species overlap at depths between 1,800–2,199 m, but *M. rostrata* continues to be important at depths >2,199 m while the abundance of *M. curvirostra* tapers off at these greater depths. The other species of *Munidopsis* collected during the present study are exclusively deep-sea species and were less abundant. Of these, *M. similis* is the only species which has been reported at depths shallower than 2,000 m. The other species, *M. bairdii, M. bermudezi, M. crassa,* and *M. sundi,* are apparently confined to great depths which may partly account for their rarity within collections from the Middle Atlantic Bight.

Munida spp., on the other hand, were collected almost entirely from the continental shelf and upper slope. Pequegnat and Pequegnat (1970) noted that *Munida* populations within the Gulf of Mexico are generally associated with moderately deep carbonaceous regions with relatively high temperatures. *Munida iris iris* and *M. longipes* are abundant species which occur on the continental slope down to 600 m. The depth ranges and depths of maximum abundance of these species coincide; however, *M. i. iris* is by far the most numerous species of galatheid collected from the Middle Atlantic Bight. *Munida forceps* also occurs within the depth range of *M. i. iris* and *M. longipes* but is apparently very rare north of Cape Hatteras. The two deeper dwelling species of *Munida* collected were *M. valida* and *M. microphthalma*. *Munida valida* is eurybathic with a depth range of 313–1,823 m and is most abundant at depths of 400–999 m. *Munida microphthalma* is much less abundant and occurs sporadically from 750–1,698 m.

In addition to having only partially overlapping bathymetric distribution, *Munida* spp. were generally more abundant than *Munidopsis* in my collections, the most abundant species being *Munida iris iris*. Pequegnat and Pequegnat (1970) also collected more specimens of *Munida* than *Munidopsis* and suggested that these disproportionate numbers might be due to avoidance of sampling gear by *Munidopsis* through burrowing. In relation to this hypothesis, it may be significant that the captures of *Munidopsis bermudezi, M. crassa,* and *M. sundi* were made during hauls in which the net was filled with mud, indicating deep penetration of the substrate. If *Munidopsis* spp. do indeed burrow, this might also explain their apparent rarity in collections from the western North Atlantic.

Although there is little information on breeding patterns of Galatheidae and Chirostylidae, some general remarks concerning reproduction of several genera can be made. Specifically, *Munida* and *Eumunida* spp. produce a large number of small eggs, whereas more deeply dwelling *Munidopsis* produce a few large eggs. This difference in fecundity and egg size may be related to development and bathymetric distribution of the larvae. Unfortunately, information concerning larvae of these genera is speculative since the larval development of *Munida* and *Munidopsis* from the western Atlantic is still unknown (Gore, 1979). Gurney (1942) found larval development to be abbreviated in *Munidopsis serricornis* (as *M. tridentata*) and related this to the greater amount of yolk stored in large eggs. Samuelsen (1972) noted that advanced morphological features were present in the early zoeal stages and that the larvae may not feed. Fage and Monod (1936) implied advanced development in the cave dwelling *Munidopsis polymorpha,* whereby the young were well advanced in development inside the egg and probably hatched into a form nearly like the adult. This species, like deep-sea *Munidopsis,* produces a few extremely large eggs. Based on the size of eggs, two means of larval development in deep-sea *Munidopsis* spp. are probable: 1) the larvae are advanced, i.e., they hatch into a penultimate or ultimate zoeal stage which passes through molts before metamorphosis to a megalopal-type stage; or

2) the larvae undergo direct development, hatching in a form similar to, but smaller than, the adult. Without evidence other than egg size, it is quite probable that either or both alternatives may occur, depending on the species. If the advanced larvae produced by *Munidopsis* remain in the bathymetric habitat of the parent as Thorson (1950) suggests, then an adaptive advantage similar to that described for deep-sea glyphocrangonid shrimp by Wenner (1978) is present. For *Munidopsis* spp., large eggs, advanced development, and a demersal larval existence are adaptations which may enhance larval survival and propagation of the species. *Munida* spp., however, most likely hatch pelagic larvae which require complete metamorphosis to attain the adult form. Gore (1979) suggested that development of *Munida* spp. consists of four to five zoeal stages. These larvae probably develop in surface waters where food sources are greater but mortality is increased. Thus, based on fecundity and egg size, I can speculate that two general modes of breeding may exist among Galatheidae: the first which appears to be characteristic of *Munida* involves production of many small eggs from which pelagic larvae emerge; the second which appears to be characteristic of *Munidopsis* involves production of a few large eggs that develop into advanced larvae which remain within the bathymetric realm of the parent. No information is currently available on development of *Eumunida* spp.; however, Pike and Wear (1969) noted that newly hatched larvae of the chirostylids *Gastroptychus* sp. and *Uroptychus* sp. were equivalent to the fourth or fifth zoea of the Galatheidae, suggesting that development is advanced in at least some chirostylids.

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