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THE PLANKTONIC OSTRACODS OF THE SARGASSO SEA OFF  
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SEASONAL DISTRIBUTION BETWEEN THE SURFACE  
AND 2000 M

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# THE PLANKTONIC OSTRACODS OF THE SARGASSO SEA OFF BERMUDA: SPECIES COMPOSITION AND VERTICAL AND SEASONAL DISTRIBUTION BETWEEN THE SURFACE AND 2000 M

GEORGIANA B. DEEVEY AND  
ALBERT L. BROOKS<sup>1</sup>

**SYNOPSIS:** A year-round qualitative and quantitative study of the planktonic ostracods was made over four depth zones (0-500, 500-1000, 1000-1500, and 1500-2000 m) at station S, 32°10'N, 64°30'W, in the Sargasso Sea off Bermuda. Samples were collected monthly from July 1968 to September 1970 with No. 8 nets (aperture 0.202 mm), and from January to September 1970 with comparable No. 2 nets (aperture 0.363 mm). Total numbers varied considerably during the period of study and decreased greatly in going from the upper waters to the 500-1000 m depth zone, where ca. one-seventh as many ostracods were found. The No. 8 net caught three to four times as many ostracods as the No. 2 net. The mean total crop obtained for the 2,000 m column was 7,000/m<sup>2</sup> for the No. 8 net samples, and 1,920/m<sup>2</sup> of sea surface for the No. 2 net hauls. The three lower depth zones together contained a quarter to a fifth as many ostracods as the upper 500 m.

Of 65 species recorded, one was a cypridinid and the others halocyprids. Of these there were 3 species of Halocyprinae, 11 species of Archiconchoecinae, 1 species of Eiconchoecinae, and 49 species of Conchoecinae, including 1 new species. The total numbers of species recorded for the four depth zones by the two nets were 35 species from 0 to 500 m, 52 from 500 to 1000 m, 42 from 1000 to 1500 m, and 33 from 1500 to 2000 m. The year-round variations in numbers of the more abundant species over the four depth zones are given, together with brief descriptions and figures of most of the species not hitherto described from these waters.

## TABLE OF CONTENTS

INTRODUCTION .....	38
ACKNOWLEDGMENTS .....	40
METHODS .....	40
THE OSTRACODS .....	40
SPECIES COMPOSITION .....	43
THE SPECIES OF OSTRACODS .....	53
Family Cypridinidae .....	53

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Family Halocyprididae .....	55
Subfamily Halocyprinae .....	55
Subfamily Euconchoecinae .....	59
Subfamily Archiconchoecinae .....	59
Subfamily Conchoecinae .....	66
<i>Mamillata</i> Group .....	66
<i>Conchoecia nanomamillata</i> , new species .....	67
<i>Spinifera</i> Group Müller .....	74
<i>Elegans</i> Group Müller .....	82
<i>Procera</i> Group Müller .....	84
<i>Acuminata</i> Group Müller .....	85
<i>Rotundata</i> Group Müller .....	85
<i>Curta</i> Group Müller .....	91
<i>Bispinosa</i> Group Müller .....	96
<i>Edentata</i> Group Gooday .....	99
<i>Gaussae</i> Group Skogsberg .....	101
<i>Magna</i> Group Müller .....	105
<i>Loricata</i> Group Müller .....	112
<i>Serrulata</i> Group Skogsberg .....	112
<i>Mollis</i> Group Müller .....	113
<i>Imbricata</i> Group Müller .....	116
<i>Daphnoides</i> Group Müller .....	121
LITERATURE CITED .....	122

## INTRODUCTION

Most recent investigations on planktonic ostracods have been concerned with the taxonomy of the species or with their vertical or geographic distributions (e.g., Angel 1969a; Poulsen 1973; Angel and Fasham 1975; Fasham and Angel 1975; Deevey 1978a, 1978b). Most planktonic ostracods are oceanic and thus virtually no year-round quantitative investigations of particular species have been made at a single station and over a wide depth range, although some seasonal data have been reported. In his year-round study of the zooplankton at Station M at 66°N in the Norwegian Sea, Østvedt (1955) tabulated the total numbers over several depth levels down to 2000 m of the three species that occur in those waters and found that from March to September the bulk of the ostracod population was between 600 and 1000 m; fewest were in the surface waters, and next highest numbers were caught between 1000 and 2000 m. Kielhorn (1952) indicated the seasonal occurrence of several species, of which *Conchoecia obtusata* was the most numerous, at Station B in the Labrador Sea, and Fish (1954) tabulated the relative percentages of ostracods over two years at Station E in the Sargasso Sea at 35°N, but both these studies sampled only the upper 150 m. Also, some data on seasonal variations in total numbers of ostracods in the Sargasso Sea have already been reported (Deevey 1968, 1971; Deevey and Brooks 1971).

As part of a year-round qualitative and quantitative study of the

zooplankton of the Sargasso Sea off Bermuda, special emphasis has been centered on the ostracods. The general results obtained during the first year of sampling and the data for the copepods have been reported (Deevey and Brooks 1971, 1977); and also several species of bathypelagic copepods have been described (Deevey 1972, 1973a, 1973b, 1974a), as well as new species of *Archiconchoecia* (Deevey 1978a). This report presents the quantitative data obtained for the planktonic ostracods during two years of monthly sampling, over four depth zones between the surface and 2000 m at Station S, and also includes brief descriptions and figures of the species not previously described from these waters.

The planktonic ostracods of this region of the North Atlantic should now be better known than those of any other waters as, aside from our investigations, Angel (1979) studied them on a DISCOVERY cruise, and in 10 days' intensive sampling at Ocean Acre, centered at 32°N, 64°W, caught a total of 60 species between the surface and 3500 m. He obtained data for day and night vertical distributions of the species over 16 depth zones between the surface and 2000 m and compared the relative abundances and the vertical ranges of the species here with their occurrences at 30°N, 23°W in the eastern Atlantic. He also made many measurements on the more numerous species, discussed differences in size ranges with depth, considered the effects of a number of variables on clutch size, and gave the zoogeographical groupings based on factor analyses of many of the species in the eastern and western North Atlantic.

Station S, 15 miles southeast of Bermuda at 32°10'N, 64°30'W, in 3200 m of water, has been occupied almost continuously as a hydrographic station since 1957. The hydrographic data for the period studied, July 1968 to September 1970, is contained in a report from the Bermuda Biological Station (Morris et al. 1973). The temperature data over a number of depth levels between 1 and 2500 m-depths are illustrated in Figure 1. Seasonal temperature changes between ca 18° and 28°C occurred primarily within the upper 200 m, although variations of considerable magnitude were noted to depths of 800 to 1000 m in February and from July to September 1970, and these incursions of cold water masses had a marked effect on the numbers and species of zooplankton. These cold water masses of lower salinity may be cold core rings from the Gulf Stream, bringing less saline slope water into this area, rather than due, as has been suggested (Angel pers. comm.), to mesoscale eddies or Meddies (McDowell and Rossby 1978) which contain higher salinity Mediterranean water mixed with eastern Atlantic water and are thought to be generated south of the Azores and to move west across the Atlantic into the region of the Sargasso Sea. The cold water masses were most noticeable throughout the permanent thermocline, which extends from ca 400 to 1000 m-depths, where the temperature decreases to 6-7°C.

North Atlantic Central Water extends to depths of ca 800 m, and overlies North Atlantic Intermediate Water which extends down to the level of the 4°C isotherm at ca 1700 m; this marks the boundary with North Atlantic Deep Water.

#### ACKNOWLEDGMENTS

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#### METHODS

Our methods have been described in detail (Deevey and Brooks 1971, 1977). From July 1968 to September 1970 zooplankton samples were collected monthly in daytime over four depth zones (0-500, 500-1000, 1000-1500, and 1500-2000 m), from the Bermuda Biological Station's research ship, PANULIRUS II. No. 8 nets (aperture 0.202 mm) were used throughout the period, an open net for the upper 500 m and a Bé (1962) multiple plankton sampler,  $\frac{3}{4}$  X  $\frac{3}{4}$  m, equipped with three nets (with separate TSK flow-meters) that were pressure-activated to sample successively the three lower depth zones. We also collected samples with comparable No. 2 (aperture 0.363 mm) mesh nets from January to September 1970. These samples are now stored at Florida State Museum.

In our study of the total zooplankton, quantitative counts were made on aliquots of the samples collected from the three upper depth zones. In the samples collected during the first year all organisms were counted from the 1500-2000 m-hauls; during the second year only half of the deepest samples were counted, as the samples were halved to obtain biomass determinations. Ostracods were counted from a greater proportion of the samples, usually from 5 to 10% of the 0-500 m hauls, from a quarter to all of the 500-1000 m samples, and one half to all of the samples collected between 1000 and 2000 m. Unless some of the species performed annual vertical migrations, such as have been noted for some species of copepods (Deevey and Brooks 1977), seasonal variations should be reflected only in the samples from the upper 500 m, where the annual temperature range was ca 16°-28°C (see Fig. 1). The 500-1000 m hauls sampled the waters of the permanent thermocline, where temperature decreased with depth from 16° to 7°C. The 1000-1500 m tows were taken in North Atlantic Intermediate Water, where the temperature dropped from ca 7° to 4°C. The temperature remained around 4°C in the deepest depth zone sampled.

#### THE OSTRACODS

##### TOTAL NUMBERS AND PERCENTAGES

For the 2000 m water column ostracods were second in abundance after copepods in both the No. 2 and the No. 8 net samples. In the earlier study (Deevey 1968, 1971) pelagic tunicates were slightly more abundant than ostracods in the upper 500 m, but this was not the case in 1968-1970. It is of interest to note that Østvedt's (1955) data for his 0-2000 m study in the Norwegian Sea also indicated that ostracods were second in numbers after copepods; his data were not quantitative, but he tabulated the total

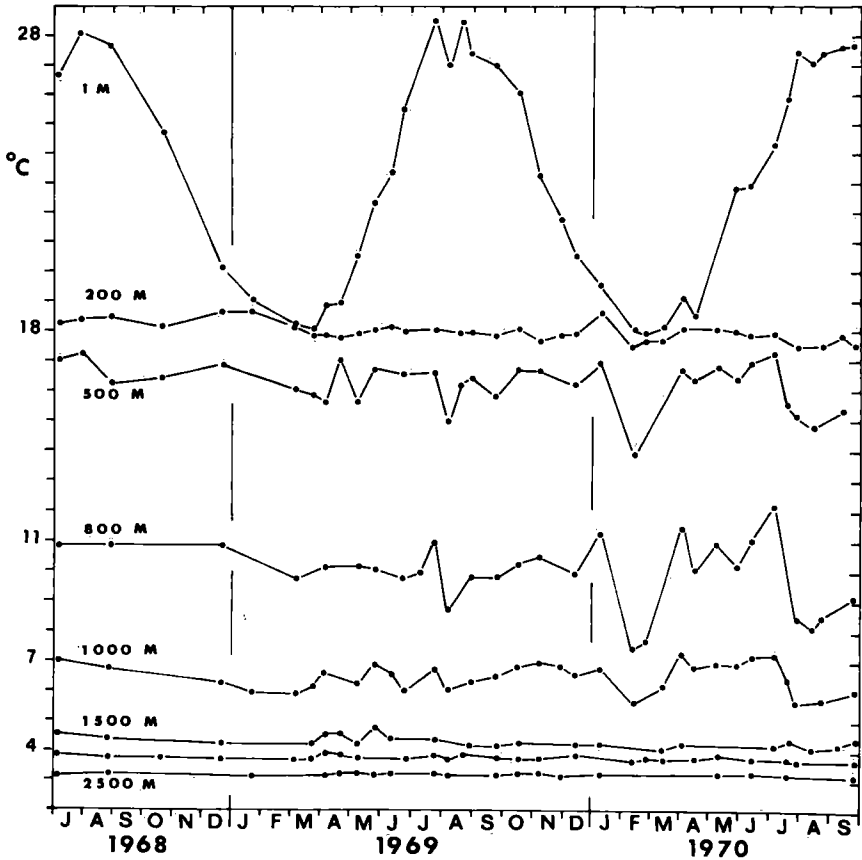


FIGURE 1. The variations in temperature at eight depths between 1 and 2500 m at Station S, from July 1968 to September 1970. The unlabelled depth is 2000 m.

numbers caught per depth zone during the year and ostracods were second in numbers, after copepods, followed by pteropods, chaetognaths and coelenterates.

The No. 8 net caught three to four times as many ostracods as the No. 2 net (see Table 1). The mean total crop obtained for the 2000 m column is 7,000/m<sup>2</sup> for the No. 8 net samples and 1,920/m<sup>2</sup> for the No. 2 net samples. The decrease in total numbers is greatest in going from the upper waters to the 500-1000 m depth zone, where approximately a seventh as many ostracods were found. The three lower depth zones together contained a quarter to a fifth as many ostracods as the upper 500 m.

Figure 2 shows the seasonal variations in total numbers over the four depth zones from July 1968 to September 1970 in the No. 8 net samples. Within the upper 500 m highest numbers were found in January, March

TABLE 1. Mean numbers of ostracods/1000 m<sup>3</sup> with their standard deviations, percent of total zooplankton, and number of species/depth zone, for 1968-1970 for the no. 8 net samples, 1970 for the no. 2 net samples.

Net	Depth (m)	No./1000 m <sup>3</sup>	% of Total Zoopl.	No. Species
8	0-500	12,340 ± 3,607	6.5	33
8	500-1000	1,716 ± 620	8.4	49
8	1000-1500	367 ± 162	5.0	42
8	1500-2000	173 ± 216	3.0	28
8	0-2000	3,502 ± 930	5.7	64
8	500-2000	778 ± 309	5.5	—
2	0-500	3,983 ± 2,384	9.2	30
2	500-1000	492 ± 242	8.6	39
2	1000-1500	101 ± 47	5.7	29
2	1500-2000	43 ± 20	3.4	16
2	0-2000	961 ± 296	6.7	55
2	500-2000	205 ± 100	5.9	—

or April, June or July, and September or October. In general the variation in numbers was similar to that of the copepods (Deevey and Brooks 1977, Fig. 2), although in 1970 highest numbers of copepods were present in June, whereas ostracods were most numerous in September. Between 500 and 1000 m and 1000 and 1500 m the variations in numbers also followed the cycles in numbers of copepods, but relatively fewer ostracods were taken in the deeper waters in 1970. Between 500 and 1000 m highest numbers were found from July to September 1968 and in March and July 1969; numbers remained low in 1970. Between 1000 and 1500 m ostracods were most numerous in July to September 1968, March and May to June 1969, and in June 1970. Over 1500-2000 m depths numbers were consistently low except for a maximum in March 1969. It would appear that the smaller numbers of ostracods found between 500 and 1000 m in 1970 were related to the intrusions of cold water masses during this period (see Fig. 1). In the upper waters total numbers were higher at this time. The No. 2 net samples yielded a maximum of 10/m<sup>3</sup> in March 1970 in the upper 500 m, but otherwise only low numbers were caught throughout the water column by the coarser net.

The mean total numbers recorded for the No. 8 net samples for the 2000 m water column and for 500-2000 m depths are compared in Figure 3. The 0-2000 m data reflect the seasonal variations in numbers in the upper 500 m, where numbers were much higher. Below 500 m, as in the case of the copepods, numbers were minimal in October 1968, April 1969, and in 1970 at times of maxima in the upper waters. Throughout the water column numbers were minimal in July and December 1968, June and November 1969, and April-May 1970. Highest numbers in the deeper



waters were found in July to September 1968, and in March and May to July 1969. Total numbers between 500 and 2000 m mirrored the variations in numbers over 500-1000 m depths, with a higher maximum in March 1969 when maxima were noted over each of the three lower depth zones.

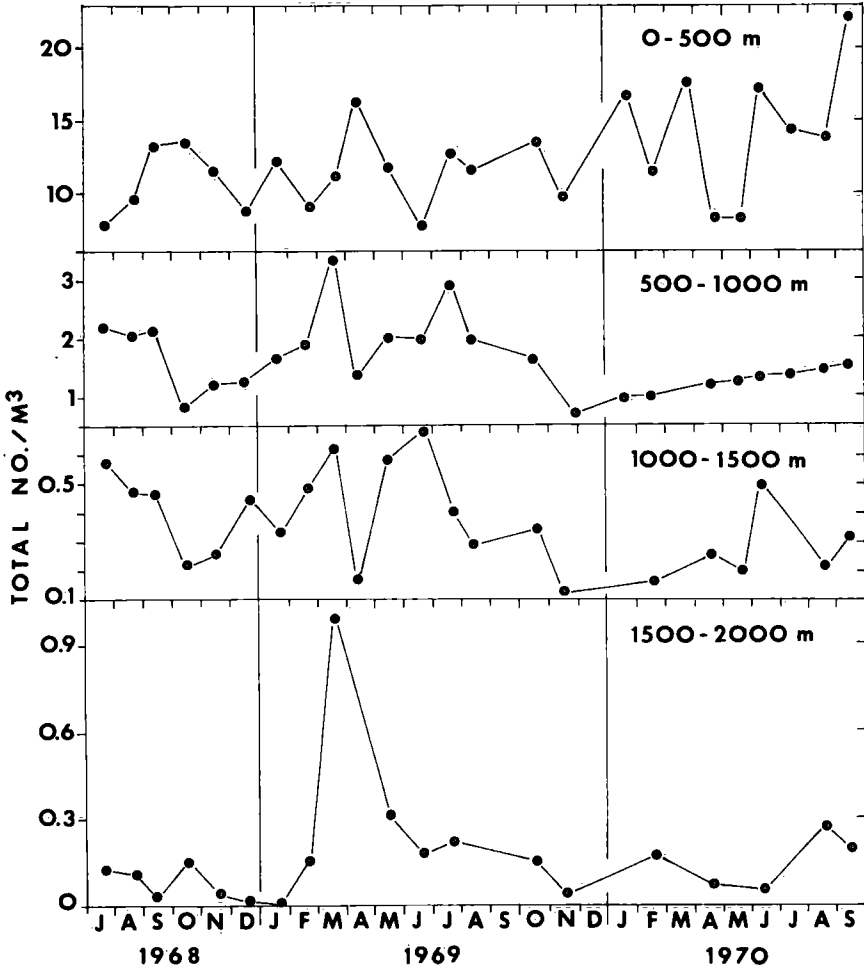


FIGURE 2. The variations in total numbers/m<sup>3</sup> of ostracods over the four depth zones, caught by the No. 8 nets from July 1968 to September 1970.

### SPECIES COMPOSITION

Over 40 species of planktonic ostracods have already been described from Station S (Deevey 1968). That study was based primarily on samples

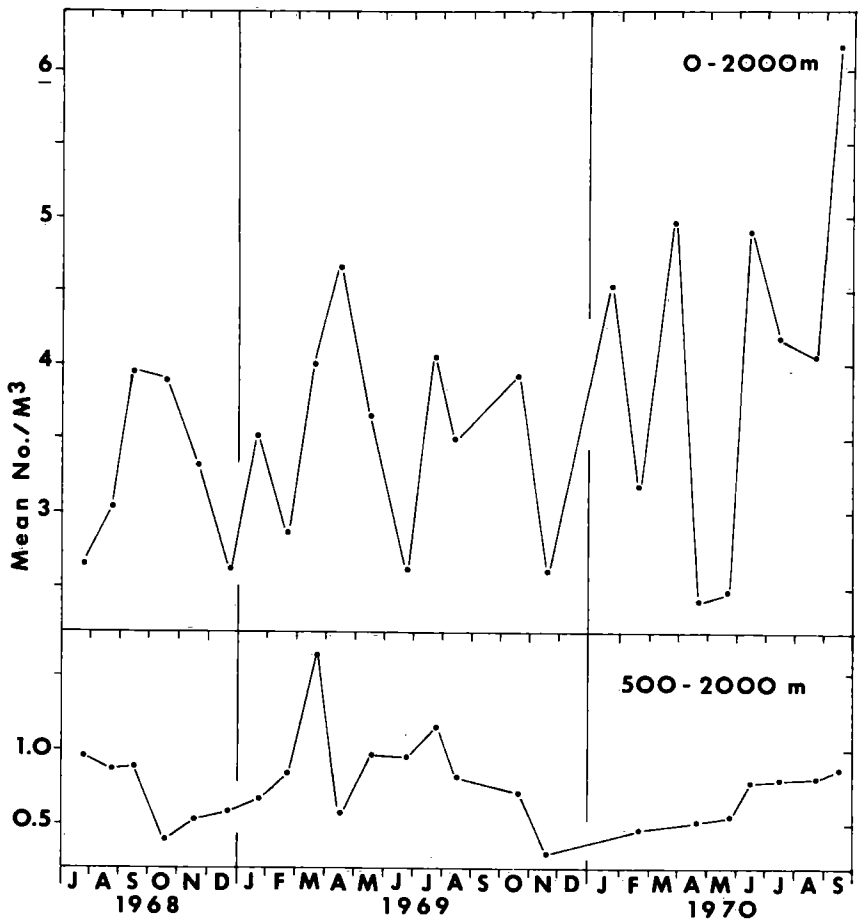


FIGURE 3. Seasonal variations in the standing crop of total ostracods from the No. 8 net samples, in numbers/m<sup>3</sup>, from July 1968 to September 1970, for the 2000 m water column and for 500-2000 m depths.

collected year-round in the upper 500 m in 1961-1962, although a few deeper samples were also available. Few quantitative seasonal data on the occurrence of individual species were included in that investigation. Sampling monthly down to 2000 m from 1968 to 1970 yielded records of some 65 species, of which 64 are halocyprid ostracods, and one, *Macrocypridina castanea*, belongs to the family Cypridinidae. The species are listed, with their periods of occurrence and depth distributions, in Table 2. The 64 halocyprids included 3 species of the subfamily Halocyprinae, 11 species of Archiconchoecinae, 1 species of Eucnchoecinae and 49 species of Conchoecinae, including one new species. All but one species were taken during the 2-year period in the No. 8 net hauls.

TABLE 2. The species of ostracods with their depth distributions and periods of occurrence, from 1968-1970.

Species	Depth Dist., m	Occurrence
<i>Macrocypridina castanea</i> (Brady) 1897	0-1500	Occasional, during year
<i>Halocypria globosa</i> Claus 1874	0-2000	February to June
<i>Halocypris inflata</i> (Dana) 1849	0-2000	Year-round
<i>Fellia bicornis</i> (Müller) 1906	500-1000	July 1969
<i>Euconchoecia chierchiae</i> Müller 1890	0-500	Rare, during year
<i>Archiconchoecia bifurcata</i> Deevey 1978	500-1500	July-November 1968, April 1969
<i>A. bimucronata</i> Deevey 1978	1000-1500	October 1968, September 1970
<i>A. bispicula</i> Deevey 1978	500-1000	June, July 1970
<i>A. cucullata</i> (Brady) 1902	500-2000	Year-round
<i>A. cuneata</i> Müller 1908	500-1000	Year-round 1968-69, then rarer
<i>A. falcata</i> Deevey 1978	1000-2000	February, June 1969
<i>A. gastrodes</i> Deevey 1978	1000-1500	February 1970
<i>A. longiseta</i> Deevey 1978	500-2000	July to December, February
<i>A. pilosa</i> Deevey 1978	1500-2000	June 1969
<i>A. striata</i> Müller 1894	0-1000	Year-round
<i>A. ventricosa</i> Müller 1906	500-1000	April, August 1969, February 1970
<i>Conchoecia acuminata</i> (Claus) 1890	0-500 (-1500)	Occasional, July to February
<i>C. aequiseta</i> Müller 1906	500-1500	Occasional, year-round
<i>C. aequiseta hirsuta</i> Müller 1906	500-1500	December to May, occasional
<i>C. ametra</i> Müller 1906	500-2000	Year-round
<i>C. arcuata</i> Deevey 1978	1000-2000	Year-round
<i>C. atlantica</i> (Lubbock) 1856	0-1000	July to October, January
<i>C. bispinosa</i> Claus 1890	0-1000	July to September, January to April
<i>C. borealis</i> Sars 1865	500-1500	June to December
<i>C. brachyaskos</i> Müller 1906	500-2000	Year-round
<i>C. concentrica</i> Müller 1906	0-500	June to September, January
<i>C. convexa</i> Deevey 1977	1000-1500	July 1969
<i>C. curta</i> Lubbock 1860	0-1000 (-2000)	Year-round

TABLE 2 continued

<i>C. daphnoides</i> (Claus) 1890	0-2000	Year-round
<i>C. dichotoma</i> Müller 1906	1000-2000	Essentially year-round
<i>C. dorsotuberculata</i> Müller 1906	500-2000	Essentially year-round
<i>C. echinulata</i> (Claus) 1890	0-1000 (-2000)	Year-round
<i>C. elegans</i> Sars 1865 (small)	0-1500	Year-round
<i>C. elegans</i> Sars 1865 (large)	500-1500	Between July and March
<i>C. gaussae</i> Müller 1908	1000-2000	June to October, March
<i>C. glandulosa</i> Müller 1906	500-2000	September-November, February to June
<i>C. haddoni</i> Brady & Norman 1896	500-2000	April, June-August
<i>C. imbricata</i> (Brady) 1880	0-1000 (-2000)	Year-round
<i>C. inermis</i> (Claus) 1890	500-1000	Essentially year-round
<i>C. kampta</i> Müller 1906	500-2000	Essentially year-round
<i>C. lophura</i> Müller 1906	500-1500 (-2000)	Essentially year-round
<i>C. loricata</i> (Claus) 1894	500-1000 (-1500)	Essentially year-round
<i>C. macrocheira</i> Müller 1906	500-1500	Between September and May
<i>C. macromma</i> Müller 1906	1000-2000	October-December, April, July
<i>C. magna</i> Claus 1874	0-1000 (-2000)	Year-round
<i>C. mamillata</i> Müller 1906	1500-2000	Year-round
<i>C. microprocera</i> Angel 1971	0-500	Year-round
<i>C. nanomamillata</i> , n. sp.	1000-1500	Year-round
<i>C. nasotuberculata</i> Müller 1906	0-1000	June 1969 & 1970
<i>C. oblonga</i> (Claus) 1890	0-1000 (-1500)	Year-round
<i>C. parthenoda</i> Müller 1906	0-1000	Year-round
<i>C. plinthina</i> Müller 1906	1000-1500	February 1970
<i>C. porrecta</i> Claus 1890	0-500	Between July and January
<i>C. procera</i> Müller 1894	0-1000	Year-round
<i>C. pseudoparthenoda</i> Angel 1972	0-500	Between June and September

<i>C. pusilla</i> Müller 1906	500-1500 (-2000)	Essentially year-round
<i>C. reticulata</i> Müller 1906	1000-2000	Occasional, year-round
<i>C. rhynchena</i> Müller 1906	500-1000	May 1969
<i>C. rotundata</i> Müller 1890	0-1000	Year-round
<i>C. secernenda</i> Vavra 1906	0-1000 (-2000)	Year-round
<i>C. skogsbergi</i> Iles 1953	500-2000	Year-round
<i>C. spinifera</i> (Claus) 1890	0-1000 (-2000)	Year-round
<i>C. spirostris</i> Claus 1874	0-1000	Year-round
<i>C. stigmatica</i> Müller 1906	500-1000 (-2000)	Occasional, year-round
<i>C. subarcuata</i> Claus 1890	0-1000	Between June and November, February.
<i>C. subdentata</i> Gooday 1976	500-1000	Between March and November

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A single juvenile *Conchoecia plinthina* was the only species caught by the No. 2 net and not by the No. 8. In 1970 the No. 2 net caught 55 species; during this period the No. 8 net also caught 55 species, though not necessarily the same species on the same occasions. A total of only 56 species was recorded in 1970. Angel (1979) identified 58 species in the upper 2000 m at Ocean Acre in March 1973. Together, his species list and ours yield a total of 73 species from these waters.

As in the case of the copepods, the greatest number of species was found between 500 and 1000 m depths, and the next highest number between 1000 and 1500 m. The No. 8 net hauls caught a total of 33 species within the upper 500 m, 49 species between 500 and 1000 m, 42 species from 1000-1500 m depths, and 28 species from between 1500 and 2000 m (see Table 1). The No. 2 net tows, in the same sequence, caught 30, 39, 29, and 16 species. The total number of species recorded for the four depth zones by the two nets were 35 species from 0 to 500 m, 52 species from 500 to 1000 m, 42 from 1000 to 1500 m, and 33 from 1500 to 2000 m. Although the total numbers of ostracods decreased sharply below 500 m, the number of species nearly doubled.

Seasonal variations in total numbers of species are illustrated in Figure 4. In general, within the upper 500 m higher numbers of species were present in winter and summer to fall; lowest numbers were found from April to June. In the deeper waters, from 500 to 2000 m, the reverse was true, especially in 1969, when low numbers were found in winter and highest numbers from March to June. Fewer species were found throughout the water column in November 1969 than at any other time during the 2-year period. This was also the month when minimal numbers of ostracods were taken. Below 500 m, numbers of species increased in 1970 to a maximum in July. Fewer species were noted in August and September 1970, when maximal numbers of species were present in the upper waters.

The present investigation increased the species list for Station S by some 24 species, most of which occurred below 500 m depths and most of which were recorded by Angel (1979) from Ocean Acre. Two of the species now known to occur in the surface waters, *C. microprocera* (Angel 1971) and *C. pseudoparthenoda* (Angel 1972), had not been described at the time of the previous study. A number of other species now known from Station S have also been recently described. Of seven species of *Archiconchoecia*, six are new (Deevey 1978a). Three other species of *Conchoecia*, *C. arcuata* (Deevey 1978b), *C. convexa* (Deevey 1977), and *C. subdentata* (Gooday 1976), are also newly described, but of these *C. arcuata* was previously wrongly identified as *C. kyrtophora* Müller. Other species we have now found at Station S include *Fellia bicornis*, *C. aequiseta hirsuta*, *C. dorsotuberculata*, *C. echinulata*, *C. gaussae*, *C. haddoni*, *C. inermis*, *C. nasotuberculata*, *C. plinthina*, *C. stigmatica*, and *C.*

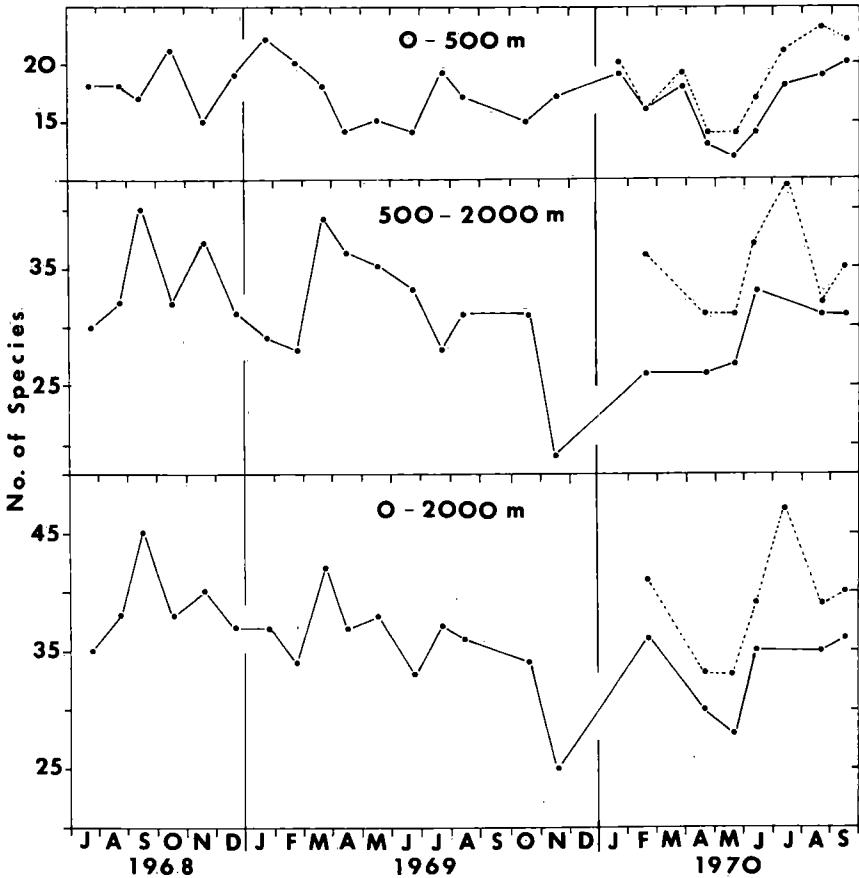


FIGURE 4. The seasonal cycles in total numbers of ostracod species caught by the No. 8 nets from July 1968 to September 1970, solid line, and the No. 2 nets between January and September 1970, dotted line, for the upper 500 m, 500-2000 m depths, and the 2000 m water column.

*macromma*, and also a new species closely related to *C. mamillata*. Larger forms of *C. elegans* have also been found between 500 and 1500 m depths. A notable change in the species composition between the early and late 1960s was the appearance of *C. echinulata*, which was not noted in the earlier study, but which by 1968 began to appear in larger numbers than the very closely related *C. curta*, becoming second or third in abundance of all the species. Angel (1979) recorded species that we did not find from between the surface and 2000 m. These include *Gigantocypris muelleri*, *Conchoecia dasyophthalma*, *C. hyalophyllum*, *C. kyrtophora*, and *C. major*.

Because our sampling program lasted for a little more than 2 years, it

is possible to determine whether continued sampling at the same oceanic station yielded greater numbers of different species over a long sampling period. In day and night tows in July 1968, 35 species or 54% were recorded; by the first four months 50 or 77% had been noted, and this increased to 80% during the first 6 months; 58 species or 90% were recorded during the first year. After 24 months of sampling the 65 species had been recorded. These percentages of numbers of species noted for months of sampling are similar to those obtained for species of copepods during the same period (Deevey and Brooks 1977). More than half the total number of species was caught on the first sampling date, but continued sampling continued to yield more different species. These results apply to our sampling methods and equipment, of course. As we have noted, in a week's time by concentrated day and night sampling in these waters with a combination of two much larger nets over 16 depth zones between the surface and 2000 m, Angel (1979) caught 58 species, including five we did not find in 2 years of sampling. Later sampling between 2000 and 3500 m yielded two more species: possibly *C. symmetrica*, hitherto known only from the Southern Hemisphere, and *Gigantocypris dracontovalis*. The nets used on the DISCOVERY cruise are the RMT 1 and RMT 8, described by Baker, Clarke, and Harris (1973).

Of the total number of species we noted, 35 or 54% were caught within the upper 500 m, even if only rarely or in a night tow, and 30 or 46% were found only below 500 m. Within the upper 1000 m 55 species occurred, and 57 species were found between the surface and 1500 m. Thirteen, or 20%, of the total number of species were found only above 1000 m, and 10 or 15% occurred only between 1000 and 2000 m. Fifteen species were noted, at one time or another, over the four depth zones between the surface and 2000 m, but only one species, *Archiconchoecia pilosa*, has thus far been recorded only from 1500 to 2000 m depths.

The overall size ranges of the species of halocyprid ostracods, ca 0.5-5 mm, is similar throughout the 2000 m water column because tiny species 0.5-0.8 mm long occur at all depths, as does the largest halocyprid species, *C. daphnoides*. The cypridinid *Macrocypridina castanea* is 6.0-6.4 mm long and was taken between the surface and 1500 m, with mature individuals present between 500 and 1500 m; the total length range was therefore greater over those depths. In the surface waters and between 1500 and 2000 m, *C. daphnoides* females were the largest specimens encountered (4.7-5.4 mm long). Most of the species of ostracods are between 1 and 3 mm long, but, as in the copepods, the dominant species in the upper waters are small, ranging from 0.8 to 2.0 mm in length. The two largest species, which constituted 1% or more of the No. 2 or No. 8 net samples, *C. secernenda* and *C. imbricata*, are less than 3 mm long. Angel (1979) considered extensively the question of changes in



size ranges of ostracods with depth at Ocean Ace, illustrated by a series of 30 histograms showing the sizes of ostracods over 25 to 100 m depth intervals down to 1000 m and over three depth zones down to 2000 m by day and by night. Diurnal migration made the day and night histograms differ somewhat within the upper 800 m; below 800 m the length spectra were the same by day and by night. He concluded that in general by day smaller animals inhabited the near surface layers and the size range gradually lengthened with larger and larger animals down to 700 m; below 700 m there were fewer larger animals. He noted changes in the size spectra at 300 m, with an increase in ostracods greater than 1.5 mm in length at 500 m, with fewer animals less than 1.0 mm long and an increase in those more than 2.0 mm in length, and at 700 m and deeper where smaller animals again predominated. Thus, although larger copepods were predominant between 1000 and 1500 m at Station S (Deevey and Brooks 1977), this does not appear to be true of the ostracods. The commoner bathypelagic species living below 1000 m depths are not necessarily larger than epipelagic species, as suggested by Mauchline (1972) for bathypelagic organisms, especially Crustacea.

Most of the species of ostracods that constituted 1% or more of the No. 2 or No. 8 net samples over the four depth zones are listed in Tables 3 and 4, which given the mean numbers/1000 m<sup>3</sup> and the mean percent of total ostracods obtained for the various species. The standard deviations given for the numbers in Table 3, in some instances larger than the means, indicate the wide variations in numbers taken during the period studied. The total numbers given for the species include identifiable juveniles. Unidentified juveniles constituted 39-72% of the ostracods caught by the No. 8 net, but no more than 16% of the No. 2 net samples. *Conchoecia spirostris* was by far the dominant species within the upper 500 m, followed by *C. echinulata*, *C. magna*, *C. procera*, *C. parthenoda*, *C. oblonga*, *C. rotundata*, and *C. spinifera*. *C. rotundata*, *C. spinifera*, *C. secernenda*, *C. imbricata*, and *C. daphnoides* made up a higher percentage of the ostracods from the 500-1000 m depth zone than from the upper waters, although mean total numbers were lower except in the cases of the No. 8 net catches of *C. imbricata* and *C. daphnoides*. All these species occurred in varying numbers year-round. The one species that was definitely seasonal, but nonetheless constituted an appreciable percentage of the total numbers averaged over the period, was *Halocypria globosa*, which appeared only between February and April in the upper 500 m. It was also found throughout the water column with appreciable numbers between 1000 and 2000 m. Other species of numerical importance in the upper waters were *Halocypris inflata* and *Archiconchoecia striata*, small species not adequately sampled by the No. 2 net. *H. inflata* was present year-round throughout the water column and increased in percentage of

total numbers in the deeper waters, although the mean numbers/m<sup>3</sup> decreased with depth.

Between 500 and 1000 m depths, aside from the species already mentioned, *C. skogsbergi*, *C. brachyaskos*, *C. ametra*, *C. loricata*, and *Archiconchoecia cucullata* were relatively abundant. Although some 52 species were noted from this depth zone, most occurred only occasionally or in small numbers. Below 1000 m and to 1500 m-depths the commonest species were *Halocypria globosa*, *H. inflata*, *A. cucullata*, *C. daphnoides*, *C. skogsbergi*, *C. ametra*, *C. dorsotuberculata*, *C. mamillata* spp., *C. arcuata*, and *C. dichotoma*. Most of these species constituted an equal or greater proportion of the total numbers present between 1500 and 2000 m.

Thus, although some 65 species of ostracods were noted from the 2000 m water column, only two dozen species occurred consistently or in sufficient numbers to make up an appreciable percentage of the total number of ostracods recorded from Station S.

The mean numbers noted in Table 3 for the various ostracod species indicate, over these broad depth zones, several patterns of depth distribution (see Fig. 5.)

1) Epipelagic species, such as *C. microprocera* (Fig. 5B) and *C. spinirostris* inhabit the upper 500 m.

2) Most of the important species living in the upper waters followed the general pattern of distribution with depth and were found in considerably lesser numbers between 500 and 1000 m. Such species include *C. procera*, *C. magna*, *C. parthenoda*, *C. oblonga*, *C. rotundata*, *C. spinifera*, and *C. secernenda* (Fig. 5B). Of these, the last three constituted higher percentages of the total numbers over 500-1000 m depths than they did in the upper waters. *H. inflata* is notable in that it was found in decreasing numbers throughout the 2000 m water column (Fig. 5B).

3) Other species, such as *C. imbricata* (Fig. 5A) and *C. daphnoides*, occurred throughout the two upper depth zones, but were more numerous between 500 and 1000 m than they were in the upper waters.

4) Some species were absent, or rarely noted, in the upper 500 m, but were most numerous between 500 and 1000 m. Of these, *C. loricata* was found only between 500 and 1000 m, and *C. ametra* (Fig. 5A) was prevalent only between 500 and 1500 m, whereas *C. skogsbergi* (Fig. 5A) occurred in decreasing numbers between 500 and 2000 m.

5) The *C. mamillata* species complex (Fig. 5A) and *C. brachyaskos* were found between 500 and 2000 m, but were present in higher numbers between 1000 and 1500 m.

6) *C. arcuata* and *C. dichotoma* were noted only between 1000 and 2000 m, in equal numbers in the No. 8 net samples.

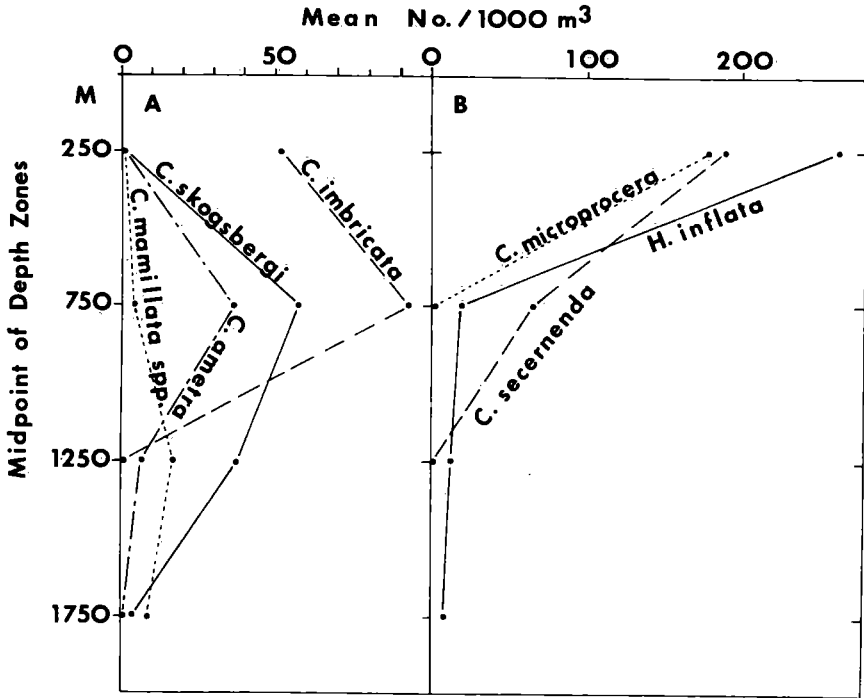


FIGURE 5. The patterns of depth distribution of ostracod species, plotted as mean numbers/1000 m<sup>3</sup> at the midpoints of the four depth zones. A: *C. imbricata*, *C. skogsbergi*, *C. ametra*, *C. mamillata* spp. B: *H. inflata*, *C. microprocera*, *C. secernenda*.

## THE SPECIES OF OSTRACODS

### SUBORDER CYPRIDINIFORMES SKOCSBERG

#### FAMILY CYPRIDINIDAE DANA

##### *Macrocypridina castanea* (Brady) s. str.

Juvenile specimens of this species were caught within the upper 1500 m every month of the year except August and November. Mature females, ranging in length from 6.0 to 6.4 mm, were taken in May and July between 500 and 1500 m-depths. In the Canary Island region Angel (1969a) found *M. castanea* most numerous between 220 and 300 m, but in the Sargasso Sea (Angel 1979) this species was taken from an overall range of 100–1250 m. In our samples it was more commonly noted between 500 and 1000 m.

DISTRIBUTION – 60°N–35°S in the Atlantic. The Indo-Pacific form has been put in a different species, *M. poulsoni* (Martens 1979).

TABLE 3. Mean numbers/1000 m<sup>3</sup> with the standard deviations of the more important ostracod species for the four depth zones in the no. 2 and no. 8 net samples.

	No. 8 Net Samples				No. 2 Net Samples			
	0-500	500-1000	1000-1500	1500-2000	0-500	500-1000	1000-1500	1500-2000
<i>Halocypria globosa</i>	138 ± 370	—	1 ± 3	1 ± 2	550 ± 1383	—	4 ± 9	2 ± 5
<i>Halocypris inflata</i>	262 ± 233	18 ± 13	12 ± 15	8 ± 18	93 ± 61	—	—	—
Total <i>Archiconchoecia</i>	146 ± 116	47 ± 27	27 ± 12	8 ± 5	—	4 ± 4	8 ± 9	6 ± 6
<i>A. striata</i>	139 ± 138	9 ± 8	—	—	—	—	—	—
<i>A. cucullata</i>	—	27 ± 21	25 ± 12	7 ± 4	—	3 ± 4	8 ± 9	3 ± 5
<i>Conchoecia</i> sp. juv.	4955 ± 1252	847 ± 335	213 ± 127	127 ± 199	10 ± 18	24 ± 15	16 ± 13	4 ± 4
<i>C. spinirostris</i>	2258 ± 1254	—	—	—	1216 ± 859	—	—	—
<i>C. echinulata</i>	880 ± 621	29 ± 38	—	—	491 ± 241	8 ± 4	—	—
<i>C. procera</i> spp. total	1208 ± 618	37 ± 45	—	—	272 ± 74	18 ± 21	—	—
<i>C. magna</i>	594 ± 311	46 ± 21	—	—	387 ± 190	35 ± 26	—	—
<i>C. parthenoda</i>	412 ± 426	13 ± 18	—	—	237 ± 77	9 ± 11	—	—
<i>C. oblonga</i>	346 ± 167	27 ± 28	—	—	202 ± 102	16 ± 20	—	—
<i>C. rotundata</i>	391 ± 288	99 ± 73	—	—	88 ± 49	28 ± 22	—	—
<i>C. spinifera</i>	331 ± 293	190 ± 89	—	—	184 ± 136	146 ± 82	—	—
<i>C. secernenda</i>	188 ± 184	65 ± 65	—	—	105 ± 85	37 ± 46	—	—
<i>C. microprocera</i>	180 ± 156	—	—	—	—	—	—	—
<i>C. imbricata</i>	51 ± 53	92 ± 55	—	—	58 ± 51	48 ± 26	—	—
<i>C. daphnoides</i>	17 ± 32	22 ± 30	—	—	14 ± 20	10 ± 6	2 ± 3	—
<i>C. skogsbergi</i>	—	57 ± 52	37 ± 27	2 ± 2	—	54 ± 37	20 ± 12	4 ± 5
<i>C. brachyaskos</i>	—	11 ± 16	16 ± 13	1 ± 2	—	7 ± 6	16 ± 18	1 ± 3
<i>C. ametra</i>	—	37 ± 33	7 ± 5	—	—	5 ± 4	5 ± 7	—
<i>C. loricata</i>	—	16 ± 15	—	—	—	13 ± 15	—	—
<i>C. dorsotuberculata</i>	—	2 ± 3	2 ± 2	1 ± 2	—	—	1 ± 2	3 ± 5
<i>C. mamillata</i> spp. total	—	4 ± 7	17 ± 12	9 ± 9	—	—	2 ± 3	4 ± 5
<i>C. arcuata</i>	—	—	8 ± 6	7 ± 8	—	—	11 ± 8	2 ± 3
<i>C. dichotoma</i>	—	—	2 ± 4	2 ± 2	—	—	3 ± 5	4 ± 8

SUBORDER HALOCYPRIFORMES SKOGSBERG  
 FAMILY HALOCYPRIDIDAE DANA  
 SUBFAMILY HALOCYPRINAE POULSEN

*Halocypria globosa* Claus

As noted during the previous study (Deevey 1968), this species was definitely a winter-spring form at Station S (see Fig. 6). It occurred from February to May 1969 and from February to June 1970, with highest numbers in the surface waters in March. Females and juveniles were

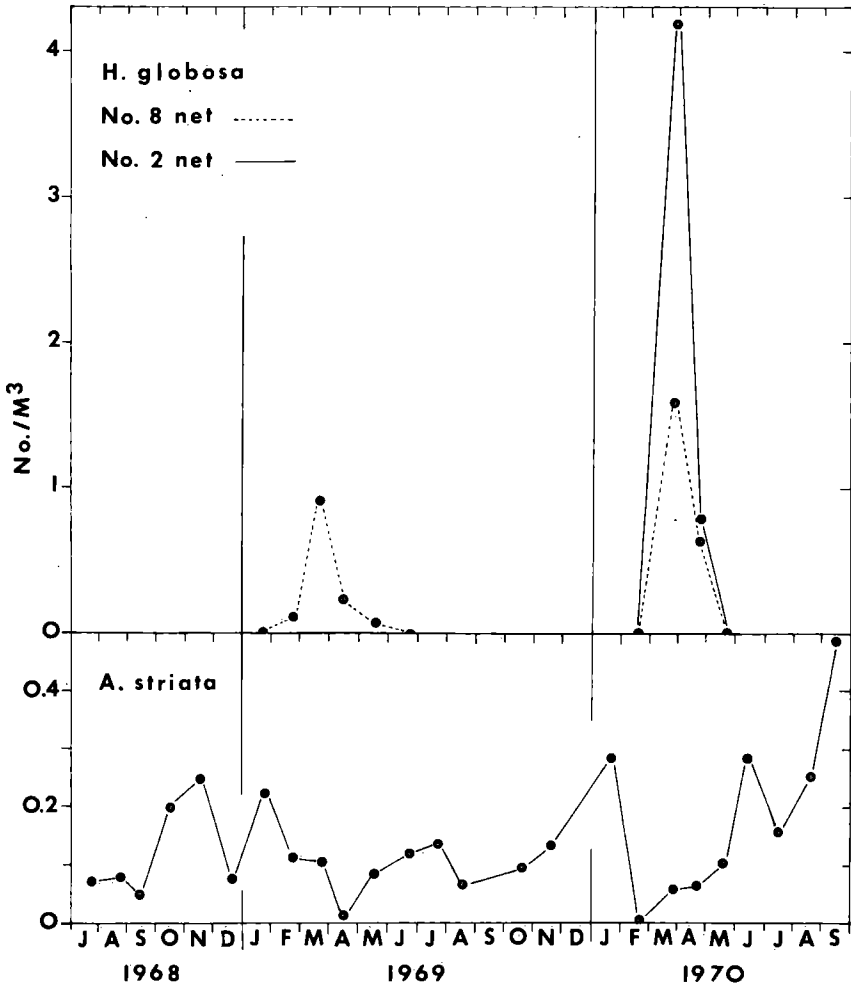


FIGURE 6. Seasonal variations in numbers/m<sup>3</sup> within the upper 500 m of *A. striata* taken in the No. 8 net samples and of *H. globosa* caught in the No. 2 net samples, solid line, and the No. 8 net samples, dashed line, from July 1968 to September 1970.

caught in the upper waters; males were found only between 500 and 2000 m depths. Males have been rarely recorded, but were reported by Müller (1906) and Poulsen (1969a) who had abundant material from the "Dana" collections. Poulsen found that females vary in length with latitude, largest specimens occurring at high latitudes, and the smallest in equatorial waters, the overall range being 2.10-2.93 mm. At Station S, females were 2.0-2.5 mm long, males 2.3 mm in length. Males differ in shape from the females, as shown in Figure 7, which also includes figures of the 1st antenna, furca and penis, and parts of the 2nd antennae. Species of this subfamily are separated from the Conchoecinae by the lack of a tubercle or processus mammillaris on the basal segment of the endopodite of the 2nd antenna (Fig. 7f); also although the distal segments of the 1st antenna bear five setae or filaments, one of them longer than the other four, these are not sexually dimorphic but similar in both sexes (Fig. 7d).

It is not clear from the published data whether *H. globosa* occurs seasonally in other localities, but it most definitely was found only between February and June at Station S. The fact that it was taken in the southeast Indian Ocean only in late spring and not on two cruises there during the winter months may indicate that it occurs seasonally also in those waters (Deevey 1981.)

DISTRIBUTION—64°N-45°S in the Atlantic, ca 38°N-52°S in the Pacific, and ca 0°-42°S in the Indian Ocean.

#### *Halocypris inflata* (Dana)

Martens (1979) recently noted that this species, previously called *H. brevis* (Dana) by Skogsberg (1920), Deevey (1968 and later publications), Poulsen (1969a,b), Angel (1979 and earlier publications), and others, by a ruling of the International Commission for Zoological Nomenclature must now be called *H. inflata* (Dana). This species occurred year-round throughout the 2000 m water column, although in small numbers in the deeper waters (see Figs. 5B and 8). In the upper 500 m it was most numerous in November 1968 and February 1969 and 1970. Throughout the water column numbers were minimal in September 1968, the fall of 1969, and the spring of 1970 (see Fig. 8). In general the numbers were maximal in winter and low the rest of the year. The mean number obtained for the total water column was 75/1000 m<sup>3</sup>, or 150/m<sup>2</sup> of sea surface. The majority of the specimens noted were juveniles.

This is the only species in this genus. Poulsen (1969a) observed no morphological differences between specimens from the Atlantic, Pacific, and Indian Oceans. There is considerable variation in size, and Poulsen reported an overall size range of 1.1-2.1 mm for females and of 0.9-1.9 mm for males. Angel (1979) suggested that possibly the large and small

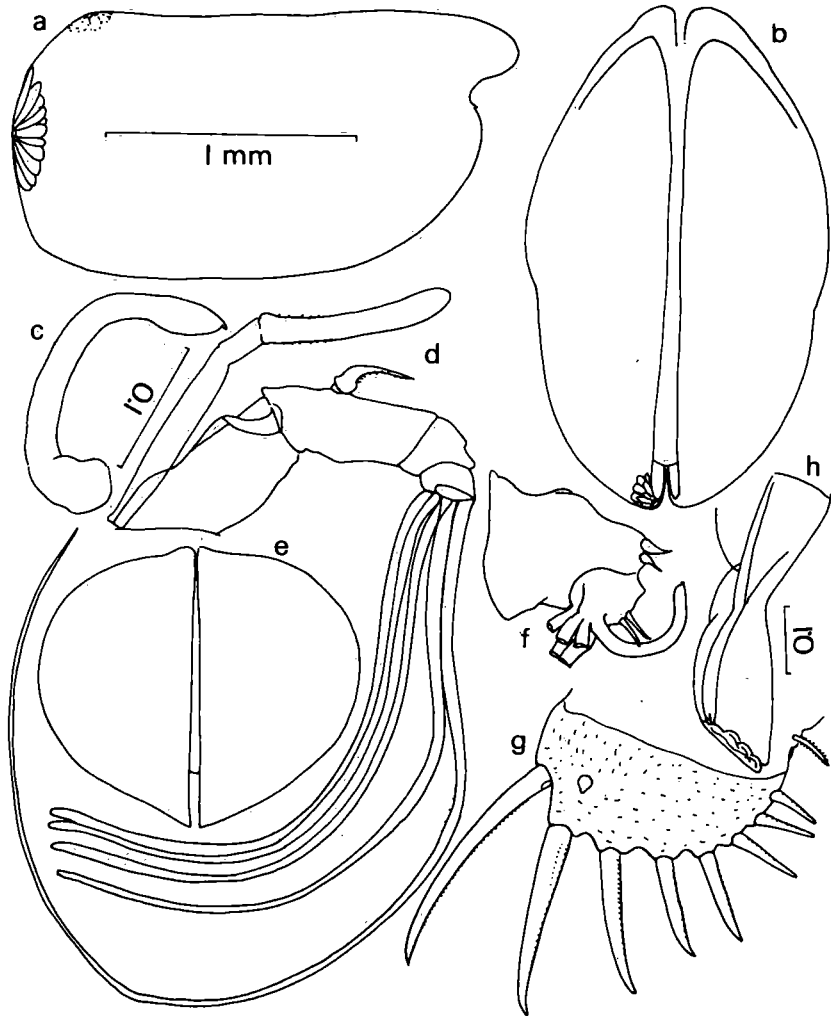


FIGURE 7. *Halocypria globosa* male. a, b, and e, Lateral, ventral, and posterior views of shell; c, Left clasper; d, First antenna; f, Endopodite of right second antenna, filaments and setae cut off; g, Furca; h, Penis. Scale on a, b, and e; at left center for c; on lower right margin for d, f, g, h. Scales in mm.

forms may represent two species. At Station S only small specimens were found, females 1.1-1.3 mm and males 0.95-1.15 mm in length. Angel gave length ranges of 1.0-1.4 mm for females and of 1.0-1.2 for males from the Ocean Acre samples.

DISTRIBUTION—Ca 47°N-49°S in the Atlantic, ca 40°N-54°S in the Pacific, and ca 10°N-45°S in the Indian Ocean.

*Fellia bicornis* (Müller)

A single female, 2.04 mm long by 1.66 mm high, was taken in a night tow in July 1969 from 500 to 1000 m-depths. This is the first record of this species from the Sargasso Sea. *F. bicornis* has been rarely recorded (Poulsen 1969a, Deevey 1970, 1978c, Chavtur 1977) since it was almost simultaneously described by Vavra and by Müller in 1906, from between 10°N and 10°S in the Atlantic and Indian Oceans. This species was briefly described and figured from the waters off Barbados (Deevey 1970, Fig. 2).

DISTRIBUTION — *F. bicornis* has been found mainly in tropical waters. Poulsen recorded two specimens from 46°28'N, 8°W in the eastern North Atlantic, but other Atlantic records are from 20°N-8°S. It has also been found in equatorial Indian Ocean waters, in Indonesian Seas, and ca 40 + °N (Chavtur 1977) to 42°S in the Pacific.

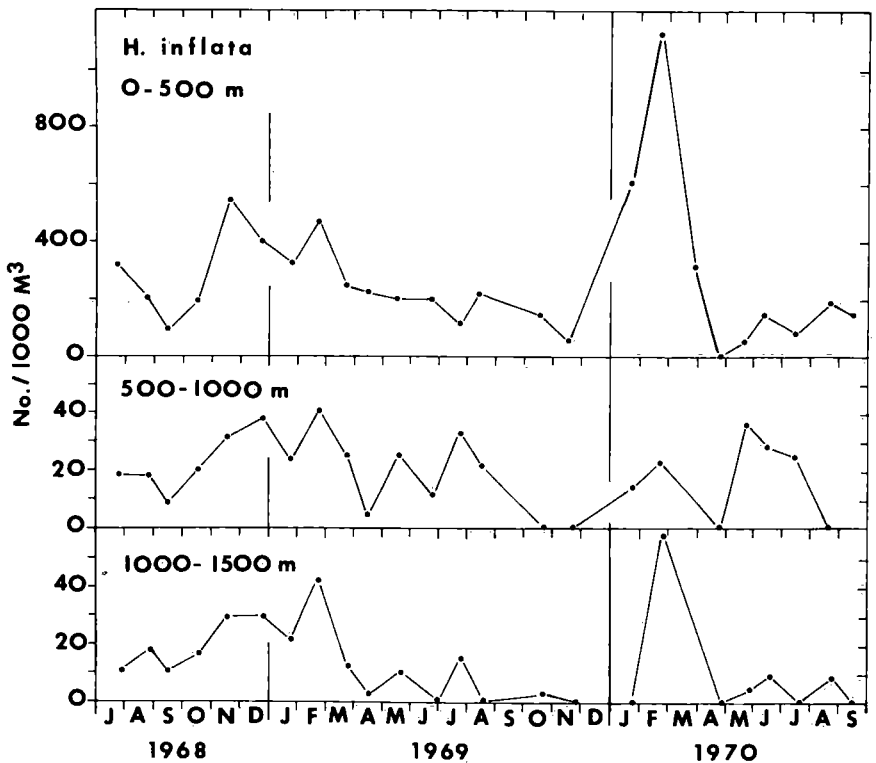


FIGURE 8. Seasonal variations in numbers/1000 m<sup>3</sup> of *H. inflata*, taken in the No. 8 net samples, from 0-500 m, 500-1000 m, and 1000-1500 m, from July 1968 to September 1970.



## SUBFAMILY EUCONCHOECINAE POULSEN

*Euconchoecia chierchiae* Müller

Although this species was previously observed as occurring seasonally between September and April (Deevey 1968), between 1968 and 1970 it occurred occasionally during the year, more frequently during the first year than during the second. This is a small neritic epipelagic species described from off the coast of Brazil (Müller 1890) and presumably is more abundant in Bermuda's inshore waters. It has been recorded from outside Delaware Bay and from Block Island Sound off southern New England (Deevey 1952, 1960), but according to Poulsen (1969a) is most abundant in tropical and subtropical regions. Females are 1.1-1.3 mm long, males 1.0-1.2 mm.

DISTRIBUTION—42°N-ca 37°S off South Africa in the Atlantic, 0°-30°S in the Indian Ocean, ca 25°N-30°S in the western Pacific Ocean.

## SUBFAMILY ARCHICONCHOECINAE POULSEN

A recent report on the species of *Archiconchoecia* found at Station S in 1968-1970 described six new species from these waters (Deevey 1978a). In all, 16 species have now been described, and the report on the species at Station S included a key to 14 of them, 10 of which occurred in the Sargasso Sea. Descriptions of the other two species, from south of the Antarctic Convergence in the South Pacific, are now in press (Deevey 1981). At present, 11 species are known from Station S, and a species described from the Caribbean Sea has since been found in these waters. Two species occurred year-round in appreciable numbers (see Tables 3 and 4), *A. striata* in the upper waters, and *A. cucullata* between 500 and 2000 m-depths. Table 4 shows that the species of *Archiconchoecia*, primarily because of *A. cucullata*, increased in importance with depth, and constituted 7% of the total numbers of ostracods between 1000 and 1500 m.

*Archiconchoecia striata* Müller

*A. striata* was most numerous in the upper waters in October-November 1968 and in January 1969 and 1970, with small numbers present in spring and summer (see Fig. 6). The picture changed in February 1970 coincident with the influx of the cold water mass, when none were taken, but numbers were relatively high from June to September, and highest in September after the second cold water mass had moved in (see Fig. 1). *A. striata* also occurred consistently in much smaller numbers, between 1 and 28/1000 m<sup>3</sup>, between 500 and 1000 m, especially from July 1968 to November 1969. The mean number obtained for the upper 500 m was 139/1000 m<sup>3</sup>.

TABLE 4. Percent of total ostracods of the more important species in the no. 2 and no. 8 net samples over the four depth zones.

	No. 8 Net Samples				No. 2 Net Samples			
	0-500	500-1000	1000-1500	1500-2000	0-500	500-1000	1000-1500	1500-2000
<i>Halocypris globosa</i>	1.1	—	0.3	0.6	13.8	—	4.0	4.7
<i>Halocypris inflata</i>	2.1	1.1	3.3	4.6	2.6	—	—	—
Total <i>Archiconchoecia</i>	1.2	2.8	7.4	4.6	—	0.8	7.9	14.0
<i>A. striata</i>	1.1	0.5	—	—	—	—	—	—
<i>A. cucullata</i>	—	1.6	6.8	4.0	—	0.6	7.9	7.0
<i>Conchoecia</i> sp. juv.	39.5	49.4	58.2	72.3	0.3	4.9	15.8	9.3
<i>C. spirostris</i>	18.2	—	—	—	30.5	—	—	—
<i>C. echinulata</i>	7.2	1.7	—	—	12.3	1.6	—	—
<i>C. procera</i> spp. total	9.7	2.2	—	—	6.8	3.7	—	—
<i>C. magna</i>	4.5	2.7	—	—	9.7	7.1	—	—
<i>C. parthenoda</i>	3.2	0.8	—	—	5.9	1.8	—	—
<i>C. oblonga</i>	2.8	1.6	—	—	5.1	3.3	—	—
<i>C. rotundata</i>	3.2	5.7	—	—	2.2	5.7	—	—
<i>C. spinifera</i>	2.6	11.0	—	—	4.6	29.7	—	—
<i>C. secernenda</i>	1.5	3.7	—	—	2.6	7.5	—	—
<i>C. microprocera</i>	1.4	—	—	—	—	—	—	—
<i>C. imbricata</i>	0.4	5.4	—	—	1.5	9.8	—	—
<i>C. daphnoides</i>	0.1	1.3	—	—	0.4	1.4	2.0	2.3
<i>C. skogsbergi</i>	—	3.9	10.1	1.2	—	11.0	19.8	4.7
<i>C. brachyaskos</i>	—	0.7	4.4	0.6	—	1.4	15.8	2.3
<i>C. ametra</i>	—	2.2	1.9	—	—	1.0	5.0	—
<i>C. loricata</i>	—	0.8	—	—	—	2.6	—	—
<i>C. dorsotuberculata</i>	—	0.1	0.5	0.6	—	—	1.0	7.0
<i>C. mamillata</i> spp. total	—	0.2	4.6	5.2	—	—	2.0	9.3
<i>C. arcuata</i>	—	—	1.9	4.0	—	—	10.9	4.7
<i>C. dichotoma</i>	—	—	0.5	1.2	—	—	3.0	9.3

This is the smallest ostracod that occurs at Station S, males and females being 0.5-0.6 mm long, and it was therefore not caught by the coarser No. 2 mesh nets.

DISTRIBUTION — 36°N-42°S in the Atlantic, 33°N-33°S in the Pacific, 7°N-33°S in the Indian Ocean, and the Mediterranean Sea. It has not been taken south of the Subtropical Convergence in the Southern Hemisphere.

### *A. cucullata* (Brady)

The variations in mean numbers of this distinctive species over the three lower depth zones between 500 and 2000 m are shown in Figure 9. Between 500 and 1000 m, *A. cucullata* was most numerous in August and December 1968, February-March and July to October 1969, and

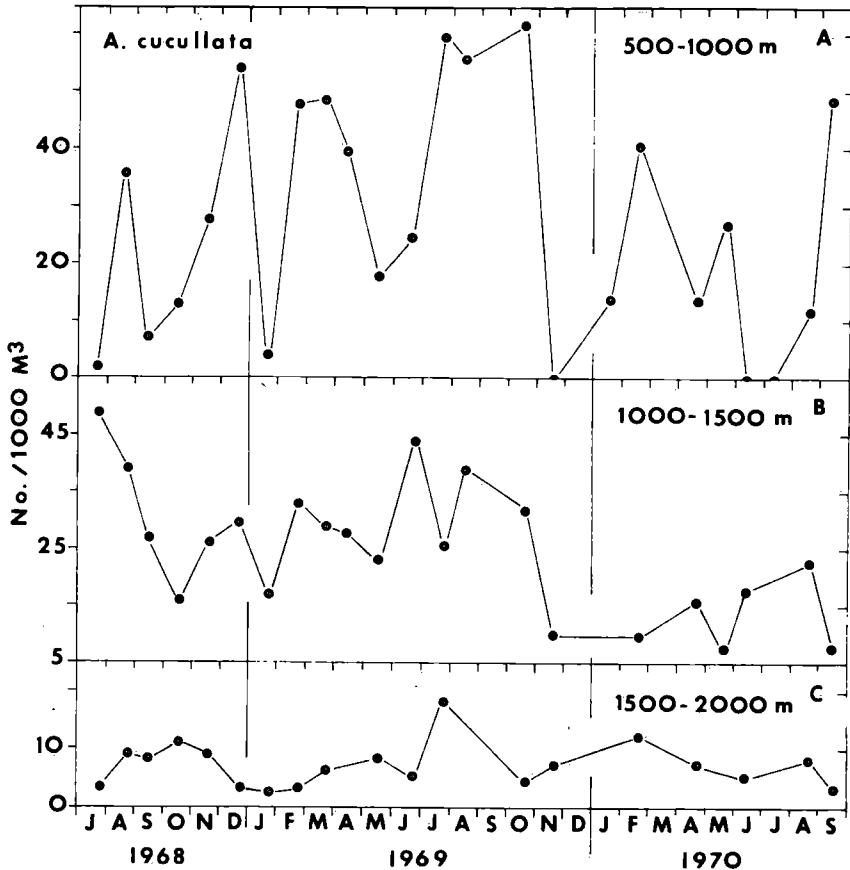


FIGURE 9. Seasonal variations in numbers/1000 m<sup>3</sup> of *A. cucullata*, taken in the No. 8 net samples, from A: 500-1000 m, B: 1000-1500 m, and C: 1500-2000 m, between July 1968 and September 1970.

February, May, and September 1970. Between 1000 and 1500 m, highest numbers were noted in July 1968 when minimal numbers were present over the other two depth zones; in general *A. cucullata* was more abundant in 1968 and 1969 and only small numbers were taken after November 1969. Between 1500 and 2000 m small numbers were present year-round. This species constituted 7-8% of the total numbers of ostracods caught below 1000 m-depths (see Table 4). The mean number obtained from the No. 8 net samples for the 1500 m column was 21/1000 m<sup>3</sup>, or 31.5/m<sup>2</sup> of sea surface.

*A. cucullata* differs from all other known species of *Archiconchoecia* in the shape and sculpturing of the shell, and in features of the 1st and 2nd antennae from all other known species of this genus, and should possibly be placed in a separate genus. It is also the largest known species. Females ranged from 1.75 to 2.45 mm in length, males from 1.6 to 2.55 mm. Poulsen (1969a) noted a similar wide size range. Angel (1979) gave length ranges of 1.58-1.80 mm for females and of 1.62-1.82 mm for males; he noted larger specimens were caught from below 1500 m at Ocean Acre and suggested that these forms may prove to be taxonomically distinct. The majority of the specimens caught at Station S were juveniles, and males were rarely noted. As this species was taken only below 500 m and the overall temperature range was ca 4°-16°C.

DISTRIBUTION—60°N-50°30'S in the Atlantic, 45°N-57°S in the Pacific, 0°-52°S in the Indian Ocean, and in Indonesian Seas.

#### *A. cuneata* Müller

This rarely recorded species was previously noted and described from these waters (Deevey 1968, Fig. 6). The female was described by Müller (1908) from a female and a juvenile specimen caught at 19°S in the Atlantic, but the male was only recently described (Deevey 1978a: 112, Figs. 3-4). Angel and Fasham (1975) have noted its presence at 18° and 40°N in the eastern North Atlantic, and Angel (1979) found it at a number of the stations on his transect at 32°N across the Atlantic as well as at Ocean Acre, where it was caught between 200 and 800 m. At Station S *A. cuneata* was the third most abundant species of this genus and was found consistently between 500 and 1000 m in numbers varying between 4 and 26/1000 m<sup>3</sup>, especially during 1968-1969. During the second year studied it was less commonly noted. This is a small species, males being 0.7-0.8 mm long and females 0.8-0.9 mm in length.

DISTRIBUTION—40°N-19°S in the Atlantic Ocean.

#### *A. bifurcata* Deevey

This species was described from this station on the basis of a female 1.65 mm long, an immature female 1.4 mm long, and an immature male 1.25 mm long (Deevey 1978a: 131, Figs. 15, 16). Four other juvenile

specimens have also been noted. One specimen was caught between 500-1000 m depths, but all others were from between 1000 and 1500 m. The juvenile specimens were present from July to November 1968, and the single female was taken in April 1969. The female 6th limb and the tip of the frontal organ are shown in Figures 10 i and j. This species is known only from this locality.

*A. bispicula* Deevey

This species was described from a single female 1.02 mm long collected in the western Caribbean Sea (Deevey 1978a: 123, Fig. 10), but it has since been noted at Station S. A female 0.96 mm long was taken in July and an immature female 0.8 mm long in June 1970, both from 500-1000 m depths. The tip of the frontal organ and the 6th limb are illustrated in Figure 10 g and h.

DISTRIBUTION — 32°N in the western North Atlantic and 17°18'N in the western Caribbean Sea.

*A. longiseta* Deevey

This species was described from two females, 1.30 and 1.27 mm long, caught between 1500 and 2000 m in February and July 1970; it differs from all other known species in that one of the six filaments or setae on the distal segments of the 1st antenna is much longer than the other five (Deevey 1978a: 119, Figs. 7-9). Females and juveniles have since been found between 1500 and 2000 m from October to December 1968, July and October 1969, and in August and September as well as February and July 1970. In October 1968 it was also present between 500 and 1500 m depths. It has therefore been caught between July and February, primarily from depths where the temperature was ca 4°C.

DISTRIBUTION — 32°N in the Sargasso Sea.

*A. pilosa* Deevey

This species is known from a single male, 1.35 mm long, collected between 1500 and 2000 m in June 1969 (Deevey 1978a: 115, Figs. 5-6); it is most closely related to *A. cuneata*.

*A. ventricosa* Müller

Müller briefly described this species in 1906; the male has since been redescribed from a specimen collected in the eastern Caribbean Sea (Deevey 1978c, Figs. 4-5). At Station S two females, 0.90 and 0.94 mm long, and a male, 0.8 mm long, were taken in April and August 1969 and February 1970 between 500 and 1000 m. This species has a characteristic shape, with a strongly swollen anterior margin (see Fig. 10a), which led Müller to give it the specific name from the Latin for "pot-bellied." Seven other species are now known to have a similar shape, and five of these

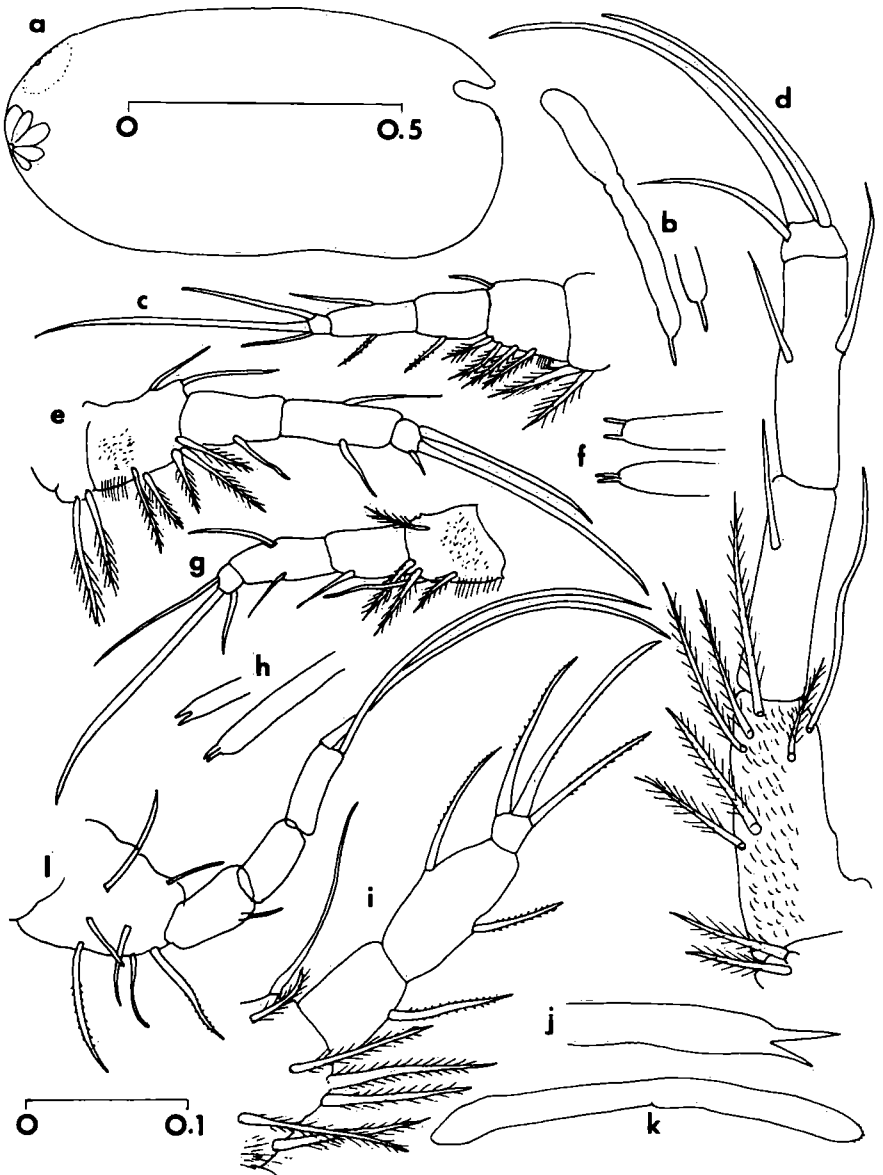


FIGURE 10. a, Lateral view of shell of female *A. ventricosa*; b, Lateral and dorsal view of frontal organ of female *A. ventricosa*; c, Sixth limb of male *A. ventricosa*; d, Sixth limb of female *A. gastrodes*; e and f, Sixth limb and dorsal and lateral view of frontal organ of male *A. bimucronata*; g and h, Sixth limb and dorsal and lateral view of tip of frontal organ of female *A. bispicula*; i and j, Sixth limb and tip of frontal organ of female *A. bifurcata*; k and l, frontal organ of female and sixth limb of immature male *A. falcata*. Scale on a for a, at bottom left for b to l. Scales in mm.

have been found at Station S. These species differ from each other in size, number of claws on the furca, and particularly in the shape of the frontal organ, in characters of the endopodite of the 2nd antenna, and in the relative lengths of the three setae on the distal segment of the 5th and 6th limbs. The *ventricosa*-shaped species known from Station S include *A. bifurcata*, *A. bispicula*, *A. gastrodes*, *A. falcata*, and *A. bimucronata*. Figure 10 illustrates the female *A. ventricosa* shell and the frontal organs and 6th limbs of these species. In *A. ventricosa* the tip of the frontal organ has a single, long, needle-like prolongation (Fig. 10b). In the known males of this type, the shell height decreases markedly posteriorly, whereas the shell height in females is similar at the anterior and posterior ends.

**DISTRIBUTION** — *A. ventricosa* has been listed as occurring up to 60°N in the eastern North Atlantic (Angel and Fasham 1975), but without any documentation. Müller (1906: 45, pl. 7, figs. 1-6) described this species from the equatorial Atlantic and Indian Oceans. Otherwise it is known from 11°45'N in the Caribbean Sea and 32°10'N in the Sargasso Sea. Other records (e.g. Poulsen 1969a and Chavtur 1977) have not been documented.

#### *A. falcata* Deevey

This species is also known only from Station S and was described from a 1.3 mm female collected in June 1969 from 1000-1500 m depths and a 1.1 mm immature male caught in February 1969 from between 1500 and 2000 m (Deevey 1978a: 125, Figs. 11-12). This species has a rounded frontal organ (Fig. 10k). The 6th limbs were missing from the female, but the immature male had distinctive 6th limbs with only two long setae on the distal segment (Fig. 10 l) although the 5th limbs were of the usual type.

#### *A. gastrodes* Deevey

This is the largest *ventricosa*-shaped species found at Station S and was described from a female, 1.85 mm long, collected in February 1969 from between 1000 and 1500 m (Deevey 1978a: 134, Figs. 17-18). The frontal organ was lost from this specimen, but the 6th limb is illustrated in Figure 10d. *A. gastrodes* is known only from Station S.

#### *A. bimucronata* Deevey

This species was described from a 0.9 mm male taken at Station S from between 1000 and 1500 m in September 1970 (Deevey 1978a: 128, Figs. 13-14). An immature female, 0.9 mm long, was found in October 1968 within the same depth range. These are the only specimens to date. The frontal organ of *A. bimucronata* has two slim needle-like prolongations at its tip, and the ventral seta on the distal segment of the 6th limb is exceptionally short (see Figs. 10e, f).

## SUBFAMILY CONCHOECINAE MÜLLER

This subfamily contains all the species of the genus *Conchoecia*, which Poulsen (1973) divided into 17 genera. Martens (1979) pointed out that nine of these genera are *nomina nuda*, as no type species were designated for them. He listed eight genera as valid, and proposed five more, two of which were among those he had named as *nomina nuda*. In this report the proposed genera are listed in parentheses as subgenera, and Müller's (1906) system of grouping species into more or less natural groups is followed. The species that Müller grouped together in the *Spinifera* Group do not all form a natural assemblage, and it is now necessary to place one of these species, *C. mamillata*, in a group of its own.

*Mamillata* Group*C. mamillata* Müller

This species differs from others that Müller put in the *Spinifera* group, and indeed from all described species of *Conchoecia*, except *C. cophopyga* and *C. dentata* of the *Dentata* Group, in the rather primitive structure of the male 6th limb; the distal segment bears two rather long setae and a short seta, instead of three very long plumose setae as in other male *Conchoecinae*. This fact was noted by Rudyakov (1962), who had a single damaged male specimen of *C. mamillata* that he could not fully describe. Müller (1906: 60, pl. 16, figs. 1-9, pl. 35, fig. 8) described only the shell and the 1st and 2nd antennae. Poulsen (1973) had only females and juveniles in the Dana material, and although this species was listed and figured from the Sargasso Sea (Deevey 1968, Fig. 12d-f), at that time only juvenile specimens had been caught. The male has therefore never been fully described.

This species also differs from most other *Conchoecia* in the location of the left asymmetrical gland, which opens on a process on the posterior margin of the shell. The location of the asymmetric glands is in fact reminiscent of some species of *Archiconchoecia*, particularly *A. cucullata*, in that the left gland opens on the posterior margin near the posterodorsal corner and the right gland a short distance down the posterior margin. Only in members of the *Daphnoides* Group and in *C. dasyophthalma* does the left gland open on the posterior margin. The armature of the principal seta of the 1st antenna of both sexes is different from that of most members of the *Spinifera* Group. The male has a large brush of innumerable long fine hairs on the principal seta, whereas other males have "teeth" or spines, though the *C. inermis* and *C. dasyophthalma* males also have long hairs. The female does not have a row of long hairs on the anterior side of this seta at the proximal end, but has short hairs on both the anterior and posterior sides. Also the distal end of the male principal seta is widened.



Müller gave the lengths of females as 1.4-1.9 mm. Most of his male specimens were 1.6-1.75 mm long, but he had two males 1.35-1.45 mm long that had a differently shaped frontal organ. At Station S, males were 1.4-1.8 mm long, and females 1.4-1.88 mm long. Examination of the males showed that two species were present. Males 1.4-1.48 mm long had the frontal organ of Müller's small form, and were different from males 1.5-1.8 mm long. The small specimens, males 1.4-1.48 mm long and females 1.4-1.5 mm long, were caught only between 1000 and 1500 m. The larger males, 1.6-1.8 mm long and females 1.7-1.88 mm long, were taken from 1500 to 2000 m depths. Juvenile specimens were caught between 500 and 2000 m. As documented records (Rudyakov 1962; Poulsen 1973; Deevey 1978b) apply to the large form, which Müller also found more frequently, the larger form is here considered to be *C. mamillata* Müller. The small form must be described as a new species.

*Conchoecia nanomamillata*, new species

Figures 11a-d, i-n; Figures 12b-g; Figures 13a, c, d

*Conchoecia mamillata* G. W. Müller 1906 (part): 34, pl. 16, figs. 1-9, pl. 35, fig. 8.

HOLOTYPE—Male, 1.48 mm long, 1 slide, to be deposited in the National Museum of Natural History, Smithsonian Institution.

TYPE LOCALITY—Station S, 32°10'N, 64°30'W, in the Sargasso Sea off Bermuda. Collected in a tow from 1000-1500 m on 19 February 1970.

DESCRIPTION OF MALE

SHELL—In both male and female (Figs. 11k, l) the shell is distinctively sculptured and shaped as figured by Müller (1906, pl. 16, figs. 1-2) for *C. mamillata*. The height is approximately 40% the length, with rounded anteroventral and posteroventral corners. The left asymmetric gland opens on a rounded process at the posterodorsal corner, the right gland on a similar process on the posterior margin. At the posterodorsal corner of the right shell is a sharp point and a medial gland opens at its base as well as at the base of the left asymmetric gland.

FRONTAL ORGAN AND 1ST ANTENNA (Figs. 11a-d)—The capitulum of the frontal organ has some hairs or spinules proximally and ventrally and a large bulbous distal section (Fig. 11d), which readily distinguishes this species from the male *C. mamillata*. In *C. mamillata* the capitulum is long and slim with hairs on the proximal half (Fig. 11e). The armature of the 1st antenna is similar to that of the male *C. mamillata*, but there are several differences. In *C. nanomamillata* the principal seta has the large brush of long fine hairs as in *C. mamillata*, but it is also slightly longer than the distal secondary seta (Fig. 11a), whereas in *C. mamillata* the distal secondary seta is longer (Fig. 11f). In both species the proximal secondary seta has a row of spines near the distal end that are virtually in-

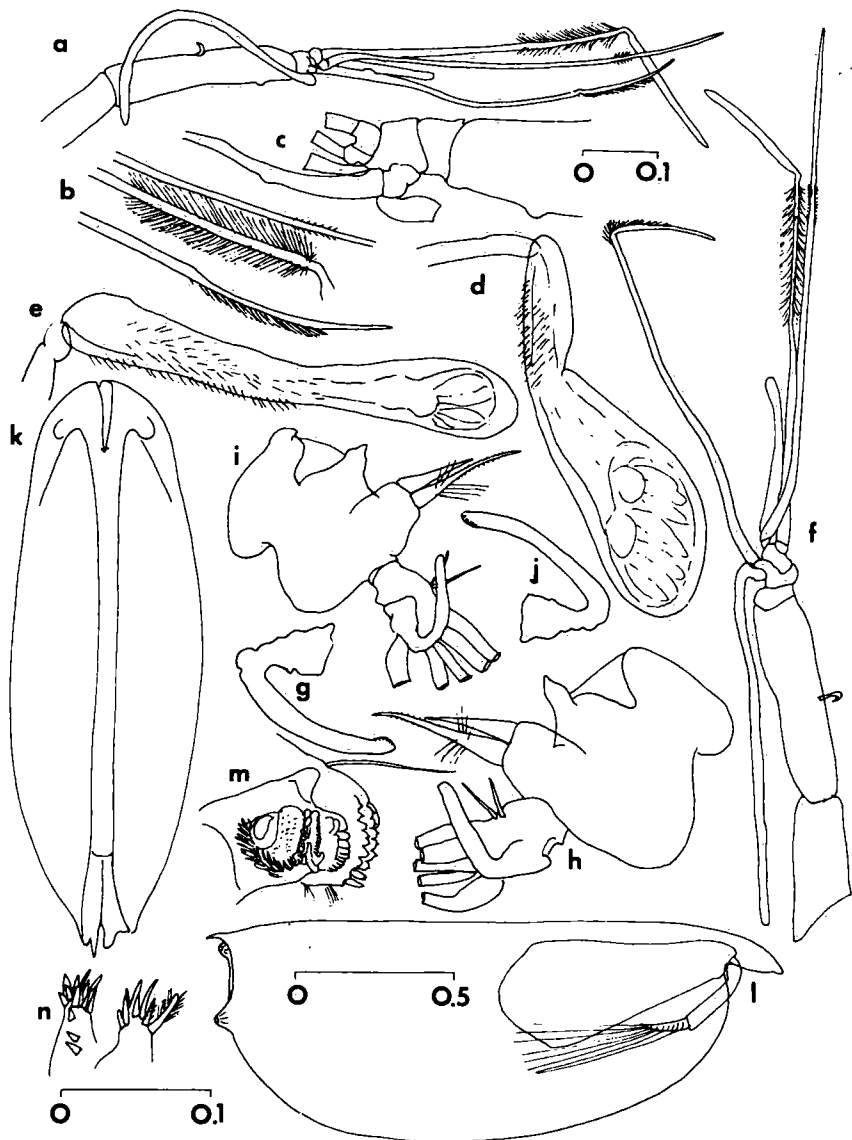


FIGURE 11. *C. nanomamillata*, n. sp., a-d: a, Male 1st antenna; b, Armature of male 1st antenna; c, Distal segments of the male 1st antenna; d, Capitulum of male frontal organ. *C. mamillata* Müller, e-h: e, Capitulum of male frontal organ; f, Male 1st antenna; g, Male right clamping organ; h, Endopodite of male left 2nd antenna, setae and filaments cut off. *C. nanomamillata*, n. sp., i-n: i, Endopodite of male left 2nd antenna, setae and filaments cut off; j, Male right clasper; k and l, ventral and lateral views of female shell; m, Tooththrow of basale of mandible and tooththrows and masticatory pad of coxa; n, coxal and precoxal endites of male. Scale on l for k and l; at bottom left for b-e, g-j, m and n; at upper right for a and f. Scales in mm.

visible when folded flat against the seta; *C. nanomamillata* has a distinctive bump or rounded protrusion on this seta near the proximal end that is not found in *C. mamillata*, as well as a similar protrusion near the ventral distal end of the 2nd segment of the 1st antenna (see Figs. 11a and c and compare with Fig. 11f). The proximal filament is very long in both species.

**SECOND ANTENNA** (Figs. 11i, j) — The lengths of the 2 setae and 3 filaments of the distal segment of the endopodite are as figured by Müller (1906, Pl. 16, fig. 6); the 3 filaments are short and about half as long as the 2 setae, which are of about the same length and widened distally (Fig. 13i). The distal bristle on the basal segment of the endopodite is long, with several long hairs proximally and tiny spinules distally, as in *C. mamillata* (Fig. 11h). The right clasping organ (Fig. 11j) is slimmer and lacks the pronounced protrusion near its base that is found on the *C. mamillata* right clasper (Fig. 11g).

**MANDIBLE** (Figs. 11m, 12g) — The toothrow of the basale has 6 serrate teeth and 2 larger teeth, as in other species. The coxale has several strong toothrows, the outermost of 10 large teeth, and a masticatory pad with bristles. No differences were noted between the two species in the character of the toothrows or the setation of the endopodite of the mandible.

**MAXILLA** (Figs. 11n, 12f) — The endopodite of the maxilla has 10 setae, only 1 of which is plumose in males and females of both species. There are 6 bare anterior setae, 1 short lateral seta, and 3 posterior setae. The distal segment bears the 2 claw-setae and 3 short slimmer setae. The *C. mamillata* maxilla is similar.

**FIFTH LIMB** (Fig. 12b) — The protopodite and endopodite have a total of 11 setae, including the 2 claws, of which 5 are plumose. The 1st segment of the exopodite has 9 setae, of which 2 are plumose, plus the long dorsal seta. The *C. mamillata* male 5th limb has 10 setae plus the long dorsal seta (Fig. 12a). The relative lengths of the 3 setae on the distal segment appear similar in both species.

**SIXTH LIMB** (Fig. 12c) — The setation of the male 6th limb definitely separates *C. mamillata* and *C. nanomamillata* from other species of *Conchoecia*. The basal exopodite segment has 6 plumose setae and a short dorsal seta. These plumose setae are exceptionally long and not vestigial or lacking as in many species of *Conchoecia*. This is a primitive character, as is the short ventral seta on the distal segment, which is not known for any other male *Conchoecia* except *C. cophopyga* and *C. dentata*. The ventral seta is only ca 20% the length of the other 2 setae (Fig. 12c). The 6th limb is also not so large and strong as in most *Conchoecia* males and appears relatively weak.

**SEVENTH LIMB** — This is a stronger appendage than is usual in *Con-*



FIGURE 12. a, Exopodite of the 5th limb of male *C. mamillata*. *C. nanomamillata*, n. sp., b-g: b, Male 5th limb; c, Male 6th limb; d, Female 6th limb; e, Distal segment of female 5th limb; f, Endopodite of male maxilla; g, Endopodite and basale of male mandible. Scale at top in mm for a-g.

*choecia* species, although it is similar in structure with 2 setae, one more than twice as long as the other. The *C. nanomamillata* 7th limb is similar to that of *C. mamillata* (Fig. 13f).

**PENIS** (Fig. 13d) — This is distinctive and is distinguishable from that of the *C. mamillata* male (Fig. 13g) in that the chitinized processes at the distal end are larger and more ornate.

**FURCA** — This is similar in both sexes of the 2 species (Fig. 13e). The claws decrease evenly in size, and there is no unpaired single bristle.

#### DESCRIPTION OF FEMALE

The shell (Figs. 11k, 1) is similar in shape and sculpturing to that of the male and of *C. mamillata*. The frontal organ extends well beyond the distal end of the 1st antenna (Fig. 13a). The capitulum of the frontal organ is similar in shape to that of the *C. mamillata* female (Fig. 13b), but differs in that it appears to be jointed to the stem; also, about half way down the dorsal margin of the capitulum is an indentation not noted on the *C. mamillata* female capitulum (compare Figs. 13a and 13b). No differences were observed in the female 1st or 2nd antennae of the two species. The principal seta of the 1st antenna has coarse hairs on the anterior and posterior sides for about two-thirds of its length. The distal bristle on the basal segment of the endopodite of the 2nd antenna is notable in that, as in the male, there are long hairs proximally and tiny spinules distally (Fig. 13c). In other species the female does not have long hairs on this bristle when the male does. The 5 filaments of the distal segment of the endopodite are subequal in length.

The mandible, maxillae, and 5th and 7th limbs appear similar in both sexes of both species. The 3 setae on the distal segment of the female 5th limb are the same relative lengths as in the male (Fig. 12e). The female 6th limb (Fig. 12d) differs from the male's only in the relative lengths of the 3 setae on the distal segment. In females of both species the basal segment of the exopodite has 6 plumose setae and a short dorsal seta as in the male.

**REMARKS** — At Station S *C. mamillata* and *C. nanomamillata* can be distinguished on the basis of size and possibly depth of capture. *C. mamillata* males were 1.62-1.8 mm long, and females 1.7-1.88 mm long, whereas *C. nanomamillata* males were 1.4-1.48 mm long and females 1.45-1.5 mm in length. However a 1.5 mm male from the Caribbean Sea proved to have the frontal organ, 1st antenna, and penis of *C. mamillata*, despite its small size. These characters differentiate the males, but aside from slight differences in the frontal organ, which may vary in individuals, females seem to differ only in size. Although *C. mamillata* adults were caught only between 1500 and 2000 m, where the temperature remains at ca 4°C year-round, and *C. nanomamillata* only from 1000 to 1500 m depths, juveniles of either or both species were found

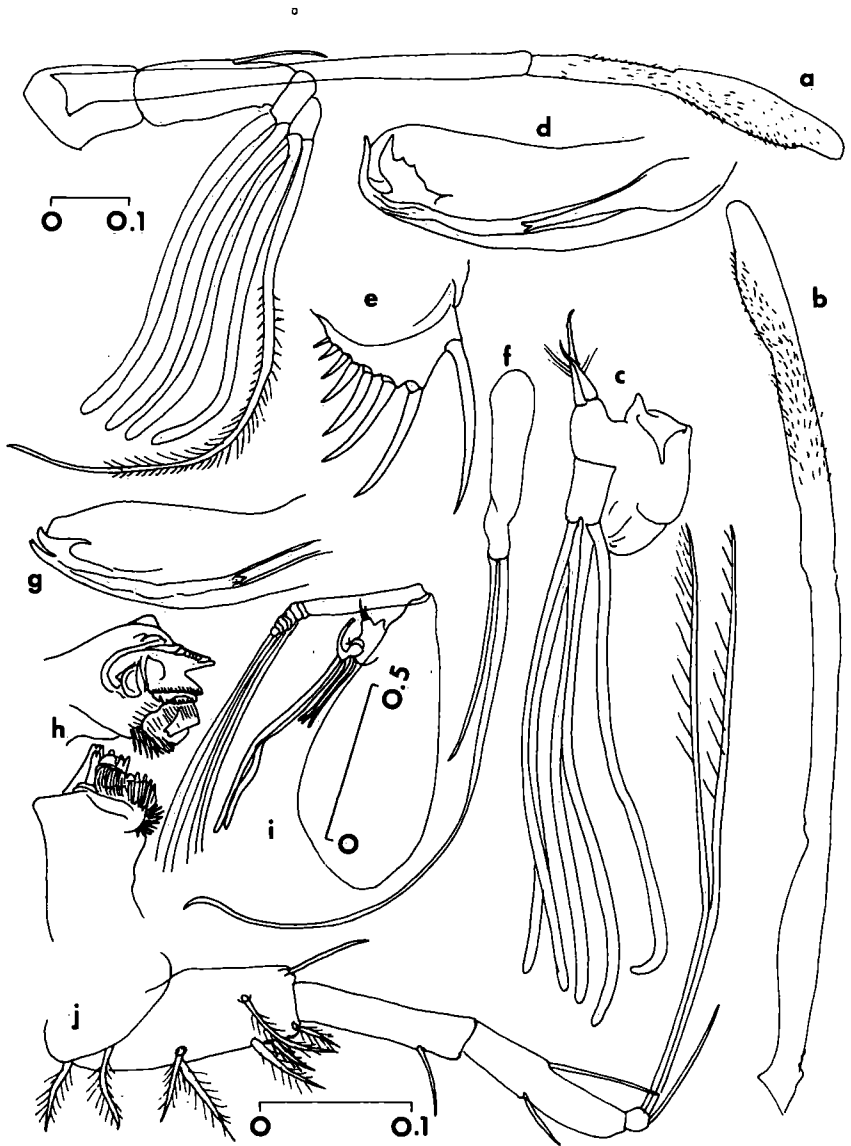


FIGURE 13. a, Frontal organ and 1st antenna of female *C. nanomamillata*, n. sp.. b, Frontal organ of female *C. mamillata*. c, Endopodite of 2nd antenna of female *C. nanomamillata*, n. sp.; d, Penis of male *C. nanomamillata*, n. sp.. *C. mamillata* e-j: e, Female furca; f, Male 7th limb; g, Penis; h, Two views of coxal tooththrows and masticatory pad of mandible; i, Male right 2nd antenna; j, Male 6th limb. Scale on i for i; at upper left for e; at bottom for a-d, f-h, and j. Scales in mm.

between 500 and 2000 m. In other localities adults of both species might be found over similar depth ranges.

The two species together constituted an appreciable percentage of the total numbers of ostracods taken between 1000 and 2000 m (see Table 4). They were not differentiated at the time the counts were made. In any event this would have been impossible, as most of the specimens taken were juveniles. The total numbers taken from between 1000 and 2000 m are shown in Figure 14C. The two species were more numerous in 1969 between 1000 and 1500 m, when maximal numbers were noted in February, April-May, and July. Fewer were caught in 1968 and 1970.

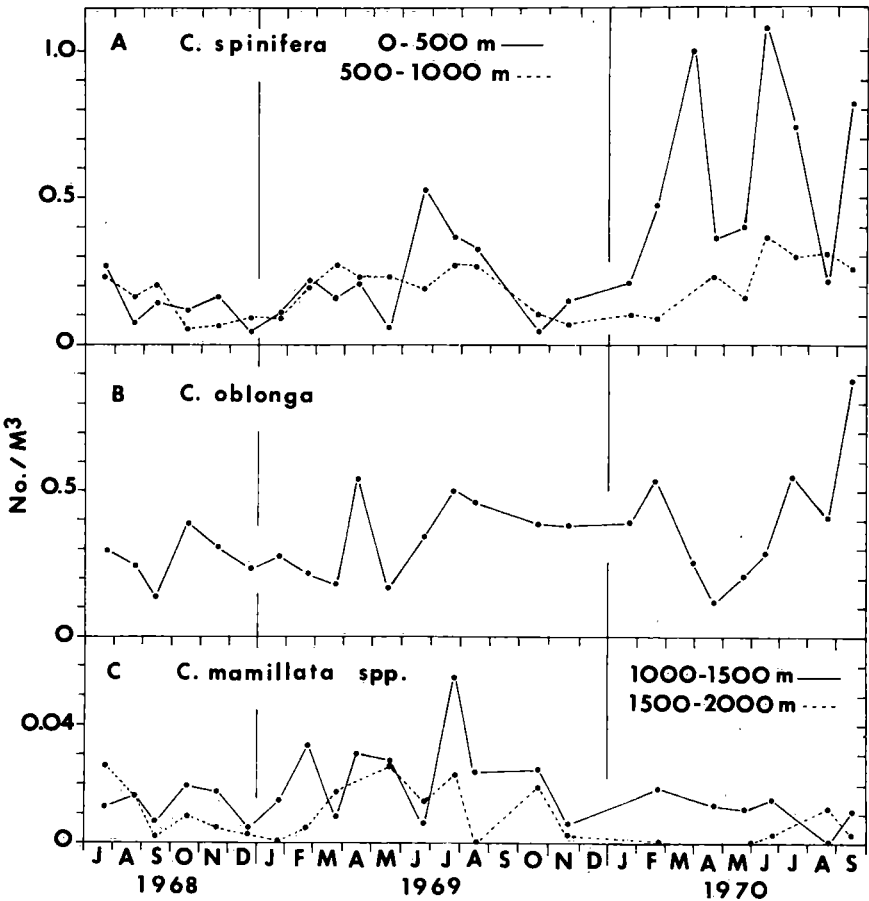


FIGURE 14. Seasonal variations in total numbers/m<sup>3</sup> of A: *C. spinifera* from 0-500 m, solid line, and 500-1000 m, dotted line; B: *C. oblonga* from 0-500 m; and C: *C. mamillata* and *C. nanomamillata* from 1000-1500 m, solid line, and 1500-2000 m, dotted line, from July 1968 to September 1970, taken in the No. 8 net samples.

Together these species constituted around 5% of the total numbers of ostracods caught from between 1000 and 2000 m in the No. 8 net samples.

DISTRIBUTION—*C. mamillata* has been documented from 32°N-56°S in the Atlantic and from 49°29'N-49°S in the Pacific Ocean. It has been recorded but not documented from 8°N-64°S in the Indian Ocean. Müller (1906) did not cite the locations where his smaller form was found, so at present *C. nanomamillata* is known only from 32°N in the Sargasso Sea and presumably from 30°N, 23°W in the eastern North Atlantic, where Angel (1979) found both large and small forms of *C. mamillata*. In the Sargasso Sea Angel found most adults between 1000 and 1250 m, and gave length ranges of 1.24-1.48 for females and 1.20-1.42 for males, so his specimens must have been *C. nanomamillata*.

#### *Spinifera* GROUP MÜLLER

Poulsen (1973) placed the species of this group in the genus *Paraconchoecia*, which Martens (1979) declared a *nomen nudum* until a type species is named. Excluding *C. mamillata*, seven species of this group have been noted at Station S, of which *C. dorsotuberculata*, *C. inermis*, and *C. aquiseta hirsuta* were not previously recorded (Deevey 1968), although Angel (1979) took them in these waters.

#### *C. spinifera* (Claus)

This was a common species year-round within the upper 1000 m. Although decreasing in numbers with depth, it constituted a higher proportion of the total numbers between 500 and 1000 m, and had the same pattern of depth distribution as *C. secernenda* (Fig. 5B). In 1968 and 1969 low numbers were present in winter, spring, and fall, but in 1970 *C. spinifera* was more abundant in the upper waters, with maxima in March, June, and September (Fig. 14A). Between 500 and 1000 m numbers were higher from March or April to September. The mean crop obtained for 0-1000 m depths from the No. 8 net samples was 261/m<sup>2</sup>. *C. spinifera* constituted 11% of the total numbers of ostracods taken in the 500-1000 m hauls with the No. 8 net and about 30% of the total numbers caught by the No. 2 nets over this depth zone (see Table 4).

*C. spinifera* is one of the larger species commonly caught in the upper waters, length of females is 1.9-2.0 mm and males 1.60-1.75 mm. Poulsen (1973) noted that the smallest individuals were found between 20°N and 20°S, and larger specimens at higher latitudes. This species undergoes some diurnal vertical migrations, but tends to remain below the seasonal thermocline (Angel 1968). In the Canary Island region it was most numerous around 500 m by day, but moved up to below 100 m at night (Angel 1969a). Angel and Fasham (1975) include *C. spinifera* with others they consider shallow mesopelagic species whose center of abundance is



between 300 and 400 m at 30°N in the eastern North Atlantic, but deepens to 400-800 m at 40°N, and then becomes shallower farther north at 53° and 60°N. In the Sargasso Sea Angel (1979) reported large catches between 300 and 800 m.

**DISTRIBUTION**—60°N-42°S in the Atlantic, to 47°30'S in the Indian Ocean, ca 40°N-56°S in the Pacific and Indonesian Seas. Poulsen (1973) noted that in the "Dana" collections it was common in Indonesian Seas, but rarely taken in the Indian Ocean and not at all in the Pacific.

### *C. oblonga* (Claus)

This is also a common year-round species at Station S, much more abundant in the upper waters than between 500 and 1000 m (see Tables 3 and 4). *C. oblonga* is medium-sized, females being 1.5-1.7 mm long, males 1.35-1.50 mm long. Angel (1979) reported females up to 1.84 mm long, with a mean length of 1.72 for females and 1.47 for males collected in these waters. Müller (1906) distinguished two forms on the basis of the location of the right asymmetric gland; form A had the gland at the posteroventral corner of the right shell, and in form B the gland was moved forward a bit on the ventral margin. Both forms occur at Station S but were not differentiated in the counts. Angel (1969a) distinguished the two forms in studying their depth distribution in the Canary Island region; both forms had their center of abundance within the upper 300 m. He noted (1968) that form A moved freely across the thermocline discontinuity, whereas form B found the thermocline a partial barrier. In the eastern North Atlantic both forms had a depth range above 500 m at 18°N, but occurred a little below 500 m at 30°N; at 40°N only form A was found above 400 m. Form A has been found more abundant east of 30°W in the North Atlantic, and form B more numerous west of 30°W (Angel 1979).

The variations in numbers/m<sup>3</sup> of *C. oblonga* in the upper 500 m are shown in Figure 14B. Times of maximal numbers reflect times of maximal numbers of juveniles. Probably at least four generations were produced during the year. In 1969 higher numbers of females and males were present in January, April, June, and October-November, but we lack data for September when higher numbers were present in 1970. *C. oblonga* is one of the species that was taken in highest numbers in September 1970 after the influx of the second cold water mass. Other such species include *C. parthenodā*, *C. spinirostris*, *C. procera*, *C. magna*, and *C. rotundata*.

**DISTRIBUTION**—48°N-42°S in the Atlantic, ca 40°N-40°S in the Pacific, to 38°S in the Indian Ocean, and in the Mediterranean Sea. It has not been taken south of the Subtropical Convergence in the Southern Hemisphere.

*C. aequiseta* Müller and *C. aequiseta hirsuta* Müller

As few samples were collected at depths greater than 500 m, *C. aequiseta* was previously recorded from Station S only on the basis of an immature male and a younger juvenile (Deevey 1968, Figs. 12a-c). Continued sampling of the deeper waters showed that one or both of these forms occurred fairly commonly between 500 and 1500 m. Females and juveniles of the two forms are indistinguishable; Müller separated the males into two species solely on the basis of long hairs on the distal bristle of the basal segment of the endopodite of the 2nd antenna of *C. hirsuta* (Fig. 15f); in the *C. aequiseta* male this bristle is bare (Fig. 16g, i). The armature of the male 1st antenna is similar in both forms. The principal seta has 45-50 closely packed pairs of teeth (Figs. 15d, 16c). The proximal secondary seta has a double comb of fine hairs or spinules, and distally spinules nearly to the tip. The distal secondary seta has a few spinules. The shape of the clasping organs is also similar in both forms (Figs. 15e, f, 16g, i), but the *hirsuta* male has only one protuberance on the inner side near the base of the right clasper (Fig. 15f), whereas the *aequiseta* male has two (Fig. 16i). Females, 3.05-3.2 mm long, and juveniles were found from August 1968 to August 1969 between 500 and 1500 m. Only a single *C. aequiseta* male, 2.5 mm long, was taken in September 1968 in a haul from 1000 to 1500 m. *C. aequiseta hirsuta* males, 2.55-2.6 mm long, occurred between 500 and 1500 m from December 1968 to May 1969; another male was noted in April 1970 in a 1000-1500 m tow. The *hirsuta* form therefore appeared to be more common, although Müller (1906) recorded it only from 35° to 37°S in the Atlantic and from 26° to 29°S in the Indian Ocean, whereas he recorded *aequiseta* males from 24°N to 31°S in the Atlantic and to 29°S in the Indian Ocean. Angel (1979) considered *C. aequiseta*, including the *hirsuta* form, a deep mesopelagic species restricted to central gyre waters in the North Atlantic.

DISTRIBUTION — The two forms have been recorded from 40°N-44°S in the Atlantic, 11°-56°S in the Pacific, 0°-25°S in the Indian Ocean and from Indonesian Seas.

*C. reticulata* Müller

The generic name *Macroconchoecia* Granata and Caporiacco 1949 has been proposed for this species.

A few individuals of *C. reticulata* were taken throughout the year between 1000 and 2000 m. Most of the specimens were juveniles, but a few males and females were caught. The females were 3.55-3.75 mm long and the males 3.1-3.4 mm. Previously a single female was recorded, and its shell and 1st antenna figured (Deevey 1968, Fig. 13). Angel (1979) suggested that more than one species may be involved, because he noted both smaller specimens with spines on the shell and larger deeper-living in-

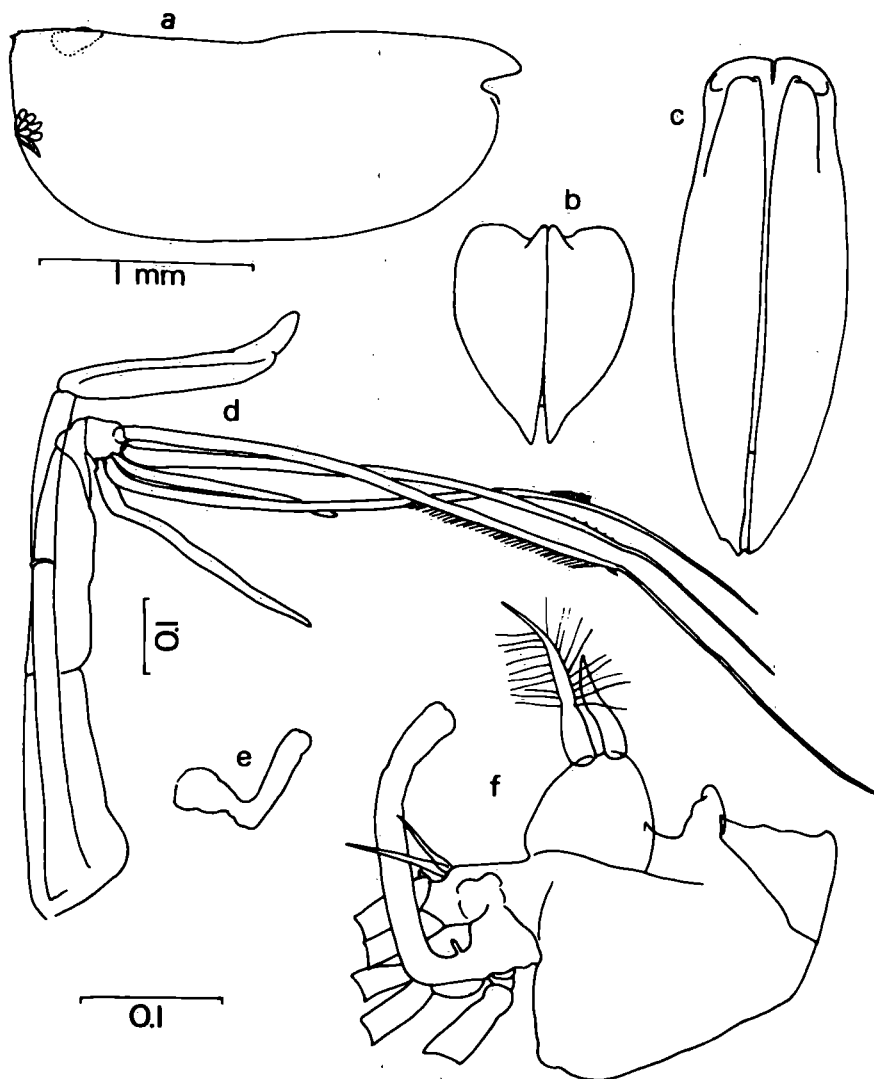


FIGURE 15. *C. aequisetia hirsuta* male. a, b, and c, Lateral, ventral and posterior views of shell; d, Frontal organ and 1st antenna; e, Left clasper; f, Endopodite of right 2nd antenna, setae and filaments cut off. Scale below a for a-c; beside d for d; at bottom for e and f. Scales in mm.

dividuals without spines. The males collected at Station S agree with Müller's (1906: 64, pl. 12, figs. 10-17) description and figures of the male shell and 1st and 2nd antennae, except that they have rounded protuberances inside at the proximal ends of the clasping organs (see Figs. 17e, f). The armature of the 1st antenna, (Fig. 17b) is as he described. The

principal seta has a relatively short and very thick double row of countless slim lamellae that do not appear to be spines. The two secondary setae are of about the same length (Fig. 17i), the distal one with only a few tiny spinules, whereas the proximal seta has a long thin callous and rows of spinules more distally. The sculpturing of the shell is distinctive as

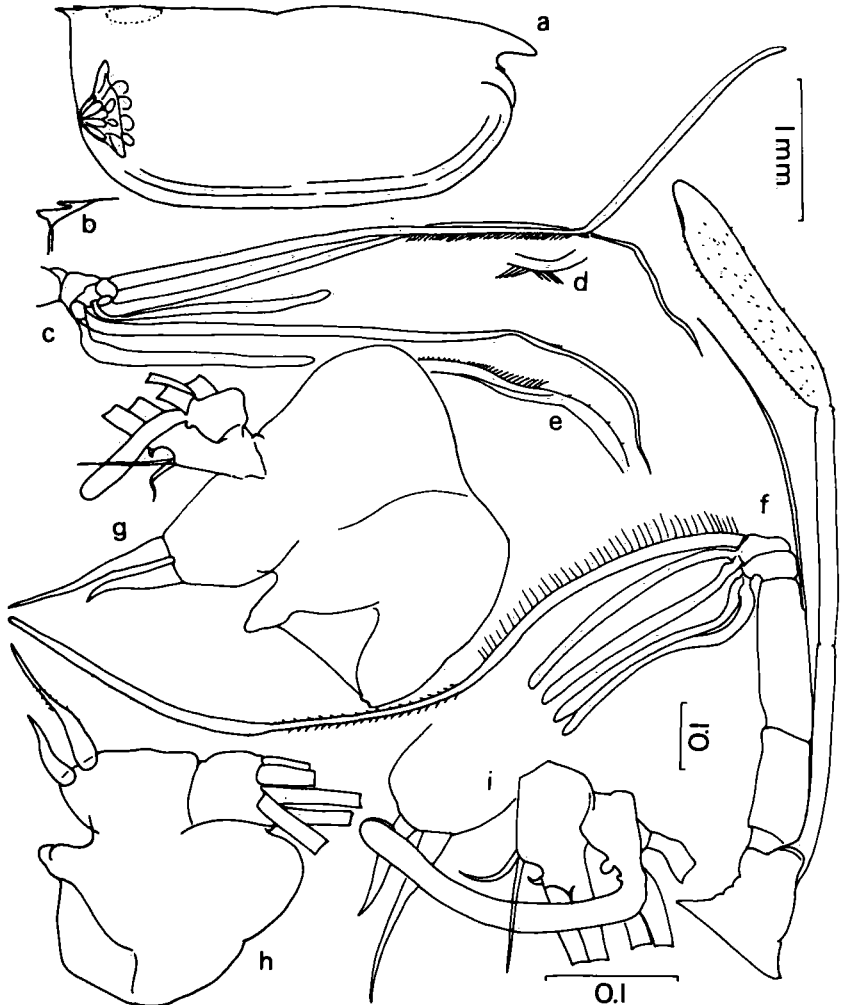


FIGURE 16. *C. aequiseta* male. a, Lateral view of shell; b, postero-dorsal corner of shell; c, Setae and filaments of 1st antenna; d, Distal end of tooththrow of principal seta of 1st antenna; e, Armature of proximal secondary seta; f, Frontal organ and 1st antenna of female; g, Endopodite of male left 2nd antenna, setae and filaments cut off; h, Endopodite of female 2nd antenna, setae and filaments cut off; i, Part of endopodite of male right 2nd antenna. Scale at upper right for a; beside f for c and f; at bottom right for d, e, g-i. Scales in mm.

described. Especially over the dorsal part of the shell on the shoulder vaults and toward the posterior end the rectangles of the sculpturing are armed with strong spines (Fig. 17k). The relative lengths of the setae and filaments of the endopodite of the 2nd antenna (Fig. 17c) are as figured by

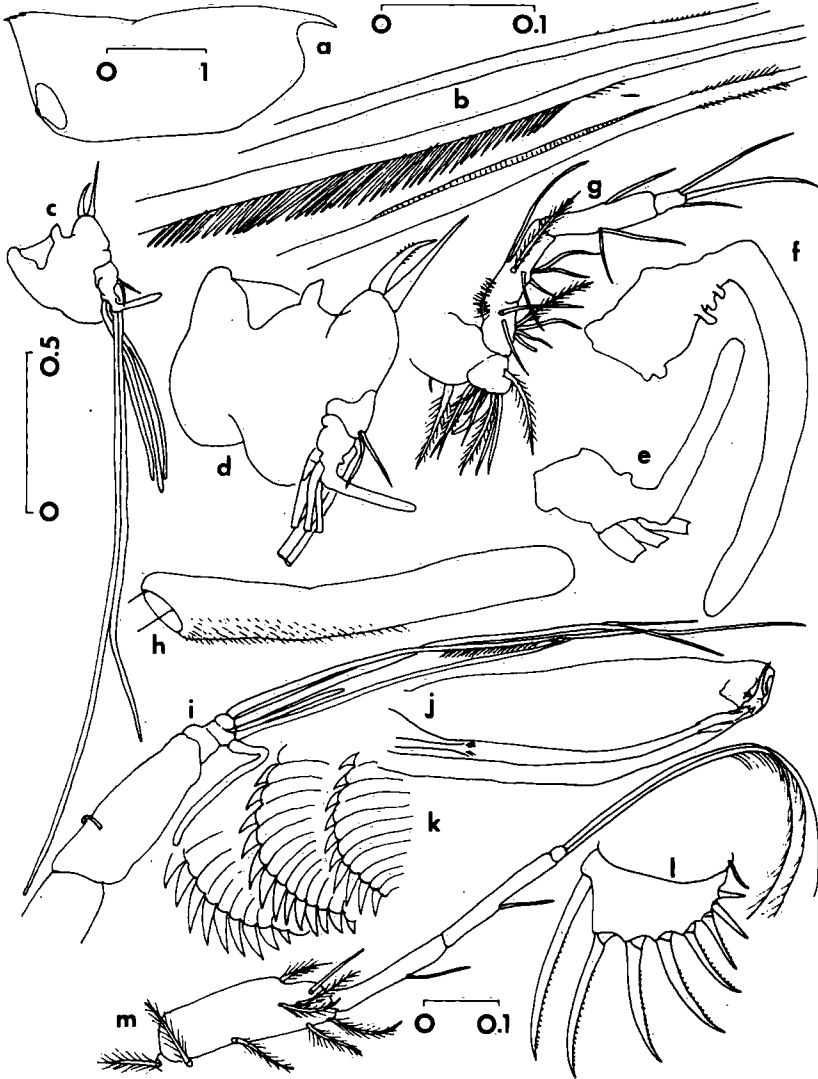


FIGURE 17. *C. reticulata* male. a, Lateral view of shell; b, Armature of 1st antenna; c, Endopodite of left 2nd antenna; d, Endopodite of left 2nd antenna, setae and filaments cut off; e, Left clasper; f, Right clasper; g, Fifth limb; h, Capitulum of frontal organ; i, 1st antenna; j, Penis; k, detail of sculpture and spines on shouldervault; l, Furca; m, 6th limb. Scale on a for a; on left margin for c, g, i, l, m; at bottom for d, h, j, k; at top for b, e, f. Scales in mm.

Müller. Although Müller did not mention the protuberances on the inner proximal sides of the clasping organs (Figs. 17e, f), Poulsen (1973, Fig. 12) described them. The 6th limb has 6 relatively long plumose setae on the basal segment, and the ventral seta of the distal segment is slightly shorter than the other two and not plumose (Fig. 17m). Judging from Müller's and Poulsen's descriptions, *C. reticulata* is most closely related to *C. caudata*, and both species should probably be removed from the *Spinifera* Group.

**DISTRIBUTION**—40°N-6°S in the Atlantic, 4°N-30°S in the Indian Ocean and the tropical Pacific Ocean. According to Poulsen, this species is widely distributed over the tropical parts of the three oceans from 28°N-33°S.

#### *C. dorsotuberculata* Müller

This species, taken throughout the year in numbers of 1-12/1000 m<sup>3</sup> between 500 and 2000 m (see Tables 3 and 4), has been rarely recorded. Müller (1906) described it from specimens caught at 40°14'N and 24°43'N in the Atlantic and from 26°S and 2°43'S in the Indian Ocean. Poulsen (1969b, 1973) recorded one specimen from the Gulf of Guinea, one male from 29°40'S in the western Pacific, and one shell from 1°S in the Indian Ocean. Angel and Fasham (1975) list it as occurring from 18° to 53°N in the eastern Atlantic as a deep mesopelagic to bathypelagic species. Most of the specimens caught at Station S were juveniles. Males 2.4-2.5 mm long and females 2.6-2.7 mm long were found between 1000 and 2000 m; juveniles occurred between 500 and 2000 m. Müller's females were 2.6 and his males 2.4 mm long. Angel (1979) gave a length range of 2.48-2.72 mm for females from Ocean Acre in the Sargasso Sea. The specimens caught at Station S agree well with Müller's brief description of the shell and 1st and 2nd antennae, except that he neither described nor figured the long hairs on the distal bristle of the basal segment of the endopodite of the 2nd antenna (see Fig. 18f), which Poulsen (1973, Fig. 8) described. The principal seta of the male 1st antenna has at least 60 long closely packed teeth, impossible to count. The principal seta is widened distal to the toothrow and the 2 filaments are exceptionally long (Fig. 18b). This species is readily identified by the location of the left asymmetric gland, which is moved forward on the dorsal shell margin to ca two-thirds of the total length from the anterior end (Figs. 18a, j), and also by the rounded posterior margin and the backward curving 5th claw on the furca. Medial glands were especially noticeable on the posterior margins near the posterodorsal corner (Fig. 18j) of the male shell.

**DISTRIBUTION**—53°N-0°50'S in the Atlantic, ca 3°-26°S in the Indian Ocean, and 30°S in the Pacific.

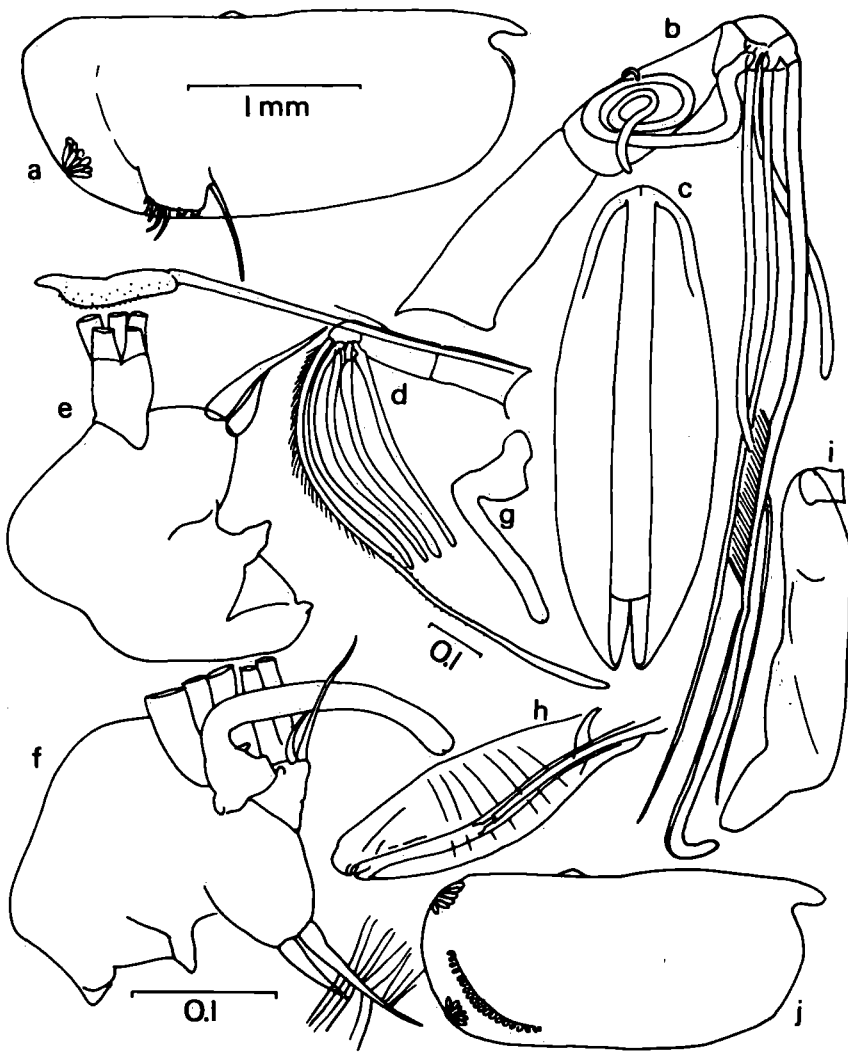


FIGURE 18. *C. dorsotuberculata*. a, Lateral view of female shell; b, Male 1st antenna; c, Ventral view of female shell; d, Female frontal organ and 1st antenna; e, Endopodite of female 2nd antenna, setae and filaments cut off; f, Endopodite of male right 2nd antenna, setae and filaments cut off; g, Male left clasper; h, Penis; i, Capitulum of male frontal organ; j, Lateral view of male shell. Scale on a for a, c, and j; in center for b, d, and h; at bottom for e-g, i. Scales in mm.

### *C. inermis* (Claus)

This species was taken infrequently in July, August and November 1968, from April to June and in August 1969, and in January, February, June, July, and September 1970, only from between 500 and 1000 m.

Angel (1979) found it only between 600 and 800 m at Ocean Acre and at comparable depths off the Canary Islands (1969a). A total of 4 females, 6 males, and several juveniles were noted. The females were 2.05-2.25 mm long and the males 1.85-2.05 mm long. This species is easily recognized by its shell shape (Figs. 19a, g) with the straight posterior margin forming right angles with the dorsal and ventral margins. The right asymmetric gland opens at the posteroventral corner, the left gland just back from the posterodorsal corner as illustrated by Müller (1906, pl. 10, fig. 4), and not on the posterior margin as figured by Claus (1891, pl. 11, fig. 1). The capitulum of the male frontal organ is similar to the female's (Fig. 19c). The principal seta of the female 1st antenna has some long hairs on the anterior surface proximally, and short spinules on the posterior surface distally (Fig. 19c). The principal seta of the male 1st antenna has a brush of long thin hairs, rather as in *C. mamillata* (Fig. 19h).

DISTRIBUTION — 53°N-16°S in the Atlantic, 11°-28°S in the Pacific, to 26°S in the Indian Ocean, and in Indonesian Seas.

#### *Elegans* Group Müller

##### *C. elegans* Sars

Poulsen (1973) placed this species in the genus *Paraconchoecia*, now declared a *nomen nudum*. Martens (1979) designated it the type species of his proposed genus *Discoconchoecia*.

This common cosmopolitan ostracod that has a wide length range of 1.0-2.2 mm and occurs from the Arctic to the Antarctic baffles investigators who have not discovered that more than one species is involved. Small individuals, 1.15-1.25 mm long, occurred year-round within the upper 1000 m in numbers up to 68/1000 m<sup>3</sup>, especially during the first year studied. None were noted during the fall of 1969, and fewer were recorded in 1970. Larger specimens were not previously noted (Deevey 1968), but from July 1968 to March 1969 males and females varying from 1.4-1.9 mm in length were caught, most from between 1000 and 1500 m, but a few from 500-1000 m depths. Larger forms were also taken in October 1969 and July 1970. In the eastern Atlantic Angel and Fasham (1975) were able to differentiate a 1.2 mm southern form that occurred from 10°30' to 18°N from a 1.6 mm form found from 30° to 60°N and a 1.8 mm form recorded from 40° to 60°N. At 44°13'N in the Bay of Biscay Angel (1977) found a wide size range that he suggested might have resulted from hybridization of the small and larger forms. Because the smaller and larger forms were not usually found over the same depth ranges at Station S, it seems likely that the larger forms have been transported at depth from more northern waters, as appears to be the case with other organisms, such as *Calanus finmarchicus*.



DISTRIBUTION — 80°N-56°S in the Atlantic, 70°N-68°S in the Pacific, to 60°S in the Indian Ocean, and in Indonesian Seas.

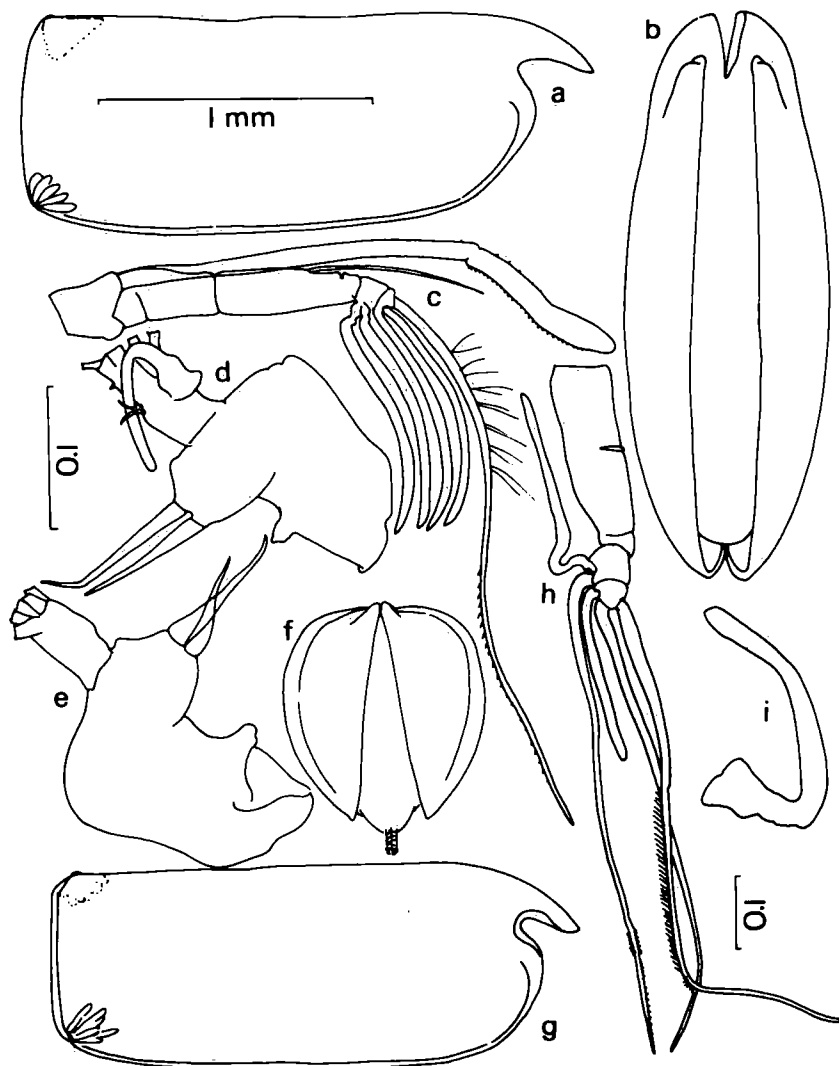


FIGURE 19. *C. inermis*. a, b, and f, Lateral, ventral and posterior views of female shell; c, Female frontal organ and 1st antenna; d, Endopodite of male left 2nd antenna, setae and filaments cut off; e, Endopodite of female 2nd antenna, setae and filaments cut off; g, Lateral view of male shell; h, Male 1st antenna; i, Male right clasper. Scale on a for a, b, f, g; at bottom right for c and h; on left margin for d-e and i. Scales in mm.

*Procera* Group Müller*C. procera* Müller and *C. microprocera* Angel

*C. procera* was one of the commonest species, probably second in numbers after *C. spinirostris*, in the upper 500 m. The total numbers, counting juveniles, may include some juveniles of *C. microprocera*. Figure 20A shows the seasonal variations in total numbers of the *procera* species and Figure 20B the variations in total numbers of the females and males of the two species. It would appear, in general, that *C. procera* was more abundant when *C. microprocera* was not. Maxima of *C. microprocera* were noted in January, March, and October 1969 and in January, March, and September 1970, whereas adults of *C. procera* were more numerous in February, April, and July 1969 and in February-March, June, and September 1970. There were four maxima of juveniles in 1969 and also four between February and September 1970. The *C. procera* complex was most numerous in the fall of 1968 and 1969 and in September 1970, and tended to show a spring minimum. These are small species. *C. procera* adults are 1.0-1.2 mm long, *C. microprocera* 0.8-0.95 mm long. Angel (1979) reported length ranges of 0.94-1.24 for *C. procera* and of 0.76-1.04 for *C. microprocera*. Based on over 800 measurements he gave mean lengths of 0.949 mm for female and 0.824 mm for male *C. microprocera* and of 1.173 mm for female and 1.003 mm for male *C. procera* in the Sargasso Sea.

DISTRIBUTION — For *C. procera*: 53°N-40°S in the Atlantic, 33°-40°S in the Pacific, and 34°38'-43°34'S in the Indian Ocean. Chavtur (1977) recorded it from the subarctic front in the North Pacific. As Angel (1971) divided *C. procera* into three species, most records are questionable. *C. microprocera* is known from 40°N-25°S in the Atlantic.

*C. brachyaskos* Müller

This is a common species at Station S, occurring year-round between 500 and 2000 m depths, predominantly between 1000 and 1500 m (see Tables 3 and 4). Between 500 and 1000 m it was most numerous in March and May-June 1969 and in January-February and June to August 1970 (see Fig. 21B). Between 1000 and 1500 m it was relatively abundant in August 1968, January to March, May-June, and October-November 1969, and in May-June 1970. Females were 1.35-1.5 mm long, males 1.3-1.4 mm long. Larger specimens are found at higher latitudes. In the Pacific between 40°-68°S females were 1.56-1.66 mm long and males 1.45-1.6 mm in length (Deevey 1978b).

DISTRIBUTION — 60°N-56°30'S in the Atlantic, ca 40°N-77°28'S in the Pacific, and to 65°S in the Indian Ocean.

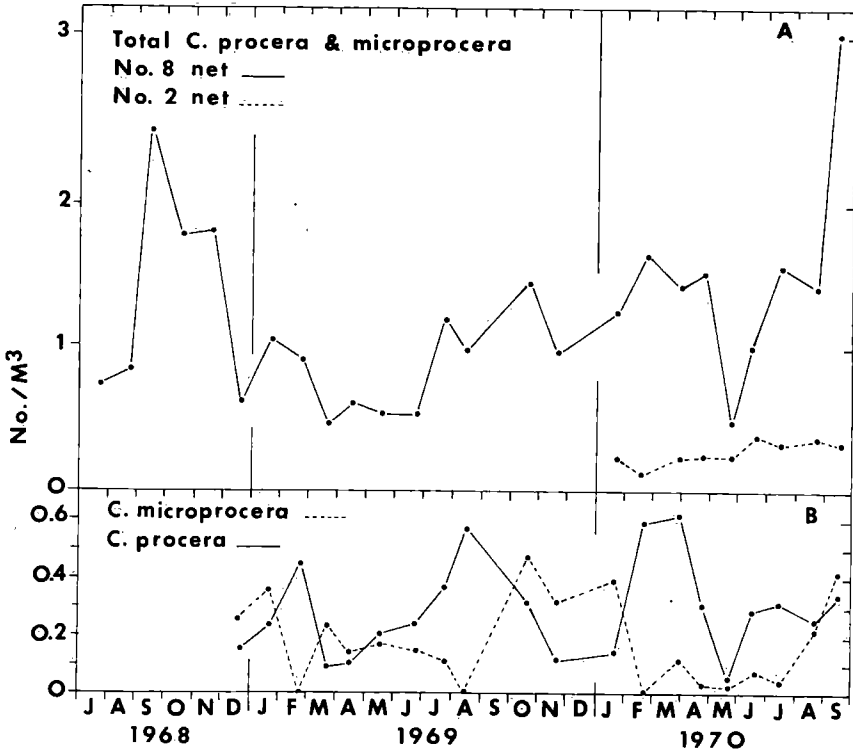


FIGURE 20. Seasonal variations in total numbers/m<sup>3</sup>, 0-500 m, of A: *C. procera* and *C. microprocera* caught by the No. 8 net, solid line, between July 1968 and September 1970, and No. 2 net, dashed line, from January to September 1970; and B: *C. procera*, solid line, and *C. microprocera*, dashed line, females and males taken in the No. 8 net samples from December 1968 to September 1970.

### *Acuminata* Group Müller

#### *C. (Conchoecetta) acuminata* (Claus)

A few specimens of this species were taken in the upper 500 m, especially between July 1968 and February 1969. *C. acuminata* has been described and figured from these waters (Deevey 1968, fig. 19). The other member of this group, *C. giesbrechti*, has never been recorded from the western North Atlantic. Females were 3.0-3.6 mm long, males 2.0-2.6 mm in length.

DISTRIBUTION—43°N-37°S in the Atlantic, the tropical Indian and Pacific Oceans, and Indonesian Seas.

### *Rotundata* Group Müller

Seven species of this group, which Poulsen placed in the genus

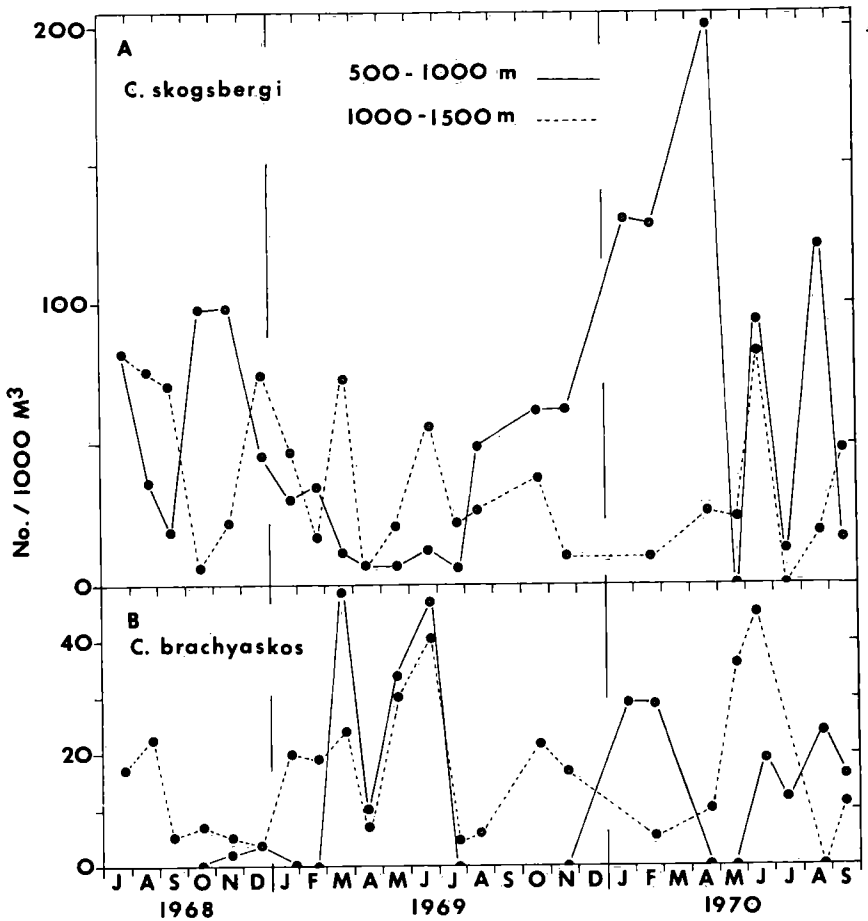


FIGURE 21. Seasonal variations in total numbers/1000 m<sup>3</sup> of A: *C. skogsbergi* and B: *C. brachyaskos* between 500 and 1000 m, solid line, and 1000 to 1500 m, dashed line, taken in the No. 8 net samples from July 1968 to September 1970.

*Metaconchoecia*, now a *nomen nudum* until a type species is designated, have been taken at Station S. Five of these were previously recorded, one of which, *C. arcuata*, was wrongly identified as *C. kyrtophora* Müller, but has since been described as a new species (Deevey 1978b). The two species we have not previously noted are *C. nasotuberculata* and *C. macromma*, although Angel (1979) recorded the latter from his Ocean Acre samples.

#### *C. rotundata* Müller

The species identified and figured as *C. rotundata* (Deevey 1968: 51) has been designated as *C. rotundata* form 15 by Angel (1979) and Angel

and Fasham (1975), who found it only at 30°N in the eastern Atlantic between 100 and 500 m. In the Sargasso Sea Angel found it between 100 and 600 m. This species occurred year-round within the upper 1000 m, in considerably greater numbers in the upper waters, although it constituted a higher percentage of the total numbers between 500 and 1000 m (see Table 4). When taken below 1000 m it was assumed to be a contaminant. The No. 8 net samples yielded mean numbers of 98/1000 m<sup>3</sup> for 500-1000 m depths (see Table 3). Total numbers varied considerably during the year, with four to five maxima in the upper waters (Fig. 22A). *C. rotundata* was taken in higher numbers from November 1969 to September 1970, with minima in January, May, and August 1970, than during the first half of the period studied. This is one of the species that was most

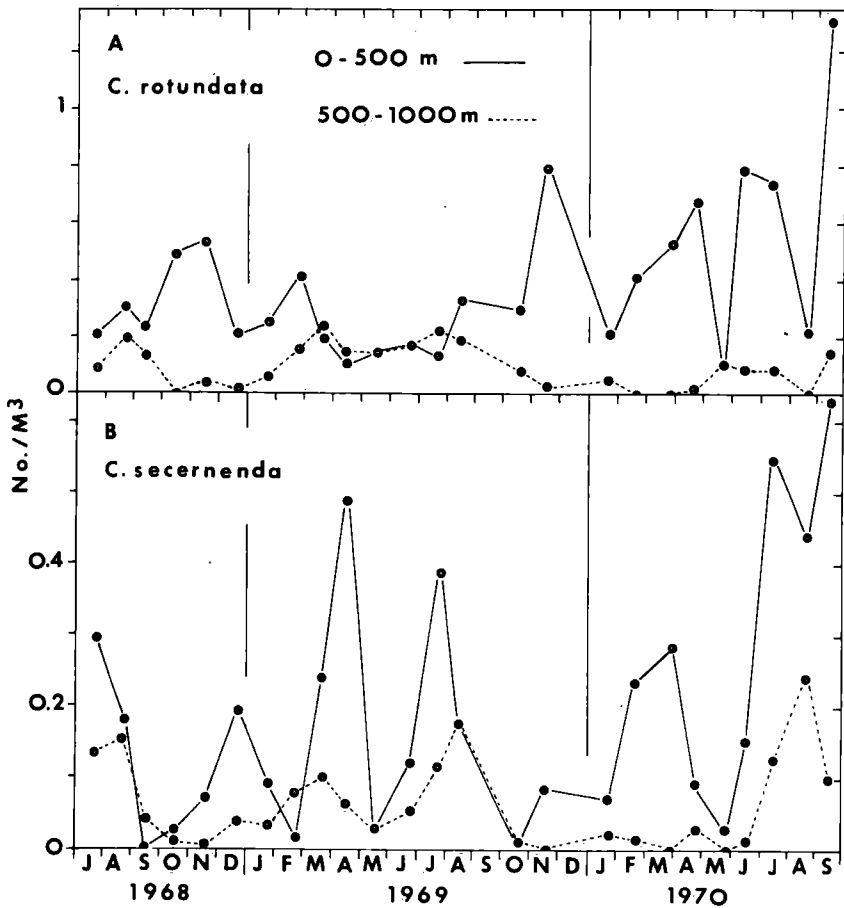


FIGURE 22. Seasonal variations in total numbers/m<sup>3</sup> of A: *C. rotundata*, and B: *C. secernenda* caught within the upper 500 m, solid line, and between 500 and 1000 m, dashed line, in the No. 8 net samples from July 1968 to September 1970.

abundant in the surface waters in September 1970. *C. rotundata* is a small species. Females are 0.8-1.0 mm long, males 0.75-1.0 mm in length.

DISTRIBUTION—40°N-35°S in the Atlantic, tropical Pacific to 49°S, and at 34°38'S in the Indian Ocean (Deevey 1981.)

#### *C. skogsbergi* Iles

The species so designated has been described and figured (Deevey 1968: 54) from Station S. Angel (1979) indicated this species is probably the same as Angel and Fasham's (1975) *C. rotundata* form 6, which they found at 30°N, 30°W as a deep mesopelagic species between 800 and 1500 m. In the Sargasso Sea Angel reported that it was common from 900 to 1500 m. At Station S it occurred year-round, primarily between 500 and 1500 m, but was occasionally taken between 1500 and 2000 m. Although it decreased in numbers with depth below 500-1000 m (see Fig. 5 and Table 3), it was more numerous than any other species between 1000 and 1500 m (see Table 4), where it constituted 10% of the total numbers caught by the No. 8 net. Highest numbers were taken in early 1970 between 500 and 1000 m, coincident with the influx of a cold water mass, although fewer were noted between 1000 and 1500 m at that time. Total numbers varied considerably from month to month (see Fig. 21A).

In the Sargasso Sea *C. skogsbergi* is small, 1.0-1.2 mm in length. Specimens up to 1.8 mm long have been recorded from Antarctic waters (Deevey 1978b). In the South Atlantic a gradual increase in size was noted in passing to higher latitudes (Deevey 1974b); small specimens were found down to 35°s and south of the Subtropical Convergence, and down to 55°S individuals were up to 1.75 mm long.

DISTRIBUTION—66°N-65°S in the Atlantic, 63°N-76°S in the Pacific, and 34°-64°21'S in the Indian Ocean.

#### *C. arcuata* Deevey

This bathypelagic species was previously erroneously listed as *C. kyrtophora* Müller (Deevey 1968: 55, fig. 23), but has since been described from the South Pacific (Deevey 1978b, figs. 12-13). Also this is Angel and Fasham's (1975) *C. rotundata* form 7. At Station S it occurred continuously from July 1968 to August 1969 and from February to September 1970 between 1000 and 2000 m, and constituted an appreciable percentage of the total numbers over these depths (Tables 3 and 4). Mean numbers of 7/1000 m<sup>3</sup> were obtained for the No. 8 net samples. In individual hauls total numbers varied from 2 to 27/1000 m<sup>3</sup>. Angel (1979) also found it abundant in the Sargasso Sea even to depths of 2500-3500 m. This is also a small species, males and females being ca 1.0 mm long in this locality.

DISTRIBUTION—60°N-45°S in the Atlantic, and 56°72°S in the Pacific Ocean.

*C. pusilla* Müller

This is another small species, females being 0.9-1.0 mm and males 0.85-0.95 mm long, that was caught consistently, especially during the first year studied, between 500 and 1000 m. Occasional specimens were taken from 1000 to 2000 m depths. It was previously recorded from two specimens caught in a haul from 500 to 1800 m (Deevey 1968: 57, fig. 25). It was not noted between August 1969 and April 1970, but was present during the rest of the period studied in numbers varying from 1 to 16/1000 m<sup>3</sup>. Angel (1979) also found *C. pusilla* in the Sargasso Sea between 700 and 1560 m and noted that it is not a very common species there.

DISTRIBUTION—60°N-64°S in the Atlantic, 28°-45°S in the Pacific, and the equatorial Indian Ocean.

*C. glandulosa* Müller

This bathypelagic and rarely noted species was previously recorded from Station S on the basis of a single juvenile 0.82 mm long (Deevey 1968, Fig. 24). Continued sampling yielded only a few more specimens from between 500 and 2000 m in October and November 1968, February, March, June, and October 1969, and February and September 1970. Angel (1979) has not caught this species in the eastern North Atlantic, but recorded a number of females, males, and juveniles from between 1500 and 3500 m in the Sargasso Sea. This is the largest member of the *Rotundata* Group, and is readily identified by its size and the location of the asymmetric glands. The female shell and 1st antennae are illustrated in Figures 23a-f. Although no males were taken at Station S, features of the 1st and 2nd antennae of a 1.7 mm male, caught at 2000 m in the Caribbean Sea are shown in Figures 23g-k. The armature of the male 1st antenna consists of a row of 15-16 pairs of teeth on the principal seta and a few spinules on the proximal secondary seta (Fig. 23j). The 2nd segment of the female 1st antenna is covered with short hairs and bears dorsally and distally a small spine in the spot where many other female *Conchoecia* have a seta (Fig. 23b). Only two females, 1.8 and 1.85 mm long, were caught at Station S in hauls from 1500 to 2000 m in June 1969 and February 1970. The other specimens were juveniles. Müller (1906) described this species from a few specimens taken in the Indian Ocean; his female was 1.9 mm and his male 1.85 mm long.

DISTRIBUTION—32°N-64°S in the Atlantic, 46°31'N in the Pacific, 26°-29°S in the Indian Ocean usually at depths of ca 2000 m or greater.

*C. nasotuberculata* Müller

A single female 0.9 mm long and a juvenile were the only representatives of this species recorded. The female was caught in June 1970 in the upper 500 m and the juvenile in June 1969 from between 500 and 1000 m.

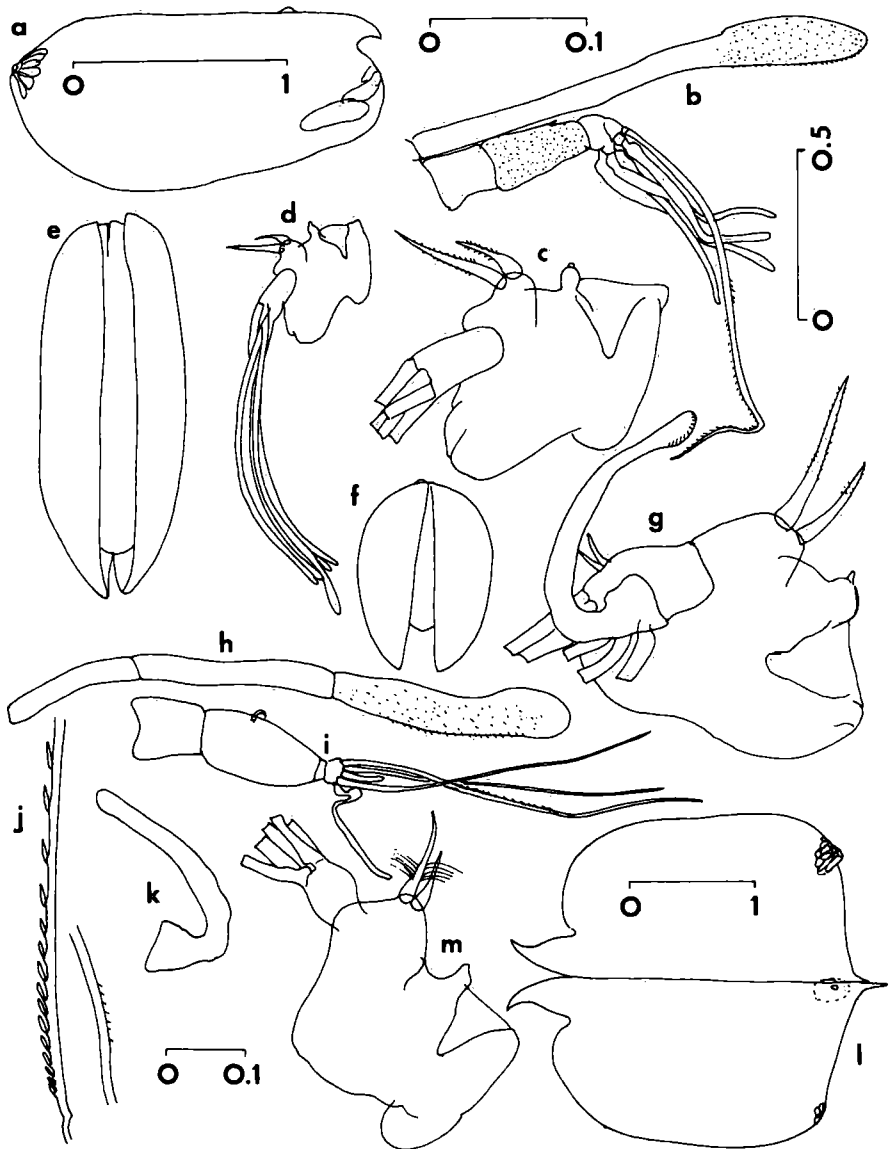


FIGURE 23. *C. glandulosa*, a-k: a, e, and f, Lateral, ventral and posterior views of female shell; b, Female frontal organ and 1st antenna; c, Endopodite of female 2nd antenna, setae and filaments cut off; d, Endopodite of female 2nd antenna; g, Endopodite of male right 2nd antenna, setae and filaments cut off; h, Male frontal organ; i, Male 1st antenna; j, Armature of male 1st antenna; k, Male left clasper. *C. plinthina*: l, Shell of 3.8 mm juvenile, opened out; m, Endopodite of 2nd antenna of juvenile, setae and filaments cut off. Scale on a for a, e, and f; on l for l; at top for c, g, j, k, m; at upper right for i, at bottom for b, d, h. Scales in mm.



This species is distinguished by the fact that the left asymmetric gland is moved forward onto the rostrum.

DISTRIBUTION—Angel and Fasham (1975) recorded this species from 11° to 18°N in the eastern Atlantic, and it has also been reported and described from Barbados (Deevey 1970, figs. 5-6), but it has not previously been found as far north as Station S in the Atlantic. At present it is known from 32°N to 42°30'S in the Atlantic, 40°N to 54°S in the Pacific, and 2° to 46°S in the Indian Ocean.

### *C. macromma* Müller

Although juveniles possibly of this species were noted continuously in 1968 and 1969 between 500 and 2000 m, only 3 females and a male were caught, all from between 1000 and 1500 m. The females were 1.24-1.28 mm long and were caught in October and November 1968 and April 1969. The male was 1.2 mm long and was taken in July 1969. In *C. macromma* the left asymmetric gland is moved back on the dorsal margin, and the right asymmetric gland is a quarter to a third of the distance down the posterior margin from the posterodorsal corner (Fig. 24a). The capitulum of the male and female frontal organs are of distinctive shape, compared with other members of this group (Figs. 24c, f). The male had 11 pairs of teeth on the principal seta of the 1st antenna (Fig. 24j), whereas Müller (1906, p. 79) described 15. These specimens were a little larger than Müller's; he gave the length of females as 1.0-1.07 mm and of males as 0.9-1.0 mm.

This species has been rarely reported. Poulsen (1973) noted a single female, 1.2 mm long, from the South Pacific. Larger specimens recorded from the South Atlantic (Deevey 1974b) have since been described as a new species (Deevey 1981). One female from 44°S was the same size as the specimens from Station S. Angel and Fasham (1975) listed *C. macromma* as occurring between 11° and 30°N in the eastern Atlantic, and Iles (1953) recorded it from the Benguela Current. Angel (1979) has taken deep-living specimens from 2000 to 2500 m depths in the Sargasso Sea, but is not sure they are conspecific with Müller's species.

DISTRIBUTION—The recorded range is 32°N-44°S in the Atlantic, 22°-64°S in the Pacific, and 13°N-2°S in the Indian Ocean.

### *Curta* Group Müller

Three members of this group, placed by Poulsen (1973) in the genus *Microconchoecia*, now amended to *Mikroconchoecia* (Martens 1979), occurred at Station S. *C. echinulata* and *C. stigmatica* were not previously recorded (Deevey 1968), but Angel (1979) caught *C. stigmatica* in these waters.



FIGURE 24. *C. macromma*. a, Lateral view of male shell; b, Endopodite of female 2nd antenna; c, Female frontal organ and 1st antenna; d, Male right clasper; e, Endopodite of male left 2nd antenna, setae and filaments cut off; f, Capitulum of male frontal organ; g, Endopodite of female maxilla; h, Toothrows and masticatory pad of female coxa of mandible; i, Female 6th limb; j, Armature of male 1st antenna; k, Female 5th limb; l, Penis, m, Furca. Scale on a for a, at bottom left for b-l; at bottom center for m. Scales in mm.

*C. curta* Lubbock and *C. echinulata* (Claus)

*C. curta* was one of the three most abundant species in the upper 500 m at the time of the previous study (Deevey 1968), and *C. echinulata* was

not noted. By 1968-1970 *C. echinulata* had appeared and, judging from the numbers of males, was more numerous than *C. curta*. It is virtually impossible to differentiate the females and juveniles of these two species, but the males are fairly easily separated by the shape of the penis, which is exceptionally large in *C. echinulata* (see Figs. 26n, o). Angel (1979; pers. comm.) does not differentiate these two species, but lumps them together as *C. curta*. Therefore, data reported by Angel (1968, 1969a, 1979), Angel and Fasham (1975), and Moguevsky and Angel (1975) on the quantities, depth levels, and distribution of *C. curta* include any *C. echinulata* that might have been present.

When the quantitative counts were made on the samples, the juveniles and females associated with the male *C. echinulata* were assumed to belong to the same species, and the total numbers and percentages listed in Tables 3 and 4 are based on this assumption. Both species were most abundant in the upper waters, and together were second or third in total numbers, although *C. curta* males were virtually absent in spring and summer 1970. Both species also occurred regularly between 500 and 1000 m, and were occasionally noted down to 2000 m depths. Possibly they were contaminants in the samples collected below 1000 m. The seasonal variations in the numbers of *C. echinulata* and *C. curta* males in the upper 500 m are shown in Figure 25A. It is evident that few *C. curta* males were noted, and highest numbers were found in July 1969 and January 1970. *C. echinulata* males were most numerous in January, March, July, and October-November 1969 and in March, July, and September 1970. The total numbers of the two species including females and juveniles (Fig. 25B) show maxima usually at the same times as the *C. echinulata* males, except that highest total numbers of over 3/m<sup>3</sup> were noted in January 1970, when males of both species were not abundant.

*C. echinulata* and *C. curta* are small species with strikingly reticulated sculptured shells, males and females being 0.75-0.9 mm long. *C. curta* was previously described and figured (Deevey 1968: 60, fig. 26). *C. echinulata* is similar in shape (Fig. 26 a, c) but the right asymmetric gland opens at about half the shell height on the posterior margin, whereas in *C. curta* it is a little below half the shell height (Fig. 26j). The principal and secondary setae of the male 1st antenna (Fig. 26g) are of equal length, and the principal seta has 5-6 small bumps as its armature, compared with 8-15 tiny knobs on the *C. curta* male principal seta. Three of the 4 filaments of the female 1st antenna are bilobed, as in *C. curta* (Fig. 26e). The most obvious difference between males of the two species is in the shape of the penis (compare Figs. 26 m and n), which in *C. echinulata* is as large or larger than the furca (Fig. 26o).

DISTRIBUTION — *C. curta* has been recorded from 48°N to 37°S in the Atlantic, ca 40°N to 40°S in the Pacific, to 38°S in the Indian Ocean, and

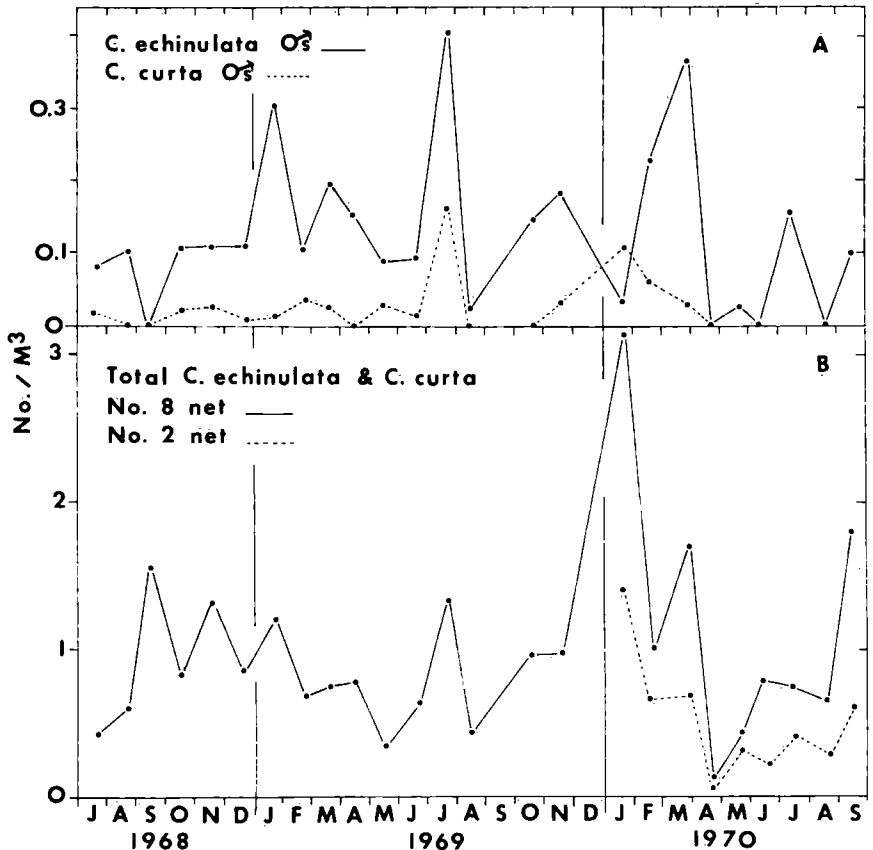


FIGURE 25. Seasonal variations in total numbers/m<sup>3</sup>, 0-500 m, of A: *C. curta* and *C. echinulata* males, and B: Total *C. echinulata* and *C. curta* taken in the No. 8 net, solid line, from July 1968 to September 1970 and in the No. 2 net, dashed line, from January to September 1970.

from the Mediterranean Sea. *C. echinulata* is known from 34°N to 37°S in the Atlantic and from 25° to 29°S in the Indian Ocean. Neither species occurs south of the Subtropical Convergence in the Southern Hemisphere.

#### *C. stigmatica* Müller

This species is very closely related in shape and structure to *C. curta* and *C. echinulata*, but is slightly larger. As in *C. echinulata*, the right asymmetric gland opens on the posterior margin at a little above half the shell height (Fig. 27 a,b), and this distinguishes this species from *C. acuticosta*, which is similar in size but has the right gland opening at below half the shell height on the posterior margin. Specimens of *C. stigmatica* were noted from August 1968 to July 1969, and in February, June, July, and September 1970, most from 500 to 1000 m depths, but a

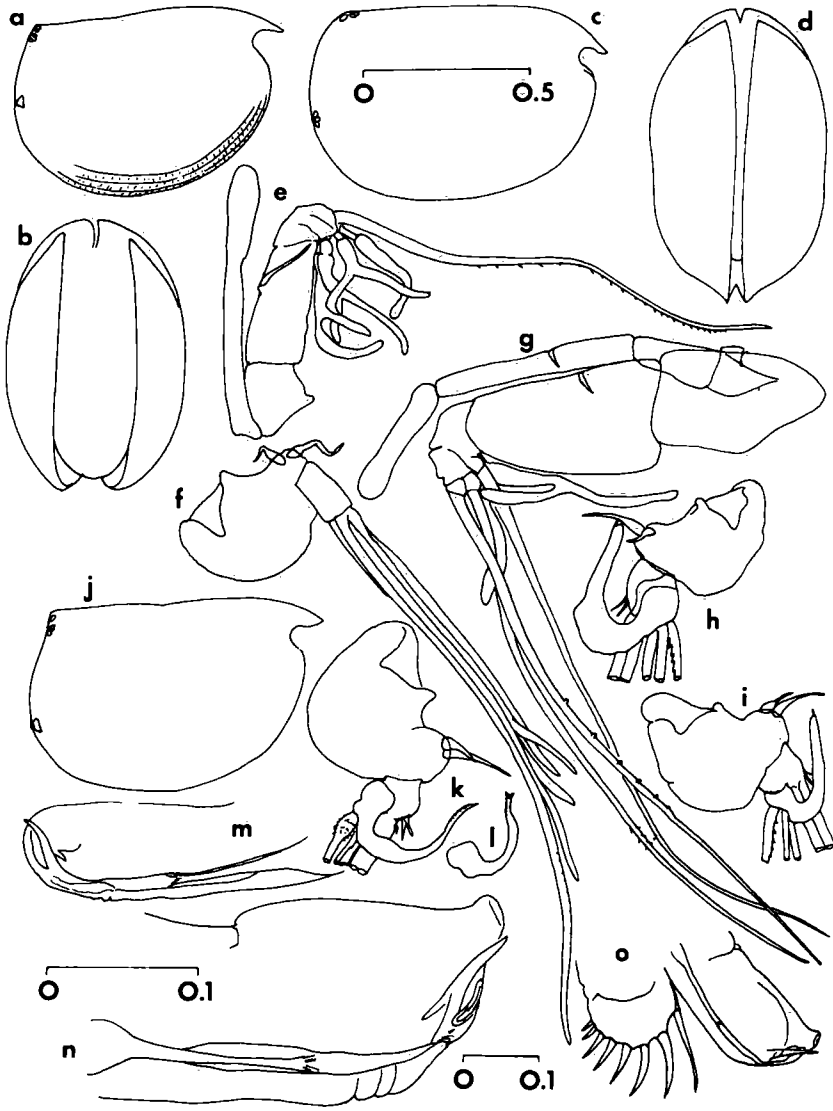


FIGURE 26. *C. echinulata* a-i: a and b, Lateral and ventral views of male shell; c and d, Lateral and ventral views of female shell; e, Female frontal organ and 1st antenna; f, Endopodite of female 2nd antenna; g, Male frontal organ and 1st antenna; h, Endopodite of male right 2nd antenna, setae and filaments cut off; i, Endopodite of male left 2nd antenna, setae and filaments cut off; *C. curta* male j-m: j, Lateral view of male shell; k, Endopodite of right 2nd antenna, setae and filaments cut off; l, Left clasper; m, Penis. *C. echinulata* male: n, Penis; o, Penis and furca. Scale on c for a-d and j; at lower left on n for e-i; k-n; at bottom center for o. Scales in mm.

few from between 1000 and 2000 m. Most of the specimens were juveniles, but two males and two females were taken, the females from 1000 to 1500 m hauls in December 1968 and June 1969, and the males from between 500 and 1000 m in June and July 1970. The females were 1.0 and 1.05 mm long, the males 1.1 and 1.25 mm in length.

The female and male shells and 1st and 2nd antennae are illustrated in Figure 27. All four filaments of the female 1st antenna are bilobed (Fig. 27c), as is the proximal filament on the male 1st antenna (Fig. 27d). The armature of the male principal seta consists of 7-8 small knobs. Juveniles of this species can be distinguished by the overdeveloped strongly arched shoulder vaults (Fig. 27j).

DISTRIBUTION — Angel and Fasham (1975) list *C. stigmatica* as occurring from 30° to 60°N in the eastern Atlantic, but all other records are from tropical and subtropical waters. It has been recorded from ca 35°S in the Pacific north of New Zealand (Barney 1921), from 7°N in the Sulu Sea (Poulsen 1973), from 7°N to 29°S in the Indian Ocean and to 31°S in the Atlantic. This is a common species in the Caribbean Sea (Deevey 1978c; unpublished data).

#### *Bispinosa* Group Müller

Four species of this group, which Poulsen (1973) placed in the genus *Orthoconchoecia*, were taken at Station S. Martens (1979) noted that this is a *nomen nudum* as no type species had been designated, but he then gave it as a new genus name with *O. striola* (Müller) as the type species. Except for *C. haddoni*, three of these four species were also reported by Angel (1979). Of these, *C. secernenda* occurred commonly within the upper 1000 m, the others were noted only occasionally.

#### *C. secernenda* Vavra

This species was found year-round within the upper 500 m but constituted a higher percentage of the ostracods caught between 500 and 1000 m (see Tables 3 and 4). In the No. 8 net samples it decreased in mean total numbers with depth, from 188/1000 m<sup>3</sup> within the upper 500 m to 64/1000 m<sup>3</sup> over 500-1000 m depths (Fig. 5). Total numbers of *C. secernenda* varied considerably during the year (see Fig. 22B). Within the upper 500 m maxima were noted in July and December 1968, March-April and July 1969, and February-March and July to September 1970. Over 500-1000 m depths highest numbers were found in August. At least 3-4 generations must have been produced each year.

This is the largest species that occurs regularly in numbers in these waters, has been described and figured (Deevey 1968: 65, figs. 29-31), and has been compared with *C. bispinosa*, a closely related species.

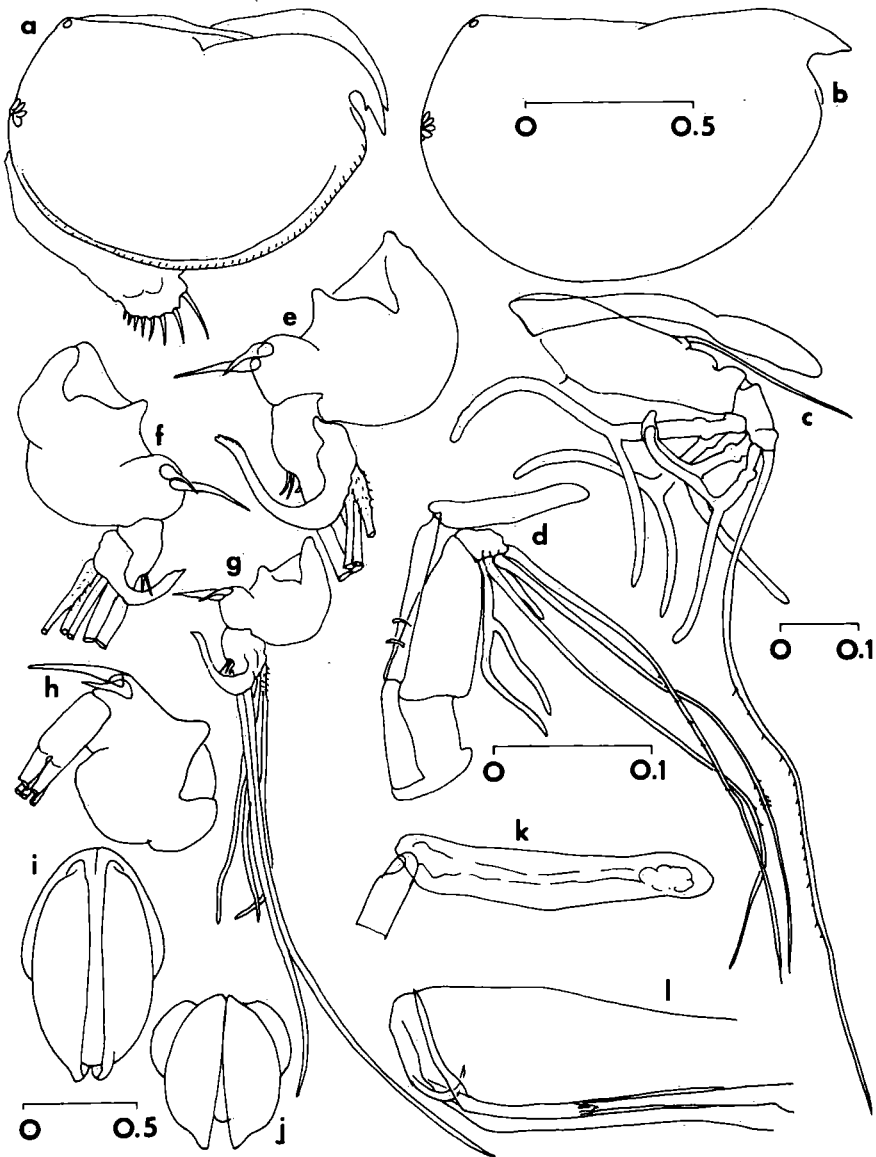


FIGURE 27. *C. stigmatica*. a and b, Lateral views of female and male shells; c, Female frontal organ and 1st antenna; d, Male frontal organ and 1st antenna; e, Endopodite of male right 2nd antenna, setae and filaments cut off; f, Endopodite of male left 2nd antenna, setae and filaments cut off; g, Endopodite of male right 2nd antenna; h, Endopodite of female 2nd antenna; i and j, Ventral and posterior views of male shell; k, Capitulum of male frontal organ; l, Penis. Scale on b for a and b; at bottom left for i and j; on right margin for d and g; below d for c, e, f, h, k, l. Scales in mm.

Females were 2.2-2.85 mm long, males 2.0-2.5 mm in length. Angel (1970) also described this species from the Canary Island region in the eastern North Atlantic, and gave the length range of females as ca 2.4-2.7 mm and of males as 2.2-2.4 mm.

DISTRIBUTION—40°N-38°S in the Atlantic, and 34°-36°S in the Pacific, and 38°-51°S in the Indian Ocean (Deevey 1981). Poulsen (1973) synonymized this species with *C. bispinosa* and therefore his distribution records cannot be included.

#### *C. bispinosa* Claus

From 1968-1970 this species was noted less frequently than during the previous study (Deevey 1968). Only 5 males and 4 females were taken within the upper 1000 m in August and September 1968, April and July 1969, and January-February and July to September 1970. The females were 1.75-1.95 mm long, the males 1.75 mm long. Angel's (1979) specimens from these waters were larger, the females having a length range of 1.92-2.16 mm, the males of 1.64-1.88 mm. His specimens from the Canary Island region (1970) were also slightly larger, the length range of females being 1.8-2.1 mm and of males 1.65-1.9 mm. This species is larger in the South Atlantic, South Pacific, and southeast Indian Ocean (Deevey 1981).

DISTRIBUTION—43°N-42°S in the Atlantic, 40°-51°S in the Pacific, and 38°-51°S in the Indian Ocean. Other records are for *C. secernenda* and *C. bispinosa* combined. Chavtur (1977) recorded *C. bispinosa* from ca 40°N in the Pacific, but he did not state whether he considers these two species synonymous.

#### *C. atlantica* (Lubbock)

This species was noted infrequently from July to October 1968, in January and July 1969, and from July to September 1970. Most of the specimens were juveniles caught within the upper 500 m. Three females, 3.35-3.5 mm long, and one male 3.6 mm long were collected in the 500-1000 m hauls. According to Angel (1979) *C. atlantica* is a low latitude near surface species with its northern limit close to 30°N in the eastern Atlantic. Poulsen (1973) found it frequent and abundant in tropical and subtropical zones of all oceans, and it is a common epipelagic species in the Caribbean Sea (unpublished data). Station S at 32°N is apparently near the northern limit of its range.

DISTRIBUTION—40°N-37°S in the Atlantic, ca 40°N-42°S in the Pacific, ca 10°N-38°S in the Indian Ocean, and in Indonesian Seas.

#### *C. haddoni* Brady and Norman

This is one of the few species recorded during our two-year study that was not caught by Angel (1979) in his intensive day and night sampling



with the RMT 1 and RMT 8 nets. It was not taken until July 1969, when 3 females were caught between 500 and 1500 m. In 1970, 3 females and 4 males were collected in April, June, and July, mostly from 500 to 1500 m depths, although 1 male was caught in a 0-500 m night tow and 1 female in a haul from 1500 to 2000 m. A juvenile specimen was also taken in August 1970, so several of these specimens appeared with the influx of the second cold water mass. The females were 2.65-3.05 mm long and the males 2.2-2.4 mm, and these are therefore larger forms than Müller's (1906) and Angel's (1970) forms from the Canary Island region, where Angel found the length range of females to be 2.15-2.53 mm and of males 1.75-2.0 mm. Although some of these specimens appeared at the time of the cold water incursions, because of their size they must have been carried into this region from more northern Atlantic waters, and possibly not as the result of mesoscale eddies that originated south of the Azores. Brady and Norman's specimens from off the coast of Ireland at 53°N were also larger forms, and larger forms occur in the South Atlantic, South Pacific, and Indian Ocean (Skogsberg 1920; Müller 1906; Deevey 1974b, 1978b, 1981).

Descriptions of *C. haddoni* have been given by Müller, Skogsberg (1920), Angel (1970), and Poulsen (1973). Figure 28 illustrates the shape of the shell and features of the appendages of the specimens from Station S. The principal seta of the male 1st antenna had 43-46 pairs of tiny teeth (Fig. 28g). Angel reported 37-42 pairs of teeth for the smaller form, but no other differences have been noted. As in other members of the *Bispinosa* Group, the female has an extra long spine on the distal segment of the endopodite of the 2nd antenna (Figs. 28d, j), and one of the two bristles at the base of the clasping organs on the endopodites of the male 2nd antenna is exceptionally long (Fig. 28i). Müller (1906, pl. 18, fig. 6) showed a short proximal filament on the male 1st antenna. The males from Station S had a longer proximal filament (Fig. 28h), as illustrated by Angel (1970, fig. 6C) and Skogsberg (1920, fig. 127-3).

DISTRIBUTION—63°N-51°30'S in the Atlantic, ca 40°N-54°S in the Pacific, 34°-54°S in the Indian Ocean, and Indonesian Seas. Poulsen (1973) noted it from only one station in the Indian Ocean at ca 8°S, and pointed out that it is rarely found in tropical regions and is commoner at higher latitudes.

#### *Edentata* Group Gooday

This group contains only two species, *C. edentata* and *C. subedentata*, as Gooday (1976) removed *C. edentata* from the *Gaussae* Group and described *C. subedentata*. Poulsen (1973) placed members of the *Gaussae* and *Edentata* Groups in the genus *Gaussicia*, now a *nomen nudum*. Only *C. subedentata* was taken at Station S.



FIGURE 28. *C. haddoni*. a, Lateral view of male shell; b, Capitulum of female frontal organ; c, Female 1st antenna; d, Endopodite of female 2nd antenna, setae and filaments cut off; e, Male left clasper; f, Male right clasper; g, Armature of setae of male 1st antenna; h, Male frontal organ and 1st antenna; i, Endopodite of male 2nd antenna; j, Endopodite of female 2nd antenna; k, Penis; l, Lateral view of female shell; m, Posterior view of male shell. Scale on a for a and m; on l for l; at top right for b, c, d, k; at left center for e-g; on lower right margin for h-j. Scales in mm.

*C. subedentata* Gooday

A total of 9 females and 16 males of this species were recorded in November-December 1968, March-April and from July to October 1969, and from April to September 1970, primarily from 500-1000 m depths, although 2 specimens were taken from between 1000 and 2000 m. The length range of females was 1.05-1.3 mm, and of males 1.1-1.2 mm. *C. subedentata*, as well as *C. edentata*, differ from other species of *Conchoecia* in several ways, and most notably in that the 5 setae and filaments of the distal segments of the female 1st antenna are of about the same length (see Fig. 29e), the principal seta not being longer than the other 4. Also, the female 6th limb, in other species considerably smaller than the male's 6th limb, is as long or longer than the male's and the setae are reduced as in the male (see Figs. 29q, r). The large ventral gland on both shells (Fig. 29a) also occurs in members of the *Gaussae* Group. The setation of the endopodite of the mandible is reduced compared with other species; the basal segment has no setae on the inner side and the 2nd segment only 1 seta (Fig. 29o). Also, the tips of some of the setae of the exopodite of the 2nd antenna are widened (Fig. 29 l), but this is the case in some other species. The principal seta of the male 1st antenna had 17-21 pairs of teeth and the proximal secondary seta a small callous and some spinules (Figs. 29b, d); the distal and proximal filaments are exceptionally long, and the proximal filament has a caecum at the proximal end (Fig. 29c). The female 1st antenna has a very short spine or seta dorsally and distally on the 2nd segment in the location where some other species have a dorsal seta (Fig. 29e).

DISTRIBUTION - 60°-10°30'N in the Atlantic. Except for the specimens from Station S the records are from the eastern North Atlantic.

*Gaussae* Group Skogsberg

This group is closely related to the *Edentata* Group and includes only *C. gaussae* and *C. incisa*. Both these species have large glands on the ventral margins of the shell as in *C. edentata* and *C. subedentata*. *C. incisa* has not yet been recorded with certainty from Station S.

*C. gaussae* Müller

Six specimens were caught in September-October 1968, March and August 1969, and June 1970 from between 1000 and 2000 m. Of these, three were males 3.0-3.15 mm long (Fig. 30), one was an immature female 2.6 mm long (Fig. 31), and the other two were juveniles, the largest 2.0 mm long. In *C. gaussae* the 4 filaments of the female 1st antenna are about half as long as the principal seta (Fig. 31b), the 6th limb is about as long as the male's (Fig. 31h) and the setae, particularly of the basal segment, are plumose and not reduced. These setae are also plumose

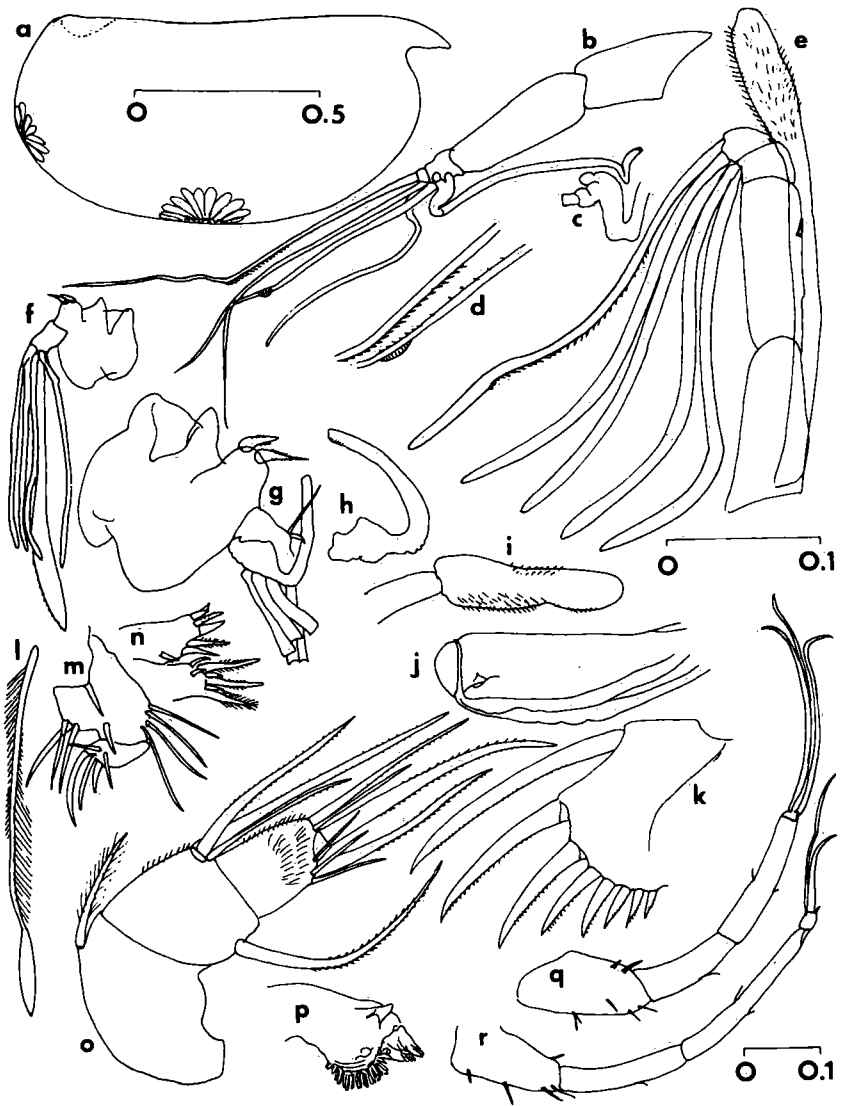


FIGURE 29. *C. subedentata*. a, Lateral view of male shell; b, Male 1st antenna; c, Proximal section of proximal filament of 1st antenna; d, Armature of the setae of the male 1st antenna; e, Female frontal organ and 1st antenna; f, Endopodite of female 2nd antenna; g, Endopodite of male left 2nd antenna, setae and filaments cut off; h, Male right clasper; i, Capitulum of male frontal organ; j, Penis; k, Male furca; l, A seta from the exopodite of the female 2nd antenna; m, Endopodite of the male maxilla; n, Coxal and precoxal endites of female maxilla; o, Endopodite of female mandible; p, Lateral view of toothrows and masticatory pad of coxa of female mandible; q, Male 6th limb; r, Female 6th limb. Scale on a; at right center for c-e, g-k, m-p; at bottom right for b, f, l, q, r. Scales in mm.

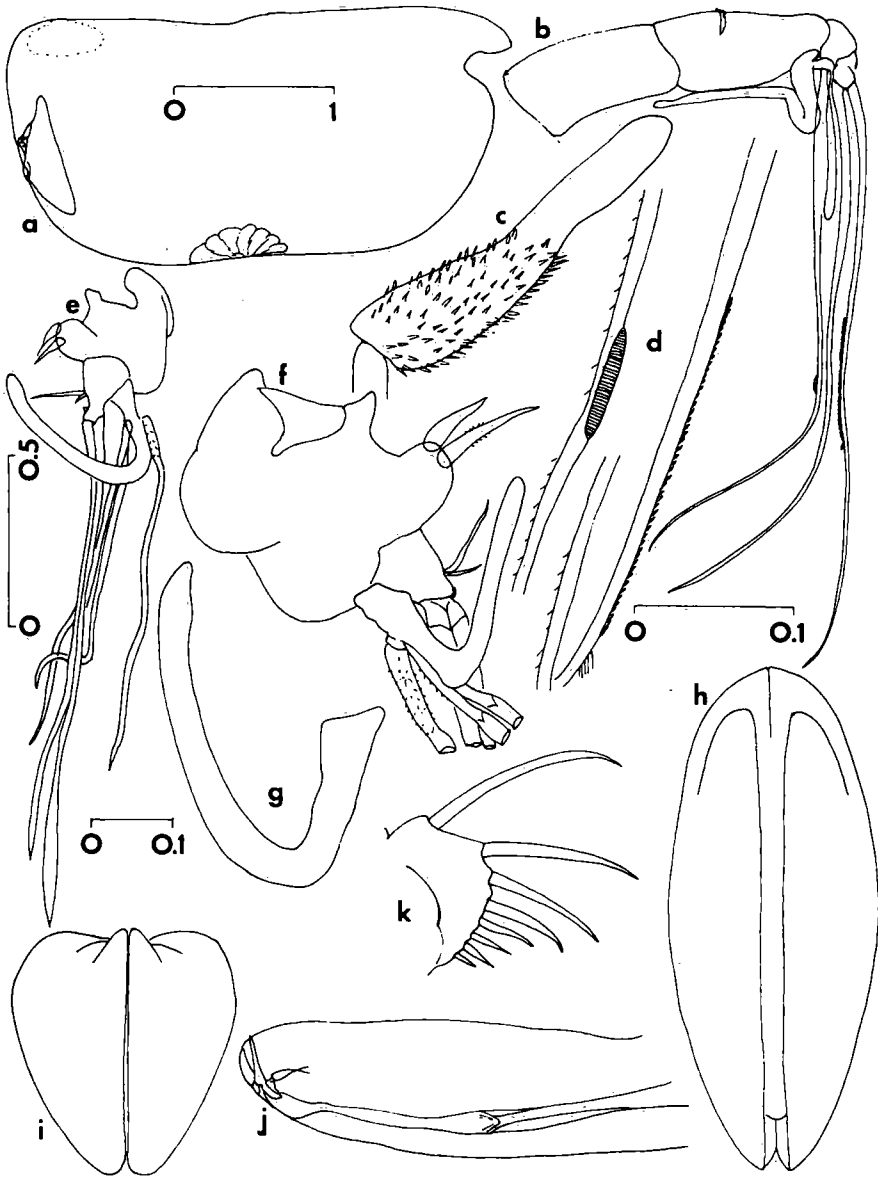


FIGURE 30. *C. gaussae* male. a, lateral view of male shell; b, 1st antenna; c, Capitulum of frontal organ; d, Armature of 1st antenna; e, Endopodite of right 2nd antenna; f, Endopodite of left 2nd antenna, setae and filaments cut off; g, Right clasper; h and i, Ventral and posterior views of male shell; j, Penis; k, Furca. Scale on a for a, h, i; on left margin for b, e, k; at right center for d; beside g for c, f, g, j. Scales in mm.

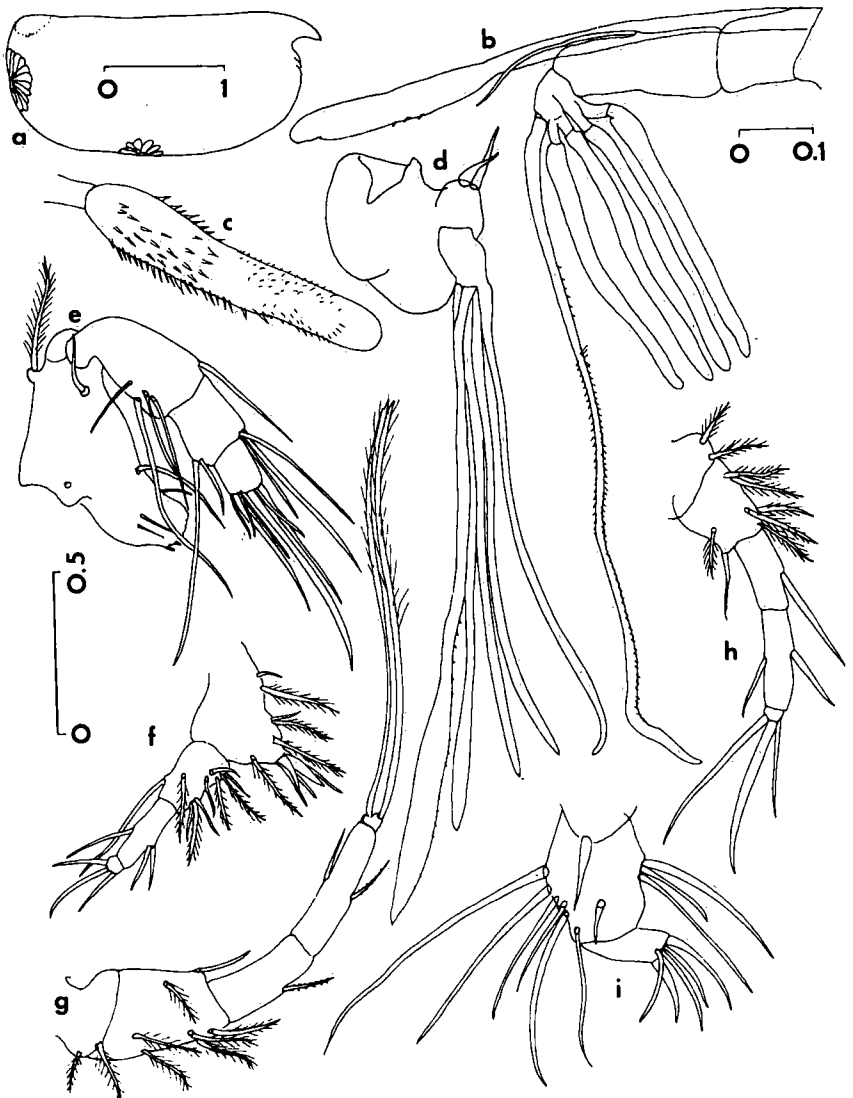


FIGURE 31. *C. gausae*. a, Lateral view of shell of 2.6 mm juvenile female; b, Frontal organ and 1st antenna of juvenile female; c, Capitulum of frontal organ of mature female. d, Endopodite of immature female 2nd antenna; e, Endopodite and basale of male mandible; f, 5th limb of male; g, 6th limb of male; h, Female 6th limb; i, Endopodite of the male maxilla. Scale on a for a; on left margin for e-h; at upper right for b-d, i. Scales in mm.

and not reduced in the male's 6th limb (Fig. 31g). *C. gausae* also differs from members of the *Edentata* Group in having 4 setae instead of 1 on the inner side of the 1st segment of the endopodite of the mandible. The prin-

cipal seta of the male 1st antenna has over 40 pairs of tiny teeth, very difficult to count (Fig. 30d), and as in the *Edentata* Group there is a callous on the proximal secondary seta. The relative lengths of the setae and filaments of the endopodite of the female 2nd antenna are similar to those of *C. subedentata*, and the longer seta is widened at the tip (Fig. 31d). The exopodite setae of the 2nd antenna are also slightly widened at the tip. The capitulum of the female frontal organ shown in Figure 31b is that of the juvenile specimen caught at Station S; that of the mature female has many more spines, as shown in Figure 31c from a mature female caught in the South Atlantic.

DISTRIBUTION — 60°N-51°30'S in the Atlantic. Poulsen (1973) recorded 3 specimens from ca 34°S off New Zealand in the Pacific and 4°S from off New Guinea. Rudyakov (1962) described a subspecies, *C. gaussae curilensis*, from the Kuril Kamchatka region of the North Pacific. Müller (1908) described this species from a male caught at 35°S in the Atlantic.

#### *Magna* Group Müller

Eight members of this group occurred at Station S. One of these, *C. pseudoparthenoda*, was described by Angel in 1972 and not previously recorded from these waters. Poulsen (1973) placed some of the members of this group in the genus *Conchoecia* and others in the genus *Spinoecia*. The latter name is now a *nomen nudum*.

#### *C. (Conchoecia) magna* Claus

This is a common species that occurred year-round in the upper 1000 m, in highest numbers in the upper 500 m, where mean numbers of 570/1000 m<sup>3</sup> were obtained for the No. 8 net samples. It was fourth in abundance in the No. 8 net samples and third in the No. 2 net tows (see Table 3 and 4). Except in September 1970, it was more abundant than *C. parthenoda*, a closely related species whose cycle of abundance was similar to that of *C. magna*. *C. magna* was most numerous in July and December 1968, March-April, July, and October 1969, and March-April, July, and September 1970 (Fig. 32B). The majority of the specimens counted were juveniles; adults were most numerous from March to July 1969 and in April 1970 (see Fig. 32B).

As previously noted (Deevey 1968), females were 1.7-1.9 mm long and males 1.6-1.75 mm in length. Angel (1979) gave length ranges of 1.70-1.96 mm for females and 1.56-1.80 mm for males from his Ocean Acre samples. He also (1969b) described this species from the Canary Island region and there females ranged in length from 1.75 to 2.05 mm, and males from 1.65 to 1.88 mm. A comparable length range has been recorded from the South Atlantic (Deevey 1974b), but larger specimens have been noted from the South Pacific, where females were 1.95-2.3 mm long and males 1.9-2.1 mm long (Deevey 1978b, 1981).

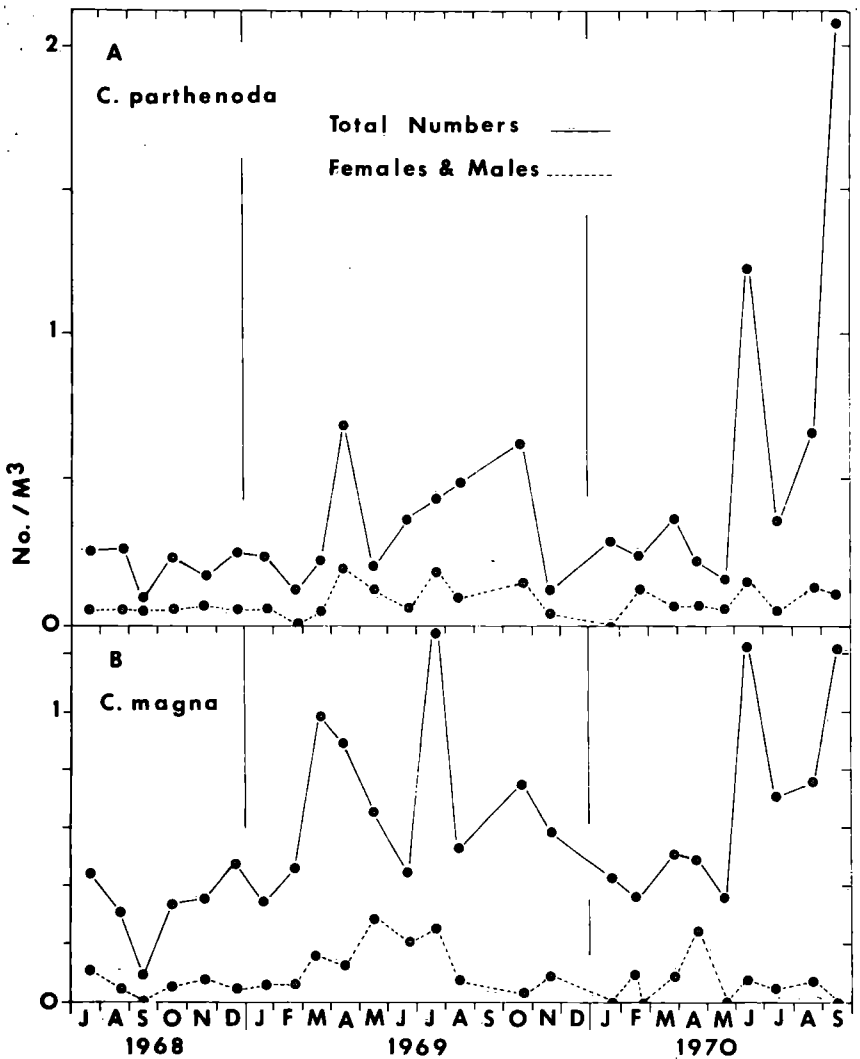


FIGURE 32. Seasonal variations in total numbers/m<sup>3</sup>, 0-500 m, of A: *C. parthenoda*, and B: *C. magna* taken in the No. 8 net samples from July 1968 to September 1970. Total numbers including juveniles, solid line; females and males, dashed line.

DISTRIBUTION—53°N-55°S in the Atlantic, ca 55°N-54°S in the Pacific, to 50°S in the Indian Ocean, and in Indonesian Seas and the Mediterranean Sea.

*C. (Conchoecia) subarcuata* Claus

Although during the previous study (Deevey 1968: 86, figs. 42-43) occasional specimens of this species were noted during every month of the



year within the upper 500 m, *C. subarcuata* was infrequently noted in 1968-1970, in August-September 1968, February, July, and November 1969, and in February and June to September 1970. The length range for females was 1.85-2.2 mm and for males 1.75-1.95 mm. Angel's (1979) specimens from Ocean Acre were slightly larger, the females varying in length from 1.96 to 2.36 mm and the males from 1.88 to 1.96 mm.

DISTRIBUTION—60°N-56°S in the Atlantic, 42°N-44°S in the Pacific, to 35°S in the Indian Ocean, and in Indonesian Seas.

#### *C. (Conchoecia) lophura* Müller

*C. lophura* occurred in small numbers throughout the year between 500 and 2000 m. Numbers of 2-29/1000 m<sup>3</sup> were recorded for the 500-1000 m depth zone and of 2-9/1000 m<sup>3</sup> for the 1000-1500 m hauls with the No. 8 nets. Several specimens were noted from the upper 500 m in 1970; only a few were caught from between 1500 and 2000 m. Most of the specimens taken were juveniles. Females were 2.4-2.6 mm long, males 2.3-2.4 mm. Angel (1979) gave length ranges of 2.28-2.68 mm for females and 2.16-2.52 mm for males from his Ocean Acre series in these waters. This species is relatively large and easily recognized by the group of gland cells at the posteroventral corner of the left shell (see Fig. 33a). Only a few females were taken during the previous study so the male was not described. Figure 33 illustrates the shape of the male shell and features of the appendages. The principal seta of the male 1st antenna has ca. 60 pairs of tiny teeth, very difficult to count, and proximally on the anterior surface a row of spinules (Figs. 33b, f). The distal bristle of the basal segment of the endopodite of the 2nd antenna (Fig. 33c) has large spines distally as well as many long fine hairs near its base. In the northeast Atlantic Angel and Fasham (1975) considered *C. lophura* a widespread shallow mesopelagic species. In the Sargasso Sea Angel (1979) found it at slightly greater depths. Females were taken between 400 and 1250 m, males from 500 to 800 m, and juveniles ranged from 500 to 1500 m.

DISTRIBUTION—60°N-48°S in the Atlantic, ca 40°N-51°30'S in the Pacific, 5°N-46°S in the Indian Ocean, and 24°N-6°S in Indonesian Seas.

#### *C. (Conchoecia) macrocheira* Müller

Only a few juvenile specimens of this species were noted, usually between 500 and 1000 m, in September and December 1968, March 1969, and February to May 1970. Two juveniles were recorded during the previous study. Angel and Fasham (1975) found *C. macrocheira* more numerous between 30° and 11°N in the eastern Atlantic, and it occurs commonly in the Caribbean Sea (Deevey 1978c; unpublished data).

DISTRIBUTION—46°N-35°S in the Atlantic, to 33°S in the Pacific, to 38°S in the Indian Ocean, and in Indonesian Seas. It has not been taken south of the Subtropical Convergence in the Southern Hemisphere.

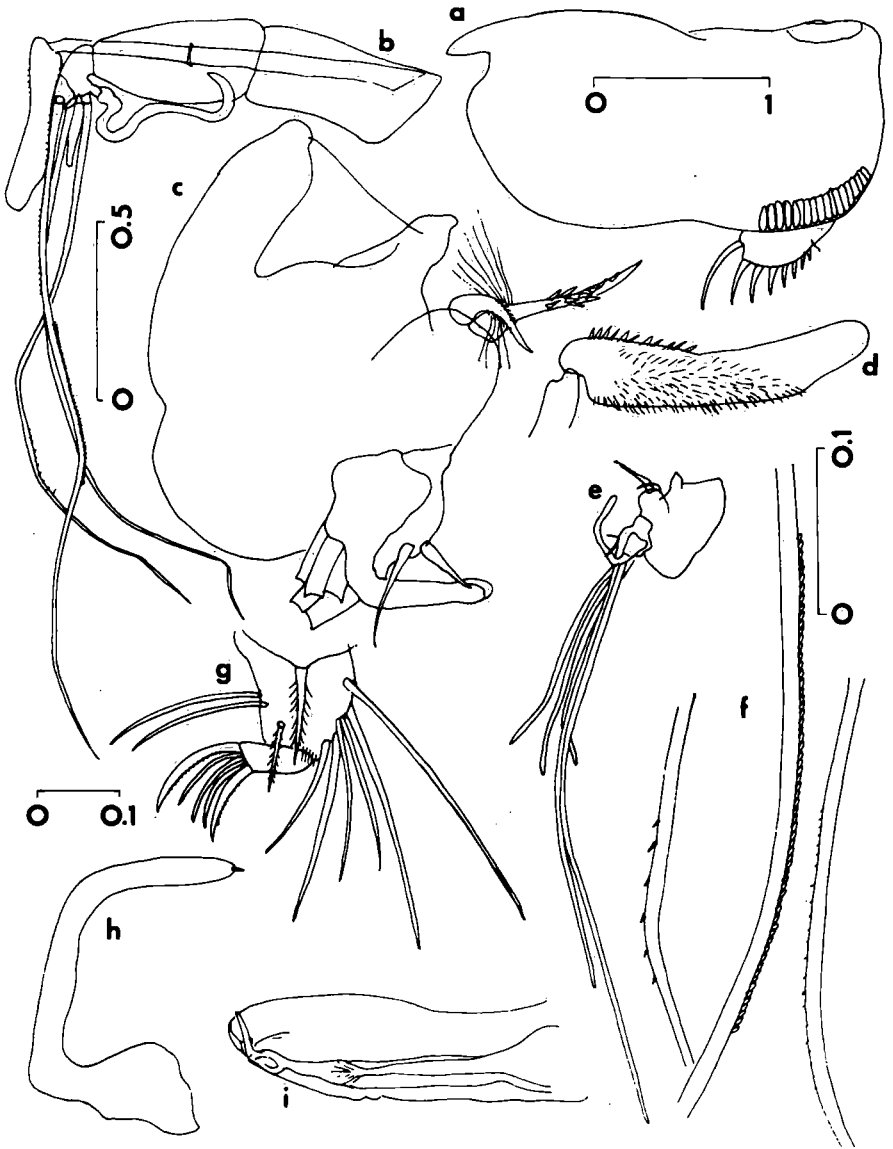


FIGURE 33. *C. lophura* male. a, Lateral view of left shell; b, Frontal organ and 1st antenna; c, Endopodite of left 2nd antenna, setae and filaments cut off; d, Capitulum of frontal organ; e, Endopodite of right 2nd antenna; f, Armature of setae of 1st antenna; g, Endopodite of maxilla; h, Right clasper; i, Penis. Scale on a for a; at upper left for b and e; at lower left for d, g, i; on right margin for c, f, and h. Scales in mm.

Poulsen (1973) found *C. macrocheira* most abundant in the tropics and less common in the Pacific than in the other seas.

*C. (Conchoecia) parthenoda* Müller

This species occurred year-round in the upper 500 m in somewhat smaller numbers than *C. magna*, except in September 1970 when over 2/m<sup>3</sup> were recorded (see Fig. 32A). In general it was more abundant at the same times as *C. magna*, although it did not have a maximum in July 1969 when highest numbers of *C. magna* were noted. For the upper 500 m mean total numbers of 404/1000 m<sup>3</sup> were obtained for the No. 8 net samples and of 236/1000 m<sup>3</sup> for the No. 2 net tows. In the upper waters it was as abundant as *C. rotundata* (see Tables 3 and 4).

Müller described the female in 1906 and placed the species in the *Obtusata* Group. The male was not described until recently (Deevey 1968: 73, figs 34-35; Angel 1969b: 59, figs. 8-9), and Angel placed the species in the *Magna* Group. Poulsen (1969b: 153, fig. 10) also described the male *C. parthenoda*, but judging by the location of the left asymmetric gland and the size, his specimens were *C. pseudoparthenoda*. At Station S females were 1.5-1.65 mm long and males were 1.35-1.5 mm long. Angel (1979) gave length ranges of 1.5-1.8 mm for females and of 1.4-1.6 mm for males. In the northeast Atlantic Angel and Fasham (1975) and Angel (1979) considered *C. parthenoda* principally an epipelagic species associated with North Atlantic Central Water.

DISTRIBUTION—53°N-30°S in the Atlantic, ca 40°N-37°S in the Pacific, to 43°S in the Indian Ocean, and in Indonesian Seas. This is a common epipelagic species in tropical and subtropical waters and has not been noted south of the Subtropical Convergence in the Southern Hemisphere.

*C. (Conchoecia) pseudoparthenoda* Angel

This species, closely related to *C. parthenoda*, was taken in the upper 500 m on only three occasions, in August 1969 and July and September 1970. *C. pseudoparthenoda* is a little larger than *C. parthenoda* and is easily differentiated from that species by the fact that the left asymmetric gland is moved anteriorly on the dorsal margin to ca a quarter of the total length from the posterodorsal corner. A male was 1.6 mm long and two females were 1.8 and 1.85 mm long. Angel (1972) described this species from specimens caught at 10°16'N, 19°47'W in the eastern Atlantic. His males had a length range of 1.56-1.72 mm and the females of 1.72-1.90 mm. An unusually large *C. parthenoda* male, 1.6 mm long, described and figured from the waters off Barbados (Deevey 1970, fig. 7) is now known to be *C. pseudoparthenoda*.

DISTRIBUTION— $32^{\circ}\text{N}$ - $30^{\circ}\text{S}$  in the Atlantic,  $37^{\circ}\text{S}$  in the Pacific. This epipelagic species appears to be restricted to tropical and subtropical waters.

*C. (Porroecia) spirostris* Claus

This species is by far the most abundant ostracod at Station S, and constituted 18% of the total numbers taken in the No. 8 net samples and 30% of the No. 2 net tows collected in the upper 500 m. Mean numbers of 2228/1000  $\text{m}^3$  for the period studied were obtained for the No. 8 net hauls and of 1216/1000  $\text{m}^3$  for the No. 2 net samples (see Tables 3 and 4). *C. spirostris* was most numerous in August to October 1968, January, April-May, and August to October 1969, and in January, March, and June to September 1970 (see Fig. 34B). A number of generations must have been produced during a year. Highest numbers of over 5/ $\text{m}^3$  were caught in September 1970. Most of the specimens counted were juveniles, and these were responsible for the maxima shown by the solid line in Figure 34B. Total numbers of males and females are indicated by the dashed line. Adults were most numerous in August and October 1968, April and August 1969, and in January to March, July, and September 1970.

Angel (1979) noted that *C. spirostris* is one of the most abundant epipelagic species in tropical and temperate waters, more numerous in the Sargasso Sea than at comparable latitudes in the eastern North Atlantic, where Angel and Fasham (1975) found it associated with South Atlantic Central Water. It was the dominant species caught at dusk and night in the neuston samples collected on cruises between ca  $30^{\circ}\text{N}$  and  $40^{\circ}\text{S}$  in the Atlantic, male *C. spirostris* constituting 88% of the halocyprids sampled (Moguilevsky and Angel 1975).

This is a small species. Females were 0.95-1.22 mm long and males 0.9-1.12 mm long. Angel (1979) listed length ranges of 1.02-1.24 mm for females and 0.94-1.08 mm for males from the Ocean Acre series, and reported a comparable length range for this species from the Canary Island region (1969c). Larger specimens have been recorded from the Indian Ocean, where females had a length range of 1.25-1.4 mm and males of 1.15-1.3 mm (Deevey 1981).

DISTRIBUTION— $45^{\circ}\text{N}$ - $42^{\circ}\text{S}$  in the Atlantic, ca  $40^{\circ}\text{N}$ - $37^{\circ}\text{S}$  in the Pacific, to  $39^{\circ}\text{S}$  in the Indian Ocean, and in Indonesian Seas and the Mediterranean Sea. It has not been taken south of the Subtropical Convergence in the Southern Hemisphere.

*C. (Porroecia) porrecta* Claus

This species is closely related to *C. spirostris* but is larger, females being 1.5-1.6 mm long and males 1.25-1.35 mm long. Muller (1906)

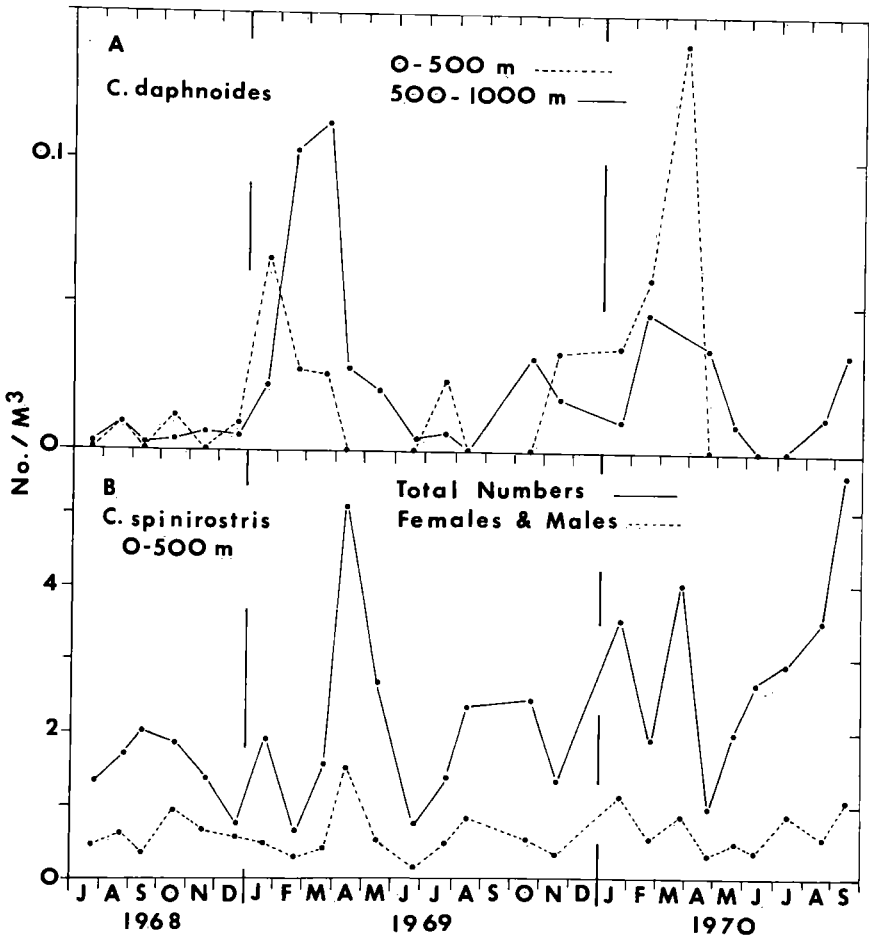


FIGURE 34. Seasonal variations in total numbers/m<sup>3</sup> caught by the No. 8 net between July 1968 and September 1970 of A: *C. daphnoides* in the upper 500 m, dashed line, and between 500 and 1000 m, solid line, and B: *C. spirostris* in the upper 500 m. Total numbers of *C. spirostris* including juveniles, solid line, females and males, dashed line.

synonymized this species with *C. spirostris*, but Skogsberg (1920) believed they were different species, although he lacked sufficient material to prove it. *C. porrecta* is now definitely considered a separate species (Angel 1969c, figs. 1-3; Deevey 1968: 83, figs. 40-41). Between 1968 and 1970 only 5 females and 3 males were noted from 0 to 500 m hauls made in October 1968, January, July, and November 1969 and July 1970, so this species was less common during this period than at the time of the previous study. Station S must be near *C. porrecta*'s northern limit in the Atlantic. Angel and Fasham (1975) found it quite abundant in the near-surface waters south of 30°N in the eastern Atlantic.

DISTRIBUTION—41°N-37°30'S in the Atlantic, ca 40°N-30°S in the Pacific, to 39°S in the Indian Ocean, and in Indonesian Seas. Gooday and Angel (1977) described a subspecies, *C. porrecta adriatica*, from the north Adriatic Sea, which Martens (1979) named the type species of the genus *Porroecia*.

In the southeast Pacific, Martens (1977) noted that the distribution of *C. porrecta* corresponded with Subtropical Surface Water.

#### *Loricata* Group Müller

This group contains two species, *C. loricata* and *C. ctenophora*, only the former of which occurred at Station S. Although Poulsen (1973) recorded the latter species from 46° to 12°N in the eastern Atlantic, and Angel and Fasham (1975) listed it as occurring from 18° to 53°N, also in the eastern Atlantic, *C. ctenophora* has not as yet been taken in the Sargasso Sea. Angel (1979) noted that this species was most abundant at his most easterly station on his 32°N transect across the Atlantic, but it rapidly decreased in numbers west of 21°W and he also did not find it in the Sargasso Sea.

#### *C. loricata* (Claus)

*C. loricata* occurred year-round in small numbers between 500 and 1000 m, although it was not noted in December 1968, or February or November 1969. On several occasions it was also taken within the upper 500 m and from 1000 to 1500 m depths. It was more abundant between May and September, with numbers up to 48/1000-m<sup>3</sup>, but no seasonal cycle was discernible. Males and females were taken during the previous study and were briefly described and figured (Deevey 1968: 92, figs. 46-47). Females were 1.8-1.85 mm long and males 1.7-1.8 mm long. Angel (1979) gave length ranges of 1.78-2.06 mm for females and 1.68-1.92 mm for males from Ocean Acre in the Sargasso Sea. Angel and Fasham (1975) considered this a widespread mesopelagic species. In his transect across the Atlantic at 32°N Angel (1979) found *C. loricata* twice as abundant in the eastern Atlantic as in the Sargasso Sea.

DISTRIBUTION—60°N-37°S in the Atlantic, ca 11°N-52°S in the Pacific, to 50°S in the Indian Ocean, and the Mediterranean Sea and Indonesian Seas.

#### *Serrulata* Group Skogsberg

*C. concentrica* is included in this group with *C. serrulata*, mainly because the shape of the shell and location of the glands are somewhat similar, but these two species are not very closely related and differ in the type of armature on the male 1st antenna and in other ways. As Poulsen

(1973) pointed out, the basale of the mandible is short in both these species; also the 1st segment of the endopodite of the mandible is longer than usual in both. *C. serrulata* is known only from the Southern Hemisphere.

*C. (Pseudoconchoecia) concentrica* Müller

Only a male and a few juvenile specimens of this species were noted in 0-500 m hauls in September 1968, July and August 1969, and in January and June 1970. *C. concentrica* was taken more frequently and described during the previous study (Deevey 1968: 95, figs. 48-50), when the length range of females was 1.55-1.8 mm and of males 1.55-1.6 mm. This is an epipelagic warm water species, recorded by Angel and Fasham (1975) only from 18°N in the eastern Atlantic. In the Gulf of Mexico and Caribbean Sea it is a common species (Deevey 1970, unpublished data) and even occurs in the waters over the Cariaco Trench where few ostracod species can survive (Deevey 1978c).

DISTRIBUTION—46°N (Poulsen, 1973) to 3°N in the Atlantic, to 29°S in the Pacific, the equatorial Indian Ocean and Indonesian Seas.

*Mollis* Group Müller

Four members of this group, which Poulsen (1973) separated into three genera, *Mollicia*, *Paramollicia*, and *Boroecia*, were found at Station S. These three names have been declared *nomina nuda* (Martens 1979).

*C. kampta* Müller

Females, males, and juveniles of *C. kampta* were caught occasionally between 500 and 2000 m depths in July, September to December 1968, March and October 1969, and April, June, July, and September 1970. Females were 2.95-3.3 mm long and males 2.55-2.82 mm long. Angel (1979) also found this a relatively uncommon species in the Sargasso Sea, and believed from his data that it is associated with Mediterranean Water in the eastern North Atlantic. The species was previously described and figured (Deevey 1968: 99, figs. 51-53).

DISTRIBUTION—53°N-2°N in the Atlantic, and the Mediterranean Sea.

*C. rhynchena* Müller

*C. rhynchena* is represented by a single male, 2.3 mm long, taken in May 1969 in a 500-1000 m haul. During the previous study also a single male, 2.3 mm long, was caught in a 1250-2000 m sample collected in February 1960 (Deevey 1968: 101, fig. 56). This species is apparently much more abundant in the eastern North Atlantic, where Angel and Fasham (1975) found it a mesopelagic species most abundant between 30° and 40°N, and recorded it from 11° to 60°N. Angel (1979) noted in his

transect of the Atlantic at 32°N that *C. rhynchena* decreased greatly in numbers west of 44°W and was very uncommon in the Sargasso Sea.

DISTRIBUTION—60°N-38°S in the Atlantic, to 46°S in the southwest Pacific, equatorial Indian Ocean, and Indonesian Seas.

### *C. dichotoma* Müller

This species occurred more or less regularly, usually as single individuals, between 1000 and 2000 m depths throughout the period studied. A number of juveniles, 10 females, and 11 males were noted. The females had a length range of 2.4-2.7 mm, the males of 2.0-2.2 mm. A female and several juveniles were taken during the previous study (Deevey 1968: 104, fig. 55), but the male was not described or figured. The shape of the shell and features of the appendages are shown in Figure 35. The principal seta of the male 1st antenna has 28-33 pairs of squat proximally pointing teeth (Fig. 35d), and the proximal secondary seta has a long slim callous opposite the distal end of the toothrow, and distal to this many spinules. The distal secondary seta is shorter, and extends just past the end of the toothrow; it has many tiny spinules distally (Figs. 35c, d). As noted by Müller (1906) in the original description and by Poulsen (1973) the proximal filament has a double caecum (Figs. 35c, e) and is exceptionally long. Neither Müller nor Poulsen noted the long hairs on the distal bristle of the basal segment of the endopodite of the 2nd antenna (Figs. 35g, h). The capitulum of the frontal organ is exceptionally long and slim, with strong spines proximally (Fig. 35f). Müller's description was based on several specimens from the equatorial Atlantic and Indian Oceans. He gave the length of females as 2.25-2.35 mm and of males as 1.85 mm, so his specimens were smaller than those since reported.

DISTRIBUTION—60°N-35°S in the Atlantic, and the equatorial Indian Ocean at 9°N. Angel (1979) considers *C. dichotoma* a medium to high latitude deep mesopelagic to bathypelagic species.

### *C. borealis* Sars

Only a few specimens of *C. borealis*, most of them juveniles, were caught at Station S in 500-1500 m hauls, from July to December 1968, June, October, and November 1969, and June, August, and September 1970. As this is an arctic species, the occurrence of *C. borealis* in the Sargasso Sea in summer and fall indicates the influx of more northern waters into this region. Three females were 2.6-2.7 mm long, and 3 males were 2.1-2.15 mm in length; 5 of these were caught from 1000 to 1500 m depths. *C. borealis* is closely related to *C. antipoda*, the Antarctic form that Skogsberg (1920) did not consider a separate species. *C. antipoda* is larger, the length range of females being 3.0-3.25 mm and for males 2.8-3.05 mm (Deevey 1974b, Müller 1906, Skogsberg, 1920). According



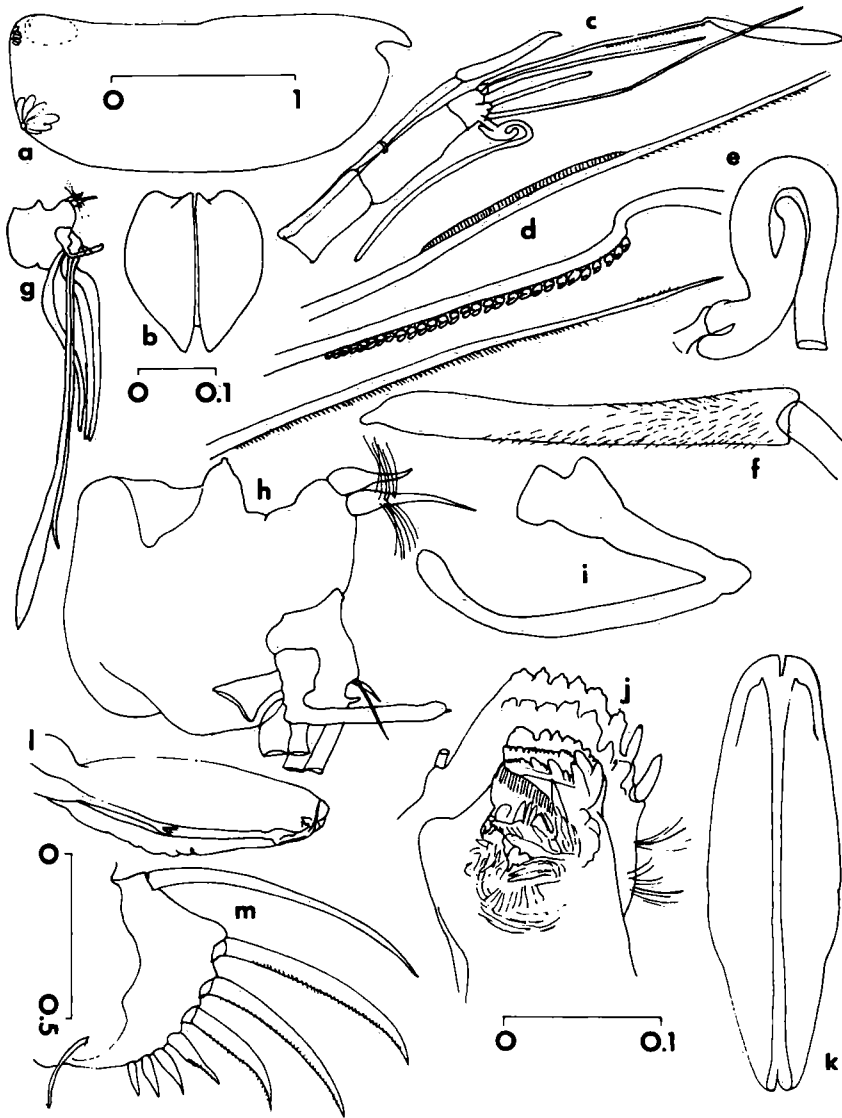


FIGURE 35. *C. dichotoma* male. a and b, Lateral and posterior views of shell; c, Frontal organ and 1st antenna; d, Armature of setae of 1st antenna; e, Proximal part of proximal filament of 1st antenna; f, Capitulum of frontal organ; g, Endopodite of left 2nd antenna, setae and filaments cut off; h, Endopodite of left 2nd antenna; i, Right clasper and toothrows and masticatory pad of coxa of mandible; j, Toothrow of basale and masticatory pad of coxa of mandible; k, Ventral view of shell; l, Penis; m, Furca. Scale on a for a, b, k; at upper left for l and m; at lower left for c and g; at bottom for d-f, h-j. Scales in mm.

to Skogsberg, male *C. borealis* from the Skager Rak, Lofoten, and the Arctic Ocean are 2.1-2.3 mm long and females 2.4-2.9 mm in length. Although smaller, *C. borealis* males have more pairs of teeth on the principal seta of the 1st antenna, 49-55 pairs (Fig. 36b), whereas *C. antipoda* males have 40-45 pairs. Female *C. antipoda* have an extra spine on the distal segment of the endopodite of the 2nd antenna that has not been noted on *C. borealis* females. Since only juvenile specimens of *C. borealis* were caught and figured (Deevey 1968, fig. 54) during the previous study, features of the male and female shell and appendages are illustrated in Figures 36 and 37. This species is easily recognized by the shape of the shell, the sculpturing, the location of the shell glands and the sharp-edged shoulder vaults, particularly in the female shell (Figs. 36a, j, 37a, b).

DISTRIBUTION — ca 80°N-30°N in the Atlantic, and the North Pacific. Angel (1979) characterized *C. borealis* as a northern high latitude species with a circumpolar distribution. Angel and Fasham (1975) recorded it from 30° to 60°N in the eastern Atlantic.

#### *Imbricata* Group Müller

Three species belonging to this group, which Poulsen placed in the genus *Conchoecissa*, occurred at Station S. Two of these, *C. imbricata* and *C. ametra*, were present year-round. Angel (1979) recorded several specimens of *C. plinthina* and also possibly of *C. symmetrica*, a species otherwise known only from the Southern Hemisphere, in his Ocean Acre series of samples.

#### *C. imbricata* (Brady)

This common species occurred in relatively small numbers year-round within the upper 1000 m. It was taken in higher numbers in the No. 8 net samples from 500 to 1000 m depths, and also constituted a greater proportion of the total numbers of ostracods over this depth level (see Tables 3 and 4 and Fig. 5). It was also taken year-round during the previous study, and figured and briefly described at that time (Deevey 1968: 108, figs. 57-58). The seasonal variations in numbers over 0-500 m and 500-1000 m depths are shown in Figure 38B. Within the upper 500 m it was most abundant in summer, and between 500 and 1000 m it was most numerous July to September 1968, February and July 1969, and from June to September 1970. Throughout the water column it was most abundant in summer, but this might represent in part a seasonal migration to deeper waters. This species also undergoes diurnal migrations, the adults moving up from 600-800 m to 100-500 m (Angel 1979) at night.

This is an easily recognized and relatively large species, females being 2.7-3.0 mm long and males 2.25-2.45 mm in length. Angel (1979) listed length ranges of 2.6-3.2 mm for females and of 2.28-2.64 mm for males

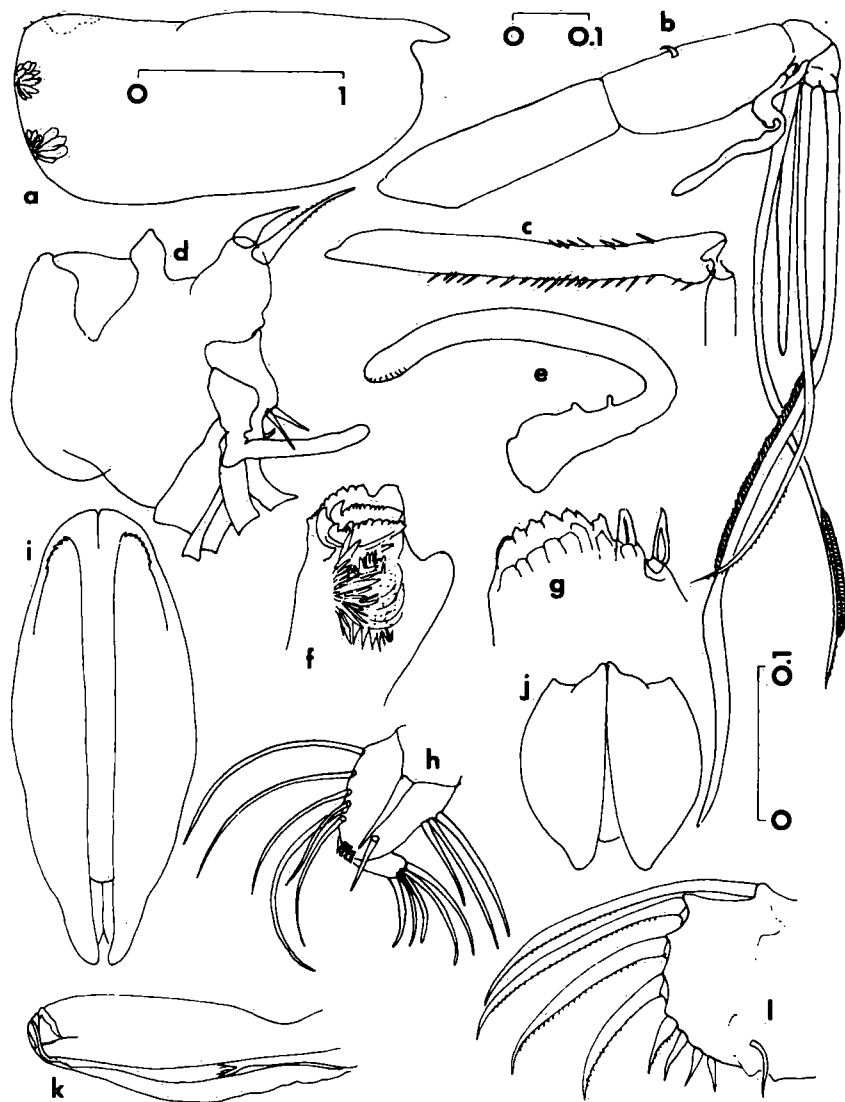


FIGURE 36. *C. borealis* male. a, i, and j, Lateral, ventral and posterior views of shell; b, 1st antenna; c, Capitulum of frontal organ; d, Endopodite of left 2nd antenna, setae and filaments cut off; e, Right clasper; f, Toothrows and masticatory pad of coxa of mandible; g, Tooththrow of basale of mandible; h, Endopodite of maxilla; k, Penis; l, Furca. Scale on a for a, i, j; at top for b, h, k, l; on lower right margin for c-g. Scales in mm.

from the Ocean Acre series. He characterized *C. imbricata* as a widespread shallow mesopelagic species.

DISTRIBUTION—Ca 65°N-55°S in the Atlantic, ca 40°N-50°S in the

Pacific, ca 8°N-48°S in the Indian Ocean, and Indonesian Seas. This is a common species in tropical and subtropical waters.

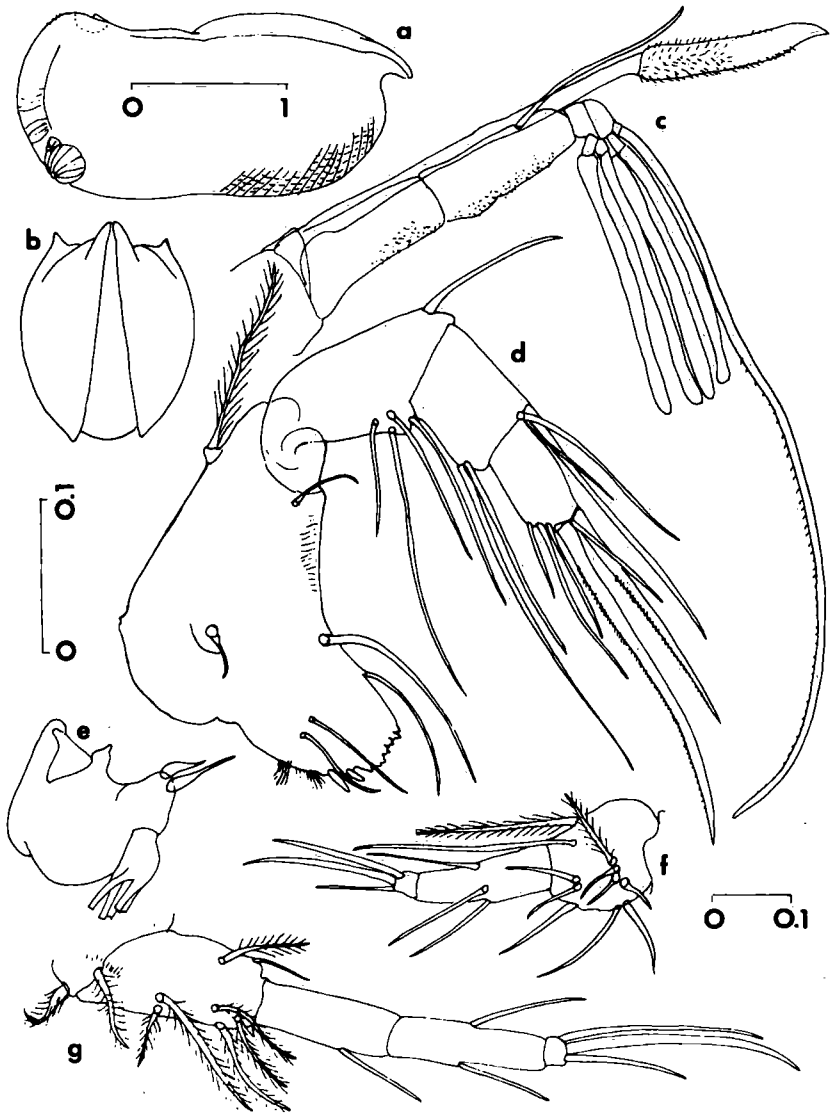


FIGURE 37. *C. borealis* female. a and b, Lateral and posterior views of shell; c, Frontal organ and 1st antenna; d, Endopodite and basale of mandible; e, Endopodite of 2nd antenna, setae and filaments cut off; f, 5th limb; g, 6th limb. Scale on a for a and b; on left margin for d; at lower right for c, e-g. Scales in mm.

*C. ametra* Müller

This species was taken year-round in small numbers between 500 and 1500 m, although a few specimens were noted from the upper 500 m and from 1500 to 2000 m depths. It was more numerous between 500 and 1000 m, but constituted a higher percentage of the total numbers caught in the 1000-1500 m hauls (see Tables 3 and 4). Between 500 and 1000 m it was most numerous from July to September 1968, in January, March, and May 1969, and in January-February, May, and August 1970 (see Fig. 38A). Small numbers occurred year-round between 1000 and 1500 m. Most of the specimens counted were juveniles.

Although the female *C. daphnoides* is 5 mm or more in total length, *C. ametra* is the largest species that occurs regularly in the deeper waters at Station S. Females had a length range of 4.0-4.65 mm and males of 3.55-4.2 mm, including rostral and posterodorsal spines. Angel (1979)

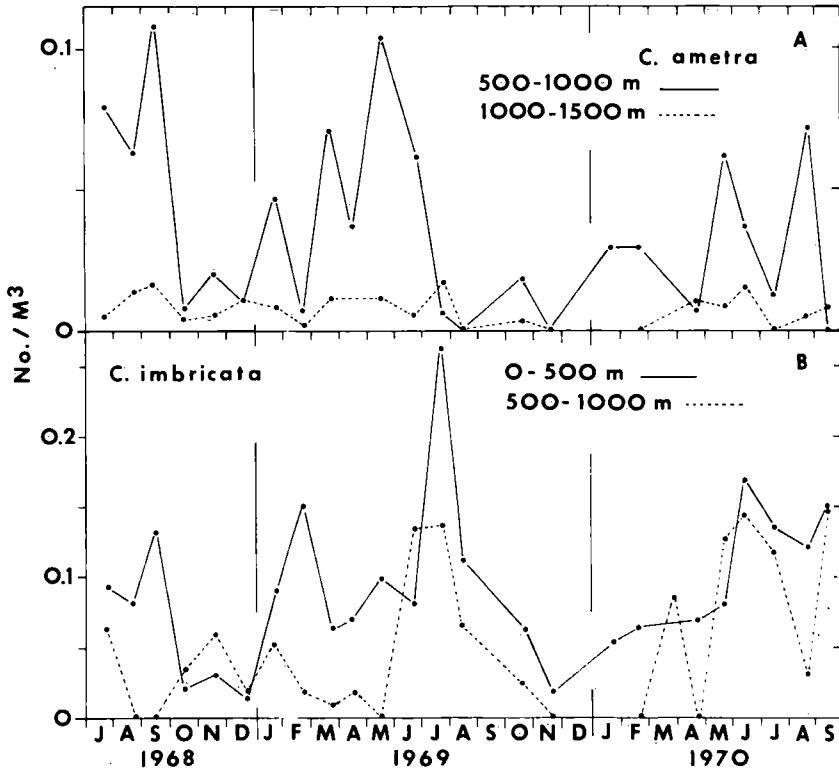


FIGURE 38. Seasonal variations in total numbers/m<sup>3</sup> taken by the No. 8 nets between July 1968 and September 1970, of A: *C. ametra* between 500 and 1000 m, solid line, and 1000 and 1500 m, dashed line, and B: *C. imbricata* 0-500 m, solid line, and between 500 and 1000 m, dashed line.

gave length ranges of 3.33-4.42 mm for females and of 3.17-4.17 mm for males from the Ocean Acre series of samples. As no males were caught during the previous study, features of the male shell and appendages are shown in Figure 39. The principal seta of the male 1st antenna has ca 34

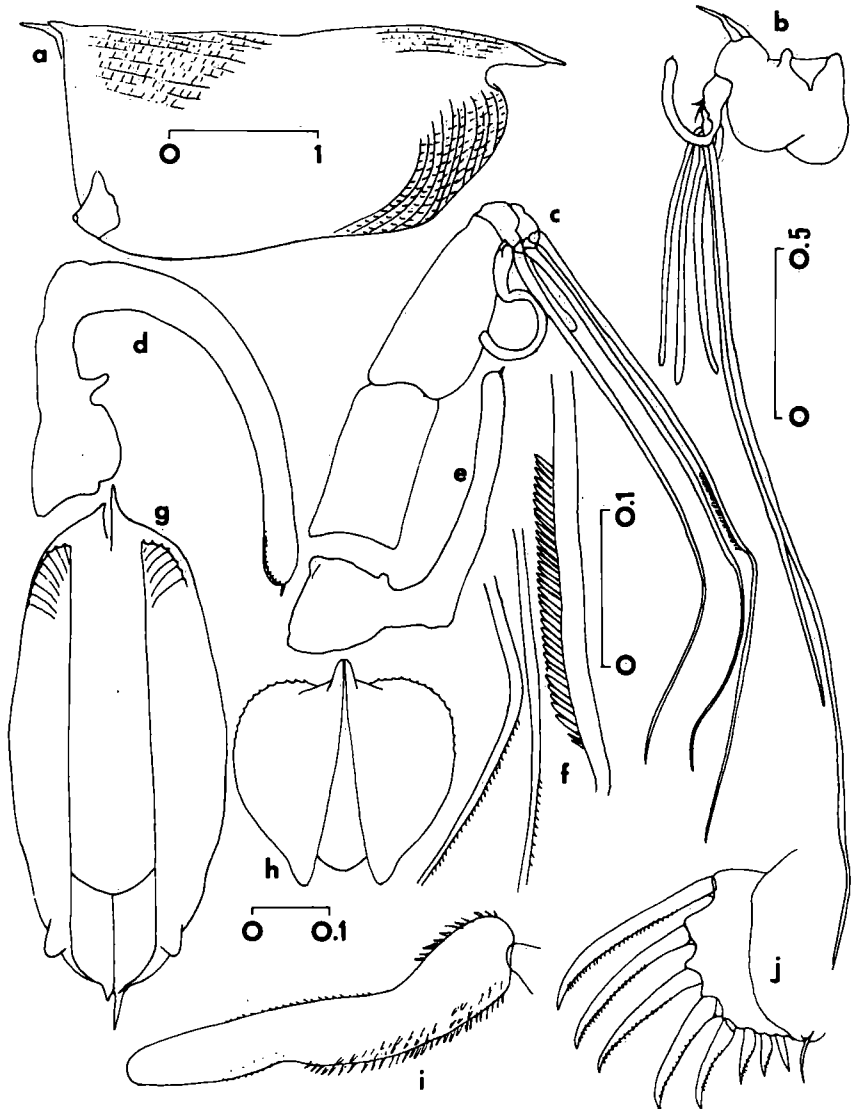


FIGURE 39. *C. ametra* male. a, g, and h, Lateral, ventral and posterior views of shell; b, Endopodite of right 2nd antenna; c, 1st antenna; d, Right clasper, e, Left clasper; f, Armature of setae of 1st antenna; i, Capitulum of frontal organ; j, Furca. Scale on a for a, g, h; at upper right for b, c, j; beside f for d-f; above i for i. Scales in mm.

pairs of leaf-like teeth (Fig. 39f); the proximal secondary seta has a long row of spinules near its tip, and the distal seta has some very fine spinules that are difficult to see. The male right clasping organ is strongly curved with one projection near the base on the inner side (Fig. 39d), but the left clasper is much smaller and straight (Fig. 39e). The claws on the furca are relatively short and strong (Fig. 39j). In the mature shell the right rostrum and the right posterodorsal spine are shorter than on the left shell (Figs. 39a, g), and this differentiates this species from *C. symmetrica*; the juveniles of these two species are less easily distinguished. The principal seta of the female 1st antenna has tiny spinules part of the way down the anterior surface, as well as spinules down the posterior surface distal to the 4 filaments.

DISTRIBUTION—64°N-44°S in the Atlantic, 20°N-49°S in the Pacific, ca 8°N-50°S in the Indian Ocean, and in Indonesian Seas.

### *C. plinthina* Müller

A single juvenile specimen, 3.8 mm long, with 7 claws on the furca, was taken in February 1970 in a haul from 1000-1500 m (see Figs. 23 m, 1). The longer bristle on the basal segment of the endopodite of the 2nd antenna had a number of long hairs (Fig. 23m). In his description of this species Müller (1906: 116, pl. 27, figs. 1-6, 9, 10, 20) said these bristles were bare, but Poulsen (1973, fig. 98c) described and figured long hairs as occurring on the male 2nd antenna. Müller gave the length range of females as 5.5-5.9 mm and of males as 4.8-5.2 mm. Poulsen reported that the largest individuals were found in the Pacific between 7°N and 4°S and 79° and 120°W. Next largest specimens were found in the western South Pacific, the Indian Ocean, and Indonesian Seas, whereas smallest individuals were taken in the Atlantic Ocean. Angel and Fasham (1975) recorded this species from 11° to 40°N in the eastern Atlantic, and Angel (1979) found none on the transect across the Atlantic at 32°N; several specimens were taken in the day and night Ocean Acre samples between 1000 and 2000 m. Angel concluded that this is an infrequent bathypelagic species restricted to tropical and subtropical waters.

DISTRIBUTION—Ca 48°N-42°30'S in the Atlantic. Poulsen reported that *C. plinthina* occurs in the Atlantic, Pacific, and Indian Oceans, almost exclusively in the tropical zones, 25°N-35°S. Chavtur (1977) listed it as occurring in the Bering Sea.

### *Daphnoides* Group Müller

#### *C. (Conchoecilla) daphnoides* (Claus)

*C. daphnoides* was present year-round over 500-1000 m depths, but was not taken as consistently in the upper waters (see Fig. 34A). It occur-

red in the upper 500 m mainly in fall to spring and over 500-1000 m depths in spring and fall, with a summer minimum. There were indications of a seasonal vertical migration, with the bulk of the population within the upper 1000 m from fall to spring and over 500-1500 m depths from spring to fall. *C. daphnoides* was never abundant, but constituted a small percentage of the total numbers of ostracods (see Tables 3 and 4). In general, it was least numerous in summer and most abundant from January to March or April. Most of the specimens counted were juveniles, but males and females were present from February to September and most numerous in March, April and May. With respect to length, *C. daphnoides* females are the largest halocyprid ostracods found commonly in these waters. The females had a length range of 4.7-5.4 mm; the males are considerably shorter, 2.85-3.2 mm long. Angel (1979) gave a length range of 4.17-5.25 for females and of 2.64-3.12 mm for males from the Ocean Acré samples. He lists *C. daphnoides* as a widespread shallow mesopelagic species. The female was illustrated in the previous study (Deevey 1968, fig. 60), and the male from the waters off Barbados (Deevey 1970, fig. 9).

DISTRIBUTION—63°N-42°S in the Atlantic, 40°N-51°30'S in the Pacific, ca 10°N-43°S in the Indian Ocean and in Indonesian Seas.

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