ELLSWORTH H. WHEELER, JR.

Atlantic Deep-Sea Calanoid Copepoda

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ABSTRACT

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Abundance of calanoid adults (excluding contaminants) was varied but always less than 29 adults/100 m^3. These results are consistent with other investigations. The ratio of numbers of species to numbers of individuals increases with decreasing latitude when data from other Atlantic collections are included. Existing hypotheses explaining latitudinal gradients in diversity do not apparently apply to the 2,000–4,000 m interval. Diversity in the deep sea is probably echoing that of upper levels. The species assemblage is cosmopolitan, with many species occurring in all oceans.

The total length of adult calanoid copepods averaged 2.14 mm, a value consistent with size ranges found in samples from other oceans.

Sixty percent of the species were represented by females only. Three species, known only from below 2,000 m, were represented by males and females in the same tows. The presence of spermatophore sacs on some females and the large number of juvenile stages indicate some reproduction is occurring at depth.

Available alternatives for the nutrition of deep-sea Copepoda are other zooplankton, organic aggregates, autochthonous unicellular organisms, organic matter transported downward, and detritus.

Four new species are described: *Mimocalanus sulcifrons, Paivella naporai, Undinella gricei,* and *Zenkevitchiella tridentae,* with systematic remarks for eight others, including two species (*Aetideopsis retusa* and *Scolecthricella timida*) not previously known from the Atlantic Ocean.

Contribution of the Graduate School of Oceanography,
University of Rhode Island

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Introduction

Published accounts of deep-sea copepod species prior to 1948 have been reviewed and discussed by Sewell (1948). Unfortunately for purposes of comparison, few of the tows listed in Sewell's compilation were taken below 2,000 m. Those few were not made with closing nets except for a series by Farran (1926) in the Bay of Biscay, using a vertical closing net without flowmeter and by Leavitt (1938) between Bermuda and the North American coast, using a horizontal closing net of coarse stramin, also lacking a flowmeter. Colman (1962) made two series of vertical, closing-net hauls in the Bay of Biscay but identified the specimens only to subclass.

The most notable report on Copepoda below 2,000 m in the Atlantic Ocean is by Grice and Hulsemann (1965), who analyzed the abundance, vertical occurrence, and taxonomy of calanoid copepods from the northeast Atlantic taken by personnel of the National Institute of Oceanography, Wormley, England, on board the R.R.S. *Discovery II*. The samples were collected with a vertical closing net incorporating a flowmeter and depth recorder.

The reports of Farran, Leavitt, Colman, and Grice and Hulsemann comprise the sum of published investigations in the Atlantic below 2,000 m with closing nets, and only the last named is truly quantitative.

Methods

Collections.—The opportunity to sample calanoid Copepoda from 2,000 to 4,000 m in the North and South Atlantic was provided by cruises 023 and 036 of R.V. *Trident*, Graduate School of Oceanography, University of Rhode Island (Figure 1, Table 1). Included in Figure 1 are station locations for the work of Farran (1926) and Grice and Hulsemann (1965).

Tows 1 through 17 were taken with a modified Nansen vertical net of 70 cm diameter (NV–70). The net is similar to that used by Grice and Hulsemann (1967), having a flowmeter mounted within the mouth and a time-depth recorder (Benthos Manufacturing Company, North Falmouth, Massachusetts) attached to the weight below the plankton bucket. The depth at closure is estimated from the ascent speed of the net (60 m/min), the descent speed of the messenger (200 m/min), the depth of the net when the messenger is released, and from the flowmeter reading and depth recording. This information indicated that most tows closed prematurely, probably due to the rolling of the ship, and a small catch resulted. For this reason a horizontal closing net was rigged.

For Tows 18 through 32, a large Clarke-Bumpus sampler (Yentsch, Grice and Hart, 1962) was used. The closed sampler was lowered vertically to about 2,000 m, opened, lowered to 4,000 m, and then towed at 3.7 km/hr average speed for approximately two and one half hours before closing and vertical retrieval. With this technique the flowmeter indicated volumes ranging from 450 to 678 m^3 were sampled. Time-depth recorder charts show sampling depth varied from 2,200 to 4,100 m. With all tows, calanoid copepods were washed from the net and preserved in 5 percent buffered formalin.

Identification.—The identification procedure involved temporary staining of the exoskeleton with Poirrior's Blue and the removal and mounting of swimming legs and oral appendages. Drawings were made with a camera lucida, and total length in mm (anterior

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TABLE 1.—*Collection data for adult calanoid copepod species (excluding contaminants) from 2000–4000 m*

Tow No.	Station No.	Date	Latitude	Longitude	Vol. Sampled (m^3)	Copepod Species	Remarks
		NANSEN VERTICAL NET (0.24 mm mesh aperture)					
1	023-1	14 Mar 65	27°48'N	58°37'W	750	4	4000-2005 m
2	023-2	16 Mar 65	24°54'N	56°00'W	20	-	3800-3750 m
3	023-3	19 Mar 65	16°45'N	53°00'W	100	-	3800-3535 m
4	023-4	30 Mar 65	6°44'N	38°08'W	200	-	4200-3660 m
5	023-5	4 Apr 65	3°57'S	34°47'W	70	-	3000-2805 m
6	023-6	13 Apr 65	1°30'S	31°30'W	540	14	4000-2570 m
7	023-7	19 Apr 65	1°33'N	21°30'W	110	-	4000-3705 m
8	023-8	21 Apr 65	0°10'S	18°30'W	220	-	4000-3410 m
9	023-9	23 Apr 65	5°00'S	15°00'W	120	2	3000-2675 m
10	023-10	27 Apr 65	10°00'S	22°00'W	290	4	4000-3220 m
11	023-11	12 May 65	23°00'S	30°00'W	55	1	4000-3860 m
12	023-12A	14 May 65	15°00'S	30°00'W	190	1	4000-3485 m
13	023-12B	15 May 65	15°00'S	30°00'W	580	-	3900-2370 m
14	023-12C	15 May 65	15°00'S	30°00'W	500	1	4000-2660 m
15	023-12D	15 May 65	15°00'S	30°00'W	250	4	4000-3325 m
16	023-12E	15 May 65	15°00'S	30°00'W	470	4	4000-2755 m
17	023-13	17 May 65	11°01'S	30°00'W	70	-	4000-3825 m
		LARGE CLARKE-BUMPUS SAMPLER (0.37 mm mesh aperture)					
18	023-CB-1	18 May 65	6°39'S	29°59'W	110	14	
19	023-CB-2	23 May 65	10°00'N	30°00'W	310	7	
20	023-CB-3	25 May 65	10°30'N	35°00'W	3	2	Pre-trip
21	023-CB-4	29 May 65	11°00'N	46°30'W	1	-	Pre-trip
22	023-CB-5	30 May 65	11°36'N	50°47'W	600	-	Closing messenger fouled
23	023-CB-6	31 May 65	11°36'N	50°47'W	-	-	Sample lost
24	023-CB-7	8 Jun 65	19°30'N	62°30'W	550	19	
25	023-CB-8	9 Jun 65	24°00'N	64°00'W	820	-	Above desired depth
		LARGE CLARKE-BUMPUS SAMPLER (0.12 mm mesh aperture)					
26	036-CB-1	28 Sep 66	37°12'N	69°39'W	470	23	
27	036-CB-2	4 Oct 66	30°38'N	65°01'W	560	8	
28	036-CB-3	5 Oct 66	28°55'N	69°49'W	530	4	
29	036-CB-4	6 Oct 66	26°59'N	70°06'W	530	3	
30	036-CB-5	8 Oct 66	24°33'N	69°30'W	450	4	
31	036-CB-6	9 Oct 66	22°10'N	68°53'W	680	9	
32	036-CB-7	10 Oct 66	19°32'N	68°08'W	510	12	

tip of cephalothorax to posterior end of caudal furcae) was measured with an ocular micrometer. Of 1,556 copepods examined, 553 (103 species) were adults and 1,003 were calanoid juveniles.

CONTAMINANT SPECIES.—Grice and Hulsemann (1965) compared NV–70 hauls of varying length above 2,000 m with tows below this level and listed 16 species as probable contaminants in their nets below 1,000 m. Their work in the Indian Ocean (Grice and Hulsemann, 1967) with a similar net added 26 species to the previous contaminant list, assuming no difference in vertical distributions of species between the two oceans. Recently, Grice and Hulsemann (1968) worked with the NV–70 net in an arrangement which allows the mouth to be closed while lowering. Their results indicate that shallow-water species are entrained as the open net descends vertically. This phenomenon would be common to all vertical nets lowered in the open position and may explain the anomalous distributions found by Wolfenden (1911), Farran (1926), and noted by Sewell (1948, pp. 345–346).

The large Clarke-Bumpus sampler is also liable to contamination, which probably occurs via the narrow and varying (0–2 mm) discrepancy between the closed shutter at the mouth of the net and the PVC barrel supporting the shutter and the flowmeter.

A conservative approach is used here in dealing with the contaminant problem. Listed below are 33 adult calanoid copepod species (310 individuals) that I consider to be contaminants below 2,000 m in all deep tows. A species is listed if so categorized by Grice and Hulsemann (1965, 1967) and if earlier reports of its vertical distribution (Leavitt, 1938; Sewell, 1948) support this decision. For example, *Scolecithrix danae* (Lubbock, 1856) is on the contaminant list of Grice and Hulsemann (1967) for NV–70 tows below 2,000

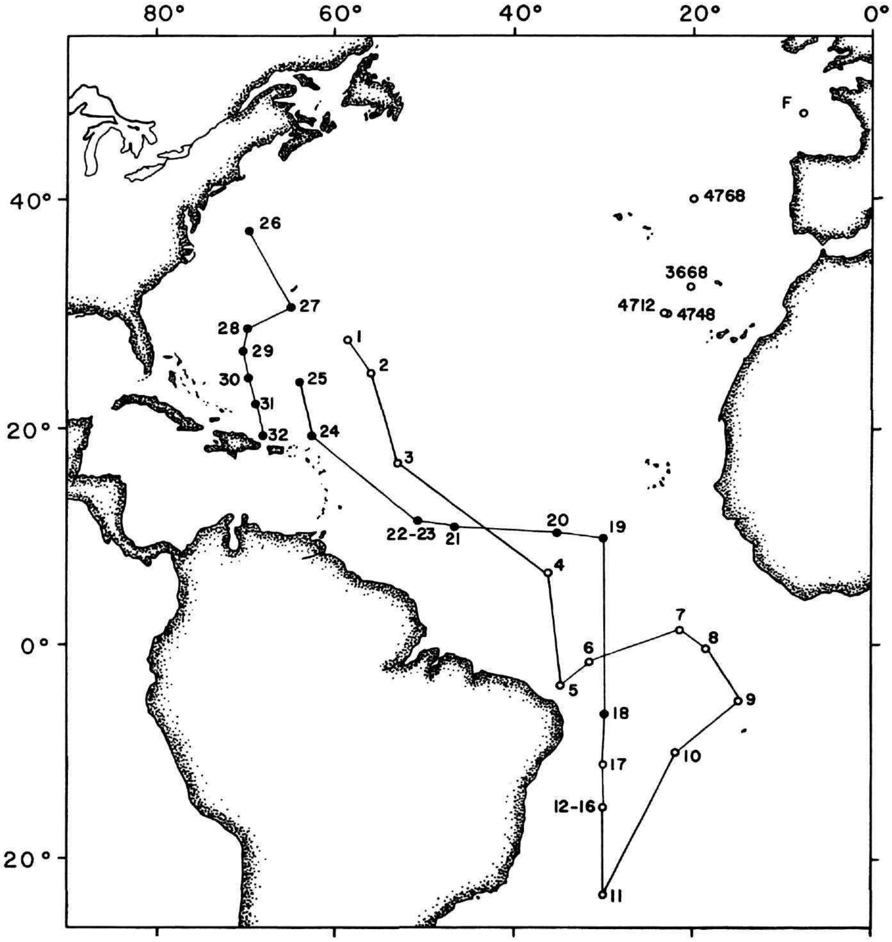

FIGURE 1.—Chart of tow locations. Open circles: vertical tows; closed circles: horizontal tows.

m in the Indian Ocean but was taken in horizontal closing net tows by Leavitt (1938) at 2,800–3,000 m depth. *S. danae* is therefore not included in my list. Contaminant species for all tows are as follows:

CALANDIDAE

1. *Calanus tenuicornis* Dana, 1849
2. *Nannocalanus minor* (Claus, 1863)
3. *Neocalanus gracilis* (Dana, 1849)
4. *Undinula vulgaris* (Dana, 1849)

EUCALANIDAE

5. *Mecynocera clausii* Thompson, 1888

PARACALANIDAE

6. *Acrocalanus longicornis* Giesbrecht, 1888
7. *Calocalanus contractus* Farran, 1926
8. *C. gracilis* Tanaka, 1956
9. *C. pavo* (Dana, 1849)
10. *C. pseudocontractus* Bernard, 1958
11. *C. styliremis* Giesbrecht, 1888
12. *C. tenuis* Farran, 1926
13. *Ischnocalanus plumulosus* (Claus, 1863)
14. *Paracalanus aculeatus* Giesbrecht, 1888
15. *P. denudatus* Sewell, 1929
16. *P. nanus* Sars, 1907
17. *P. parvus* (Claus, 1863)
18. *P. pygmaeus* Claus, 1863

PSEUDOCALANIDAE

19. *Clausocalanus arcuicornis* (Dana, 1849)
20. *C. furcatus* (Brady, 1883)
21. *C. paululus* Farran, 1926

22. *C. pergens* Farran, 1926
23. *Ctenocalanus vanus* Giesbrecht, 1888

AETIDEIDAE

24. *Euaetideus acutus* (Farran, 1929)

SCOLECITHRICIDAE

25. *Scaphocalanus curtus* (Farran, 1929)
26. *Scolecithrix bradyi* Giesbrecht, 1888

CENTROPAGIDAE

27. *Centropages violaceus* (Claus, 1863)

LUCICUTIIDAE

28. *Lucicutia gaussae* Grice, 1963
29. *L. gemina* Farran, 1926

CANDACIIDAE

30. *Paracandacia bispinosa* (Claus, 1863)
31. *P. simplex* (Giesbrecht, 1889)

ACARTIIDAE

32. *Acartia danae* Giesbrecht, 1889
33. *A. negligens* Dana, 1849

The Population

ABUNDANCE.—Numbers of adult copepods per 100 cubic meters for each station are given in Table 2. The results vary widely regardless of the volume of water sampled and the type of net used. The horizontal nets sampled more uniform volumes of water, but Tows 26 through 32 show values ranging from 0.6 to 10.0 adults/100 m³. The fact that only certain vertical tows failed to catch any adults cannot be considered a sampling artifact since juvenile copepods were taken in these tows—that is, the net was functioning.

The abundance of adult copepods also varies among tows at the same location. Tows 12 through 16 were taken at 15°00′S, 30°00′W. Values ranged from 0.0–1.6 adults/100 m³ with a mean of 0.6 When these data are considered with the results of other investigations, the scarcity of adult calanoid copepods from 2,000 to 4,000 m is apparent. Grice and Hulsemann (1965) found the maximum concentration of adults in the 10–50 m interval (600 to 2,200/100 m³), with a secondary peak at 200 to 500 m (900/100 m³) at the same stations where 10 to 30 adults/100 m³ were found below 2,000 m. From a series of tows in the Bay of Biscay (labeled "F" on Figure 1), Farran's (1926) data, when converted to these units, show 140 to 160 specimens/100 m³. These values represent adult calanoid and cyclopoid copepods as well as juvenile calanoids and cyclopoids and are therefore comparable.

TABLE 2.—*Abundance of adult calanoid copepods (excluding contaminants)* (See Table 1 for station data)

Tow No.	Adults	Adults /100 m³	Vol. (m³) Sampled
1	5	0.7	750
2	-	-	20
3	-	-	100
4	-	-	200
5	-	-	70
6	21	3.9	540
7	-	-	110
8	-	-	220
9	2	1.7	120
10	21	7.2	290
11	1	1.8	55
12	1	0.5	190
13	-	-	580
14	1	0.2	500
15	4	1.6	250
16	4	0.9	470
17	-	-	70
18	31	28.2	110
19	7	2.3	310
20	-	-	3
21	-	-	1
22	(see Table 1)		
23	(see Table 1)		
24	50	9.1	550
25	(see Table 1)		
26	47	10.0	470
27	6	1.1	560
28	6	1.1	530
29	3	0.6	530
30	6	1.3	450
31	9	1.3	680
32	18	3.5	510

Calanoid Copepoda were the most abundant metazoans in the samples. Their scarcity below 2,000 m emphasizes the small standing crop of other zooplankton.

SPECIES DIVERSITY.—Diversity indices (Fisher, Corbet, and Williams, 1943; Margalef, 1958, and others) cannot be applied to the data of this investigation because of small sample size (Slobodkin, 1962; Hessler and Sanders, 1967). Information on the species to individuals relationship can be obtained from frequency distribution of species according to the number of adult individuals in each species (Figure 2). When all samples are pooled, 70 species (243 adults) are represented (solid bars). Most species occur as single individuals. A rapid decrease to an extreme of one species with 27 specimens characterizes the rest of the graph. The species to individuals ratio (70/243) equals 0.29. Included on the graph are data from N.I.O. samples (2,000–4,000 m; see Figure 1) in the northeastern Atlantic (Grice and Hulsemann, 1966, unpublished *Discovery II* station data and list of species for Grice

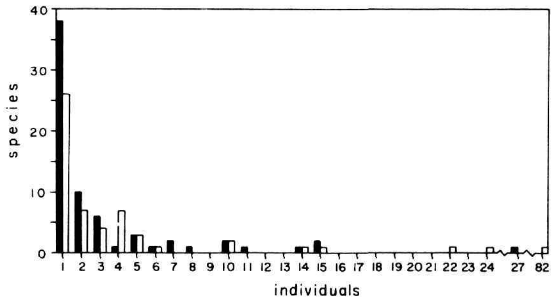

FIGURE 2.—Frequency distribution: numbers of species arrayed according to number of adult individuals in each species (excluding contaminants). Solid bar: Wheeler; clear bar: Grice and Hulsemann (unpublished data from northeastern Atlantic).

and Hulsemann, 1965). Their results are similar: the diversity ratio (55/278) equals 0.20 and most species are represented by a single individual. Their most abundant species (82 individuals) was *Spinocalanus abyssalis* (including "var. *pygmaeus*") of which over half were taken in one haul (Station 3668). This copepod numbers 14 individuals in my tows, where the most abundant species is *Lucicutia flavicornis* with 27 individuals (considered a contaminant by Grice and Hulsemann).

After contaminant species are subtracted, Farran's (1926) data give a diversity ratio of 16 calanoid species to 154 individuals (0.10).

To avoid confusion by pooling tows from the same latitude in different groups, Tows 26 and 27 (37°12'N, 30°38'N) can be combined with the N.I.O. data from 29°57'N to 40°03.5'N. This grouping gives a diversity ratio of 0.34 (59/176) for the pooled data of my investigation (all tows less numbers 26 and 27) and a ratio of 0.20 (66/328) for the N.I.O. samples plus Tows 26 and 27. These ratios are plotted against latitude in Figure 3. The values indicate a trend of increasing diversity with decreasing latitude for adult calanoid Copepoda from 2,000–4,000 m, longitudinal differences notwithstanding.

Grice and Hulsemann's (1967) report does not include the numbers of individuals collected at each station. If we assume their sampling to be consistent, numbers of species taken between 2,000 and 4,000 m suggest this same change in diversity with latitude in the Indian Ocean:

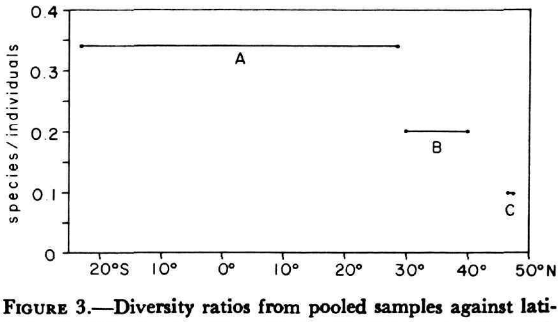

FIGURE 3.—Diversity ratios from pooled samples against latitude. A: Wheeler less Tows 26, 27; B: N.I.O. plus Tows 26, 27; C: Farran (1926). Length of horizontal line indicates latitudinal spread only.

Station	*Latitude*	*Depth (m)*	*Species*
328	18°02'N	3000–2000	18
332	10°04'N	3000–2000	19
332	10°04'N	4000–3000	8
334	06°01'N	3000–1894	16
336	01°30'N	3000–1940	21
338	02°38'S	3000–2000	26
340	06°00'S	2950–1990	28
342	10°07'S	3000–1980	32
349	26°03'S	3000–2000	8
349	26°03'S	4000–3000	8
355	29°38'S	3000–2000	3
355	29°38'S	4000–3000	8

A similar trend exists for calanoids from Pacific surface waters (Brodsky, 1959, cited by Fischer, 1960) and for Copepoda and other zooplankton from shallower levels of the Atlantic (Grice and Hart, 1962).

Hypotheses for the causes of latitudinal gradients in species diversity (specifically, more species at low latitudes) have been reviewed by Pianka (1966). Each approach links changing diversity with another latitudinal gradient existing in the environment or faunal community: age of the community, environmental complexity, intensity of interspecific competition, or climatic stability and productivity. None of these hypotheses appear to apply to the pelagic deep sea because there is no evidence for an accompanying gradient in the environment. Nearer the surface such latitudinal gradients do exist, as do larger populations of copepods which vary in diversity. I believe species diversity in the deep sea is echoing that of upper levels, and that one must look to the upper strata as the major source of deep-living copepod species rather than hypothesizing a population which is largely endemic.

SPECIES OCCURRENCE.—The species assemblage below 2,000 m is cosmopolitan. Table 3 lists the number of species from other regions which are in common with those from this investigation. Items 3 and 5 are not from closing net data but come from lists of species occurrence collated by the authors; items 5 and 6 are not limited to the 2,000–4,000 m level and are included for regional consideration.

Ten species from this investigation are listed below with indications of their occurrence in the regions and depths of Table 3. The number of cosmopolitan species could be doubled by including higher strata (1,000–2,000 m) of the northeastern Atlantic and Indian oceans.

Species	*Region* (see Table 3)
1. *Mimocalanus cultrifer*	2, 3, 4
2. *Spinocalanus abyssalis*	1, 2, 3, 4
3. *S. magnus*	1, 2, 3, 4, 5, 6
4. *Scaphocalanus brevicornis*	4, 5, 6
5. *S. magnus*	3, 4, 5, 6
6. *Metridia brevicauda*	1, 4, 5
7. *M. princeps*	1, 3, 4
8. *Lucicutia curta*	1, 2, 3, 4
9. *Heterorhabdus compactus*	2, 3, 4, 5
10. *Haloptilus longicornis*	1, 4, 5

Exceptions to the general, vertical distribution of 1,000–4,000 m for these species and others are *Foxtonia barbatula* Hulsemann and Grice, 1963, and *Temorites discoveryae* Grice and Hulsemann, 1965. First described from the northeastern Atlantic, then reported from the Indian Ocean, in no case have these species been taken above 2,000 m. Their occurrence appears to be widespread though restricted vertically. Both species occurred in my tows (see Taxonomy section).

TABLE 3.—*Number of species from other regions in common with this investigation*

Region	Number species total	Number species in common
1. Bay of Biscay (Farran, 1926) 4000-2000 m	16	8
2. Northeast Atlantic (Grice and Hulsemann, 1965) 4000-2000 m	55	22
3. Antarctic (Vervoort, 1965b) "abyssal species"	48	14
4. Indian Ocean (Grice and Hulsemann, 1967) 4000-2000 m	67	24
5. Pacific Ocean (Brodsky, 1957) "abyssal calanoid fauna"	113	14
6. Polar Basin (Johnson, 1963) 2000-1000 m	7	4

MEAN SIZE.—Adult calanoid copepods (excluding contaminant species) averaged 2.14 mm total length. This result is consistent with mean lengths of northeast Atlantic, Indian Ocean, and tropical Pacific calanoid species (Grice and Hulsemann, 1965, 1967; Vinogradov, 1962).

SEX RATIOS.—Sixty percent of the species were represented by adult females only, with lesser percentages for categories of heterogeneous occurrence in males only. Many species of marine Copepoda are known and described from female specimens alone. Males may be present but escape sampling because they are short-lived, dying immediately after reproduction (Bogorov, 1939, cited by Mednikov, 1961). Hulsemann (1964) has suggested the female may devour the male after copulation, as is known to be the case with certain Arachnida and Insecta. Such a large intake of food could replenish reserves depleted during egg formation. There is no evidence for parthenogenesis among calanoid Copepoda as an explanation for the observed sex ratio (Charniaux-Cotton, 1960; Marshall and Orr, 1955; Vervoort, 1965b).

The spermatophore which is transferred from the male to the female during copulation is often lost during collection; a few, however, were seen on females from deep tows. This evidence (plus the large number of juvenile stages found) indicates that some reproduction is taking place below 2,000 m. *Foxtonia barbatula, Temorites discoveryae,* and *Zenkevitchiella atlantica*—known only from below 2,000 m—are represented by both sexes (Grice and Hulsemann, 1965, 1967), and *F. barbatula* from my tows had female and male individuals in two of the five tows in which it occurred.

FOOD RELATIONSHIPS.—Available alternatives to the conventional primary producer as a source of nutrition for pelagic crustacean omnivores and carnivores of the deep sea include other zooplankton, organic aggregates (Riley, 1963), autochthonous unicellular organisms (Hentschel, 1936; Bernard, 1964; Fournier, 1966), organic matter transported downward by a "ladder of migrations" (Vinogradov, 1962), and detritus of plant or animal origin. Figure 4 illustrates these alternatives. The 2,000 m level does not imply a scale of depth from the surface downward but separates the region under consideration from the familiar producer-

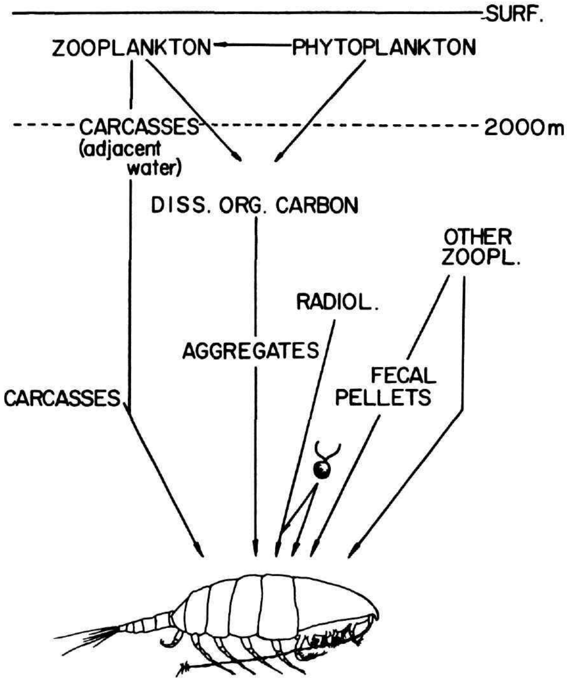

FIGURE 4.—Sources of food for deep-sea copepods. The flagellate represents unicellular organisms other than Radiolaria.

consumer relationships of upper waters. Two main routes are emphasized for the transfer of carbon from the surface to below 2,000 m: sinking of zooplankton carcasses from adjacent waters, a source presumably linked to surface waters by mortality during vertical migrations (Wheeler, 1967); and addition to the dissolved organic carbon pool via metabolic activity and autolysis. The line connecting "dissolved organic carbon" with "aggregates" is based on the hypothesis that adsorption of dissolved organic material onto organic aggregates occurs throughout the water column (Riley, Van Hemert, and Wangersky, 1965). Radiolarian fragments have been observed in gut-contents of deep-sea copepods (Wheeler, 1967) as have the small cells described by Fournier (1966).

Until the effect of hydrostatic pressure on copepod metabolism is determined, and carbon requirements can be estimated, the adequacy of these suggested food sources is unknown.

Taxonomy

Four new species are described below, along with systematic remarks for eight others. The holotypes are deposited in the National Museum of Natural History collections. Two males, *Spinocalanus* species and *Bathypontia* species, which may be referable to known species are also figured. The 70 species found (243 adults, excluding contaminants) are listed in Table 4. Included in the list and discussion are two species (*Aetideopsis retusa* Grice and Hulsemann, 1967; *Scolecithricella timida* Tanaka, 1962) which are not previously known from the Atlantic Ocean.

In the discussion the first through the fifth pedigerous segments refer to those to which the first through fifth pairs of legs are attached. Size reference scales are in millimeters. Total length is measured from the anterior tip of the cephalothorax to the posterior end of the caudal furcae. Terminology used is that proposed by Gooding (1957).

Mimocalanus sulcifrons, new species

FIGURES 5–20

OCCURRENCE.—Tow 30: 1 male (2.02 mm).

DIAGNOSIS (male).—Prosome elongate, with cephalosome flaring laterally midway between front of head and anterior border of 1st pedigerous segment. Lateral margin of 1st pedigerous segment minutely dentate. Fourth and 5th pedigerous segments fused. Posterolateral margins of 5th pedigerous segment broadly rounded. Urosome of 5 subequal segments.

Anterior portion of cephalosome appears bilobed, indented dorsally with rounded, V-shaped groove, bearing fine setae on interior sides. Rostrum absent.

First antenna with 24 free segments; segments 2–8 adorned with horn-shaped esthetes. Antennae extend 1–2 segments beyond furcal rami. Basipod of 2nd antenna with 1 proximal and 2 distal setae. Exopod 7-segmented; segments 3–6 each bearing 1 seta; segment 7 with 1 lateral seta and 3 strong terminal setae. Endopod is 2-segmented, the distal segment with 13 setae and a row of small spines along distolateral margin. Base of mandibular palp with 2 setae; endopod 2-segmented, with 2 setae on 1st segment and 8 setae on terminal segment. Exopod 4-segmented, with a total of 6 setae. Gnathal lobe of mandible appears reduced, with 2 blunt teeth. First inner lobe of 1st maxilla reduced and devoid of spines or setae. Second and 3rd inner lobes bear 1 and 2 setae respectively; 2nd basal segment with row of 4 sharp spines on distal inner margin. Endopod with 9 setae; exopod with 10 setae. Second maxilla reduced, with 7 distinct lobes; proximal

TABLE 4.—*List of adult calanoid copepod species (excluding contaminants) and corresponding tow numbers* (see Table 1)

EUCALANIDAE	
1. Eucalanus pileatus Giesbrecht, 1888	6
2. Rhincalanus cornutus (Dana, 1849)	6, 18, 24, 26
PSEUDOCALANIDAE	
3. Microcalanus pygmaeus Sars, 1900	20, 32
4. Farrania frigida (Wolfenden, 1911)	19
SPINOCALANIDAE	
5. Mimocalanus cultrifer Farran, 1908	24, 26, 27, 30, 31, 32
6. Mimocalanus sulcifrons new species	30
7. Monacilla tenera Sars, 1907	19, 26
8. M. typica Sars, 1905	29
9. Spinocalanus abyssalis Giesbrecht, 1888	19, 27, 31
S. abyssalis var. pygmaeus Farran, 1926	10, 18, 19, 26, 32
10. S. angusticeps Sars, 1920	26
11. S. magnus Wolfenden, 1904	24, 26
12. S. spinosus Farran, 1908	26
13. Spinocalanus species	26
14. Teneriforma naso (Farran, 1936)	27
AETIDEIDAE	
15. Aetideopsis retusa Grice and Hulsemann, 1967	26
16. Bradyetes brevis Farran, 1936	26
17. Euaetideus giesbrechti (Cleve, 1904)	18
18. Euchirella pulchra (Lubbock, 1856)	15
19. E. rostrata (Claus, 1866)	1
20. Gaetanus curvicornis Sars, 1905	24
21. G. minor Farran, 1905	6, 18
22. G. pileatus Farran, 1903	6
23. Gaidius tenuispinus Sars, 1900	6, 24, 26
24. Paivella naporai new species	16
25. Pseudochirella fallax (Sars, 1907)	32
EUCHAETIDAE	
26. Euchaeta marina (Prestandrea, 1833)	18
27. E. media Giesbrecht, 1888	6, 24
28. Paraeuchaeta gracilis (Sars, 1905)	6
SCOLECITHRICIDAE	
29. Scaphocalanus brevicornis (Sars, 1903)	26
30. S. echinatus (Farran, 1905)	24, 32
31. S. longifurca (Giesbrecht, 1888)	26, 27
32. S. magnus (T. Scott, 1894)	26
33. Scolecithricella dentata (Giesbrecht, 1892)	24
34. S. laminata Farran, 1926	26, 32
35. S. timida Tanaka, 1962	19
36. Scolecithrix danae (Lubbock, 1856)	9, 10, 12, 15, 18
THARYBIDAE	
37. Undinella gricei new species	32
TEMORIDAE	
38. Temoropia mayumbaensis T. Scott, 1893	19, 26, 28, 31, 32
METRIDIIDAE	
39. Metridia brevicauda Giesbrecht, 1889	6, 24
40. M. discreta Farran, 1946	6, 26, 31
41. M. longa (Lubbock, 1854)	24
42. M. princeps Giesbrecht, 1892	16, 26
43. M. venusta Giesbrecht, 1892	24
44. Pleuromamma abdominalis abdominalis (Lubbock, 1856)	16, 18, 24
45. P. borealis (Dahl, 1893)	6, 18
46. P. gracilis gracilis (Claus, 1863)	11, 15, 24
47. P. piseki Farran, 1929	28
48. P. xiphias (Giesbrecht, 1888)	1, 6, 29
LUCICUTIIDAE	
49. Lucicutia curta Farran, 1905	14
50. L. flavicornis (Claus, 1863)	10, 15, 18, 24, 28, 30
51. L. intermedia Sars, 1905	1, 24
52. L. longiserrata (Giesbrecht, 1889)	1
53. L. magna Wolfenden, 1903	28
54. L. ovalis Giesbrecht, 1898	6
HETERORHABDIDAE	
55. Heterorhabdus abyssalis (Giesbrecht, 1889)	6, 26
56. H. compactus (Sars, 1900)	26
57. H. papilliger (Claus, 1863)	18, 24
58. Heterostylites major (Dahl, 1894)	26
AUGAPTILIDAE	
59. Euaugaptilus bullifer (Giesbrecht, 1892)	26
60. E. rostratus (Esterly, 1906)	18
61. Haloptilus fons Farran, 1908	24
62. H. longicornis (Claus, 1863)	18, 24, 27, 30, 32
63. H. mucronatus (Claus, 1863)	31
64. H. spiniceps (Giesbrecht, 1892)	18
BATHYPONTIIDAE	
65. Bathypontia sarsi Grice and Hulsemann, 1965	32
66. Bathypontia species	6
67. Foxtonia barbatula Hulsemann and Grice, 1963	19, 31, 32
68. Temorites brevis Sars, 1900	9
69. T. discoveryae Grice and Hulsemann, 1965	31, 32
70. Zenkevitchiella tridentae new species	27

lobe without setae; remaining lobes with 2–3 setae each. Maxilliped with elongate basipodal segments, each with 1 distal seta. Anterior lateral margins of both segments of basipod with row of fine hairs on either side of their common articulation. Endopod is 5-segmented with a total of 19 setae.

Endopod of leg 1 unisegmental bearing an inner lobe, 1 subterminal, and 2 terminal setae. Second segment of basipod with several small spines on distolateral corner. First segment of exopod apparently without setae or spines. Remainder of exopod missing. Only the basipods and 1st segments of exopod and endopod of legs 2–4 remain on this specimen. Endopod segments without spines or setae; 1st segment of exopod with stout distolateral spine. First basipodal segments of pairs 2–4 with 1 inner seta. Fifth legs uniramous and 5-segmented, left leg slightly longer than right leg. Terminal segment of left leg ending in 2 small points, that of right leg in 1 small point. Holotype: USNM 122646.

REMARKS.—This species differs from the generic description of Farran (1908, cited by Davis, 1949) in that the fourth and fifth pedigerous segments are fused rather than separate; the genus was established, however, on the basis of female specimens only. The male described here conforms most closely to the male of *Mimocalanus nudus* Farran, 1908, described by Grice and Hulsemann (1965) except for minor differences in the number of setae on the oral appendages, the fusion of the last two pedigerous segments on this species, and the unique configuration of the front of the cephalosome. The indentation on the head also distinguishes this species from the male of *M. cultrifer* Farran, 1908, first described by Tanaka (1956).

The males of *M. inflatus* Davis, 1949, and *M. major* Sars, 1920, have not been described. The former species is unique in having inflated endopodal segments on the swimming legs, whereas the latter is large (4.20 mm total length). The present species is not referable to either *M. inflatus* or *M. major.* Brodsky (1950) described *M. distinctocephalus* from females of north Pacific waters and Johnson (1963) reported three females from the Polar Basin. Brodsky's figures show no indentation on the cephalosome, nor is there additional evidence for considering my specimen to be the undescribed male of *M. distinctocephalus,* particularly in view of the absence of *M. distinctocephalus* from the Atlantic.

The species described above is here named *Mimocalanus sulcifrons* for the peculiar structure of the anterior portion of the head.

Monacilla typica Sars, 1905

FIGURES 21–22

OCCURRENCE.—Tow 29: 1 male (1.01 mm).

REMARKS.—Sars (1924–1925) described the male *M. typica* from an individual of 1.90 mm total length. Farran and Vervoort (1951) gave a size range for the male of 1.60–2.30 mm. The present specimen is smaller and differs from Sar's figures in that the endopod of the left fifth leg is more club-shaped than styliform and terminates in a small spine. The terminal spine of the right fifth leg is missing. Until additional males are found, this evidence is insufficient for erecting a new species.

Spinocalanus sp. Johnson, 1963

FIGURES 23–26

OCCURRENCE.—Tow 26: 1 male (1.66 mm).

REMARKS.—This male is similar to two males described by Johnson (1963) from the Polar Basin. His specimens, which he identified as "Spinocalanus ? male" were larger (1.85 mm) and differed from the usual genus description by having uniramous, asymmetrical fifth legs and by lacking spinules on the posterior surfaces of the swimming legs.

Tanaka (1956) described a similar species, *S. longipes,* from one male occurring in a 1,000–0 m vertical haul from Sagami Bay. The fifth legs were asymmetrical, but the exopod of the right fifth leg was shown with one segment.

Only the basipod segments of the elongate right fifth leg are present on this individual; the similarity, however, to Johnson's figures for his specimen is close. A full species description requires additional individuals.

Teneriforma naso (Farran, 1936)

FIGURES 27–28

Tanyrhinus naso Farran, 1936, pp. 86–87, fig. 4—Grice and Hulsemann, 1965, p. 231, fig. 8.

Teneriforma naso Grice and Hulsemann, 1967, p. 22, figs. 36–38.

OCCURRENCE.—Tow 27: 1 female (1.20 mm); 1 V female (1.05 mm). Tow 29: 1 V female (0.86 mm).

REMARKS.—This rare copepod was first reported by Farran (1936) from outside the Great Barrier Reef where a single female was found between 600 m and the surface. Grice and Hulsemann (1965) reported the first Atlantic record with a female from 500–180 m and another from 3,000–2,000 m in the northeastern Atlantic, considering the latter individual a contaminant from higher levels in the deep, vertical tow. These authors (1967) found at least three additional specimens (including the previously undescribed male) in hauls of 2,000–750 m, 3,000–1,940 m, and 2,000–1,000 m from the Indian Ocean. Including the three individuals from my samples (taken in deep, horizontal tows), eight of the ten known specimens were taken in deep tows, justifying its designation as a deep-sea form.

Aetideopsis retusa Grice and Hulsemann, 1967

FIGURES 29–30

OCCURRENCE.—Tow 26: 1 female (2.25 mm).

REMARKS.—A prominent frontal organ, distinctly separate rostral rami, long first antennae, and a smaller total length distinguish this species from *A. rostrata* Sars, 1903, and *A. multiserrata* (Wolfenden, 1904). Described from the Indian Ocean, this is the first record of *Aetideopsis retusa* from the Atlantic and the second known specimen.

Gaidius tenuispinus Sars, 1900

FIGURES 31–32

OCCURRENCE.—Tow 6: 1 female (2.02 mm). Tow 24: 1 female (2.48 mm). Tow 26: 1 male (2.95 mm).

REMARKS.—The individuals taken agree with specimens described from the North Atlantic (Vervoort, 1952) except for the larger total length of the male: 2.95 mm vs. 2.00 mm. Males reported from the southern ocean (Vervoort, 1957), however, exceeded 3.00 mm in total length, indicating a wide variation for the species.

Illustrations of the male fifth legs are not numerous, and a detailed view is included here.

Paivella naporai, new species

FIGURES 33–48

OCCURRENCE.—Tow 16: 1 female (1.27 mm).

DIAGNOSIS (female).—Prosome elongate with cephalosome and 1st pedigerous segment, 4th and 5th pedigerous segments fused. Posterolateral margin of cephalothorax triangularly produced and pointed, overlapping genital segment by about one-third.

Urosome 4-segmented. Genital segment produced into 2 distinct protuberances extending ventrally and laterally, visible in dorsal view. Length of furcal rami twice the width.

Rostrum acutely double-pointed and ventrally directed. Frontal organ with 2 hairs visible in dorsal view. First antenna with 22 free segments reaching to middle of urosome; 8th and 9th, 24th and 25th segments fused. Basipod of 2nd antenna with 1 proximal and 2 distal setae. Exopod 7-segmented; segments 1 and 3–6 bearing 1 strong seta each, segment 2 with 2 setae, and segment 7 with 3 terminal setae. Endopod 2-segmented; 1st segment with 1 distal seta, 2nd segment with a total of 14 setae. Base of mandibular palp with 2 setae; endopod 2-segmented, with 1 large and 1 small seta on 1st segment, 10 setae on terminal segment; exopod 5-segmented bearing 6 setae. Mandible blade with fine, sharply pointed teeth on broadly pointed bases in irregular rows. First inner lobe of 1st maxilla with 9 spines and 4 setae; 2nd inner lobe with 4 setae; 3rd inner lobe with 3 setae. Second basal segment with 5 setae; endopod with 11 setae and 11 setae on exopod. Outer lobe with 7 setae. Second maxilla 5-lobed; 1st, 2nd, and 3rd lobes with 3 setae each and bearing fine spinules; 4th lobe with 2 thin and 1 coarse seta; 5th lobe with 2 setae on either side of thickened, minutely dentate spine. Endopod 3-segmented with a total of 5 setae. Basipodal segments of maxilliped elongate; endopod 5-segmented.

Four pairs of swimming legs. Exopods 3-segmented; endopods of pairs 1 and 2 with 1 segment, pairs 3 and 4 with 3-segmented endopods. First basipod of pair 1 without spine on lateral margin. Pair 4 with 2 rows of stout spines on 1st basipod; distal row on thickened ridge. Terminal spines of pairs 2–4 with strong, acute teeth on external margin. Holotype: USNM 122647.

REMARKS.—In describing the genus *Paivella*, Vervoort (1965a) considered it to be intermediate between *Aetideus* Brady, 1883, and *Snelliaetideus* Vervoort, 1949, as well as agreeing in certain aspects with *Euaetideus* Sars, 1925. The unique feature of the genus is the presence of 2 transverse rows of stout spines—"teeth" according to Vervoort (1965a, p. 200)—on the posterior side of the first basipodal segment of the fourth legs.

This species agrees closely with the type and only species in the genus, *Paivella inaciae* Vervoort, 1965, except for minor differences in numbers of setae on the second antennae and oral appendages, and the presence of protuberances on the ventral aspect of the genital segment, similar to those described by Tanaka (1958) for certain *Pareuchaeta* species.

The profound structural difference in the genital segment provides for the establishment of a new species, *Paivella naporai*. It is dedicated to Dr. Theodore A. Napora, chief scientist on R.V. *Trident* cruise 023, who gave freely of his energy and time supporting the deep-sampling program of which the results are reported here.

Scolecithricella timida Tanaka, 1962

FIGURES 49–50

OCCURRENCE.—Tow 19: 1 female (1.84 mm).

REMARKS.—Although larger in size (1.84 mm vs. 1.52 mm total length) than the original specimens described by Tanaka (1962) from deep water of the northwestern Pacific, the female here agrees with his description and with the additional illustrations of Grice and Hulsemann (1967), except for the segmentation of the fifth legs. The present specimen shows clearly a 3- segmented, uniramous leg, whereas previous figures of this appendage suggest three but define only two segments. The placement of apical and lateral spines is similar in all cases.

Scolecithricella timida has not been previously recorded from the Atlantic.

Undinella gricei, new species

FIGURES 51–66

OCCURRENCE.—Tow 32: 1 male (1.88 mm).

DIAGNOSIS (male).—Prosome elongate with barely discernible separation between cephalosome and 1st pedigerous segment. Each lateral margin of 2nd and 3rd pedigerous segment with posteriorly directed point (not visible in dorsal view); 4th and 5th pedigerous segments fused. Posterior margins of 5th pedigerous segment with small protrusions adjacent to 1st segment of urosome. Fifth urosome segment one-sixth the length of preceding segment.

Rostrum prominent, extending ventrally as a broad, flattened structure with slight concavity between rostral rami. Margin of concavity with 2 small points. First antenna with 23 free segments, extending to 2nd urosome segment. Basipod of 2nd antenna with proximal tuft of fine, hairlike setae. Exopod 7-segmented with 1 strong seta on segments 2–5; segments 1 and 6 without setae; segment 7 with 2 terminal setae. Endopod 2-segmented with 1 distal seta on 1st segment, 12 setae on 2nd segment. Mandibular palp with 2 strong spines on base; endopod 2-segmented with 1 setae on 1st, 9 setae on 2nd segment. Exopod 5-segmented with 5 setae. Gnathal lobe of mandible with 7 long teeth; outer 2 teeth bidentate. Mandibular blade with large, hirsute seta at inner edge and fine setae surrounding teeth. First maxilla with large, inner lobe bearing 13 strong spines; 2 remaining inner lobes with 2 and 3 setae. Second basal segment with 3 setae, endopod with 6 setae, outer lobe with 5 setae. Maxilliped with 5-segmented endopod; basal segments elongate. Distal margin of 1st basipod segment with row of small hairs between seta and articulation of 2nd segment.

Exopods of legs 1–4 with 3 segments. Endopod of pair 1 with 1 segment, pair 2 with 2 segments, pairs 3 and 4 with 3 segments. Fifth legs enlarged and modified. Second basal segment of each fifth leg tumid, right larger than left. Right 5th leg 2-segmented and uniramous. First segment elongate and flattened distally; terminal segment recurved inward, ending in a small, cup-shaped structure. Left 5th leg biramous; exopod 2-segmented terminating in 2 processes; inner process with lobed configuration with row of fine hairs; outer process narrow, ending in small knob. Left 5th leg 3-segmented, 2nd segment with 4-lobed process. Terminal segment regular and cylindrical, ending in single knob. Holotype: USNM 122648.

REMARKS.—The points on the second and third pedigerous segments and the configuration of the fifth legs distinguish this species from males of *U. oblonga* Sars, 1900, *U. brevipes* Farran, 1908, and *U. frontalis* (Tanaka, 1937). The specimen differs from *U. simplex* (Wolfenden, 1906) by lacking points on the postero-lateral corners of the fifth pedigerous segment and in the structure of the fifth legs. An *Undinella* male now being described by Grice (personal communication) appears closely allied in that the pedigerous segments are similar; differences here in the fifth legs, however, provide the basis for erecting a new species.

This copepod is named for Dr. George D. Grice of the Woods Hole Oceanographic Institution, who encouraged this work.

Temoropia mayumbaensis T. Scott, 1893

FIGURES 67–75

OCCURRENCE.—Tow 19: 1 female (0.56 mm). Tow 26: 2 females (0.76, 0.75 mm). Tow 28: 1 female (0.86 mm). Tow 31: 1 female (0.83 mm). Tow 32: 1 female (0.79 mm).

REMARKS.—Grice and Hulsemann (1965) considered this species a contaminant in vertical tows below 500 m, presumably from earlier records such as Farran (1929), 120–0 m; Grice (1962), 150–1 m; and Vervoort (1965a), 100–0 m. Closing net tows by Farran (1908), however, contained *T. mayumbaensis* from 1,200 m, and Grice and Hulsemann found eight individuals above 1,000 m compared to 46 specimens in tows closing below 1,000 m in the North Atlantic. Thirteen of their Indian Ocean samples out of 24 from below 1,000 m also contained the species. This evidence plus the six females taken in this collection with a fine-meshed horizontal net suggests that the vertical distribution is not restricted to the upper 500 m.

According to Vervoort (1965a) *T. mayumbaensis* is a widely distributed species in which small, structural differences occur, suggesting morphological variation within the species or that closely related forms have been considered as one. Two types of fifth legs are seen on the females of this collection: "slender" and "thickened." The configurations illustrated are different enough to exclude flattening by the cover slip in the process of mounting the legs as an explanation. Accompanying the thickened feature of the legs is the presence of a spinelike process on the genital segment of the adult female (see Grice, 1962, p. 214, pl. 20, figs. 1–3). Individuals with slender fifth legs do not show this spine. Both types were found and are illustrated here. Examination of additional individuals may provide a basis for eventually separating these two types.

Metridia princeps Giesbrecht, 1889

FIGURE 76

OCCURRENCE.—Tow 16: 1 male (7.65 mm). Tow 24: 1 V male (5.70 mm). Tow 26: 1 female (7.42 mm).

REMARKS.—Davis (1949) described a new species, *Metridia bicornuta,* from the northeastern Pacific Ocean on the basis of a pair of lateral points projecting from the side of the head in dorsal view. Sars (1924–1925, pl. 53, fig. 3) did not describe this feature but his figure indicates the structure on a lateral view of *M. princeps.* Grice and Hulsemann (personal communication) consider *M. bicornuta* to be referable to *M. princeps.* The lateral points illustrated here are most prominently seen on the copepodite stage V male from Tow 24.

Bathypontia sarsi Grice and Hulsemann, 1965

FIGURES 77–90

Bathypontia minor Sars, 1907, p. 27.
Bathypontia sarsi Grice and Hulsemann, 1965, p. 249.

OCCURRENCE.—Tow 32: 1 male (3.08 mm).

REMARKS.—*Bathypontia minor* Sars, 1907, was renamed *B. sarsi* by Grice and Hulsemann (1965) when the name became a junior homonym to *Bathypontia minor* (Wolfenden, 1906), an entirely different species. Sars described and illustrated the female in 1924–1925 but included one figure of the male fifth legs. A description of the important features of the male is given below with additional figures.

Cephalosome and 1st pedigerous segment are separate as are the 4th and 5th segments. Posterolateral corner of cephalothorax angular. Rostrum a single. elongate lobe. Urosome 5-segmented.

First antenna extends to 2nd urosome segment. Exopod of 2nd antenna 7-segmented; exopod slightly shorter and 2-segmented. Gnathal lobe of mandible with hirsute seta. Second maxilla with 7 terminal spines flattened for distal third of their length. Maxilliped more slender than 2nd maxilla.

Endopod of 1st leg with 2 segments; legs 2–4 with 3-segmented endopods. Exopod of right 2nd leg with elongate, external spine on 2nd segment which exceeds length of distal segment. Third leg with external spine on 2nd basipodal segment, extending beyond proximal segment of endopod. Fifth legs uniramous.

The fifth legs on this male differ from Sars' figure in that this specimen has a thickened, internal seta on the second basipodal segment of the right leg, where Sars shows no seta.

This species is most readily distinguished from *B. minor* (Wolfenden, 1906) by the angular shape of the posterolateral corner of the cephalothorax.

Bathypontia species

FIGURES 91–93

OCCURRENCE.—Tow 6: 1 female (2.81 mm).

DIAGNOSIS (female).—Cephalosome and 1st pedigerous segment separate, 4th and 5th pedigerous segments separate. Posterolateral corner of cephalothorax a well-defined, rounded extension overlapping 1st third of genital segment. Rostrum a single, elongate lobe. Urosome 4-segmented.

First antenna with 24 free segments extending to genital segment. Gnathal lobe of mandible with hirsute seta. Second maxilla with 7 terminal spines, flattened for distal half of their length. Maxilliped more slender than 2nd maxilla.

Endopod of 1st leg 2-segmented; pairs 2–4 with 3-segmented endopod. Fifth legs uniramous, symmetrical. Each ramus ending in 2 spines; internal spine dentate, exceeding terminal spine in length.

REMARKS.—While the general appearance, size, rostrum, mandible, and fifth legs are closely similar to *Bathypontia sarsi* Grice and Hulsemann, 1965, the protruded lateral corners of the fifth segment of the cephalothorax are not figured on any *Bathypontia* species for which the female has been described. Grice and Hulsemann (1967) described a new male, *B. regalis,* from the Indian Ocean, for which this may be the female; the gnathal lobe, however, is closer in appearance to that of *B. sarsi.*

The specimen is in poor condition, lacking the exopods of the second to fourth legs. It is therefore assigned to the genus *Bathypontia* Sars, 1905, until additional females are taken.

Temorites discoveryae Grice and Hulsemann, 1965

FIGURES 94–96

OCCURRENCE.—Tow 27: 1 copepodite (0.49 mm). Tow 31: 1 male (0.64 mm); 1 copepodite (0.41 mm). Tow 32: 2 females (0.56–0.64 mm).

REMARKS. The sex and juvenile stage of the copepodites taken in Tows 27 and 31 could not be determined. Fifth legs were not present, suggesting no further advancement than stage IV; total length measurements support this estimate.

The large female (0.64 mm) from Tow 32 differs from the original diagnosis of the species in that the distal segment of the fifth legs has two terminal spines in addition to one on the inner lateral margin near the midpoint of the segment. The second female (0.56 mm) conforms to the original description of Grice and Hulsemann. Both sets of fifth legs are figured here.

Foxtonia barbatula Hulsemann and Grice, 1963

FIGURE 97

OCCURRENCE.—Tow 19: 1 female (1.20 mm); 1 IV male (0.98 mm). Tow 25: 1 female (1.20 mm). Tow 27: 1 IV male (0.94 mm). Tow 31: 1 female (1.35 mm); 1 IV male (1.01 mm). Tow 32: 2 females (1.20–0.90 mm); 1 V female (1.12 mm).

REMARKS.—This unique species was first taken in the northeastern Atlantic in vertical tows below 2,000 m (Hulsemann and Grice, 1963). These authors (1967) also reported it from three deep samples in the Indian Ocean. Figured here is the small adult female from Tow 32 near Puerto Rico. The adult male has not yet been taken.

Zenkevitchiella tridentae, new species

FIGURES 98–109

OCCURRENCE.—Tow 27: 1 female (0.79 mm).

DIAGNOSIS (female).—Prosome ovoid, cephalothorax separate from 1st pedigerous segment. Fourth and 5th pedigerous segments separate, with posterolateral corners of 5th segment broadly rounded. Urosome 4-segmented; genital segment with ventral, spinelike protrusions.

Rostrum with 2 long filaments, not visible in dorsal view. Anterior and posterior lips of mouth prominent and visible in lateral and ventral view. First antennae missing. Exopod of 2nd antenna with 1st segment inflated along outer margin and bearing a small point distally; remaining segments (presumably 4) broken off. Endopod 2-segmented with 12 setae on 2nd segment. Mandibular palp with 2 setae on basal segment. Exopod 4-segmented with 3 terminal setae and 1 seta each on 3 preceding segments. Endopod 2-segmented, the 1st bearing 3 setae, the 2nd with 9 setae. Mandible blade with 1 sharp tooth, 2 bidentate teeth; lateral margin of blade with row of small spines terminating in 2 longer spines. First maxilla with 7 spines on 1st inner lobe; 2nd inner lobe with 3 setae; 3rd inner lobe with 1 seta. Second basal segment with 1 seta; endopod absent; exopod with 5 long setae. Outer lobe without setae. Second maxilla with 1st 4 lobes bearing 4, 2, 2, and 3 setae of which one on 4th lobe is strong. Fifth lobe and terminal setae broken off. Maxilliped with large columnar 1st segment; remaining segments (probably 6) missing.

First 4 pairs of legs with 3-segmented exopods. Pair 1 with 2-segmented endopods; 1st segment with enlarged external margin and 1 internal seta. Second segment with row of fine hairs on external margin. Endopods of pairs 2–4 with only 1st segment remaining. Second basal segment of pair 3 with distolateral spinelike protrusion. Fifth legs biramous and symmetrical with 3-segmented exopod. First 2 segments of exopod with small spines on distal, external margin; terminal segment with 3 spines. Internal margin of 2nd segment with 1 large, thick seta. Fifth leg with endopod of 1 segment ending in 2 short spines. Holotype: USNM 122649.

REMARKS.—Although certain segments of the second antennae, second maxillae, maxillipeds, and second through fourth legs are missing from this specimen, it can be placed in the genus *Zenkevitchiella* Brodsky.

This female is readily distinguished from *Z. abyssalis* Brodsky, 1955, by its small size (0.79 mm vs. 2.37 mm), by the presence of a small spine on the second basal segment of the third leg, and by the large, thick setae on the second segment of the exopod of the fifth leg. The spinelike structures on the ventral side of the genital segment figured here do not exist on *Z. atlantica* Grice and Hulsemann, 1965. In addition, *Z. atlantica* has only two segments in the exopod of the fifth leg, and the one-segmented endopods are bulbous without terminal spines.

The remaining species in the genus, *Z. crassa* Grice and Hulsemann, 1967, was established for one male from the Indian Ocean, and the female has yet to be described; a comparison of second antennae, feeding appendages, and first legs, however, shows fundamental differences between this species and *Z. crassa:*

	Z. tridentae	*Z. crassa*
(1) 2nd antenna:	1st segment of exopod short with lateral spine.	1st segment of exopod long with no spine.
(2) mandible:	blade with row of short spines on lateral margin.	blade with several fine setae on lateral margin.
(3) 1st maxilla:	2nd inner lobe with 3 setae; 3rd inner lobe with 1 seta; outer lobe with no setae.	2nd inner lobe with 1 seta; 3rd inner lobe with 2 setae; outer lobe with 3 setae.
(4) 1st leg:	endopod with two segments.	endopod with one segment.
(5) mouthparts:	prominent.	not prominent.

The evidence above does not permit the identification of the present female as *Z. crassa.* It is therefore named *Zenkevitchiella tridentae,* while it is realized that a final description requires the examination of additional specimens. The species is named for the R.V. *Trident,* of the Graduate School of Oceanography, University of Rhode Island, on which the copepod was taken.

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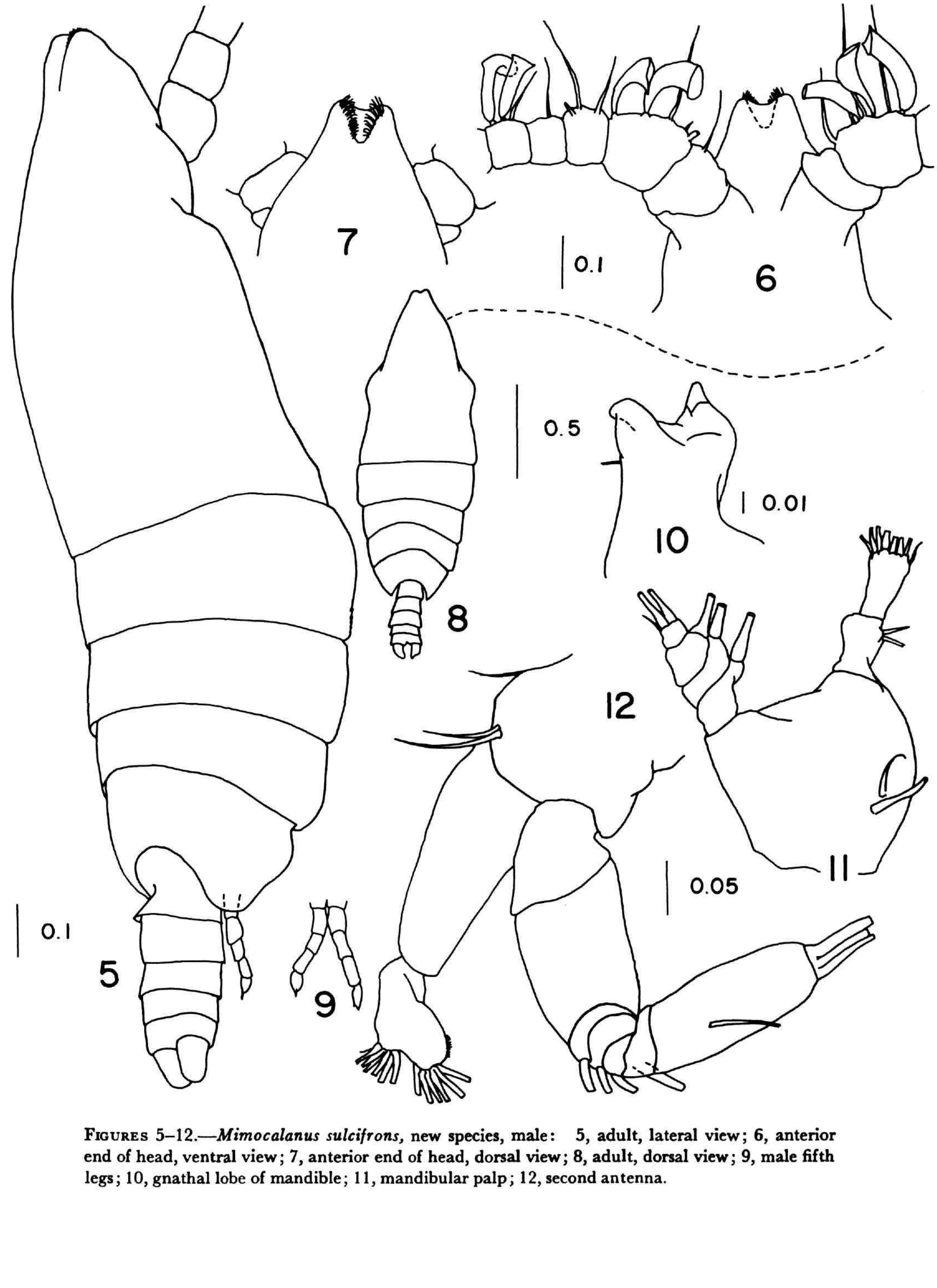
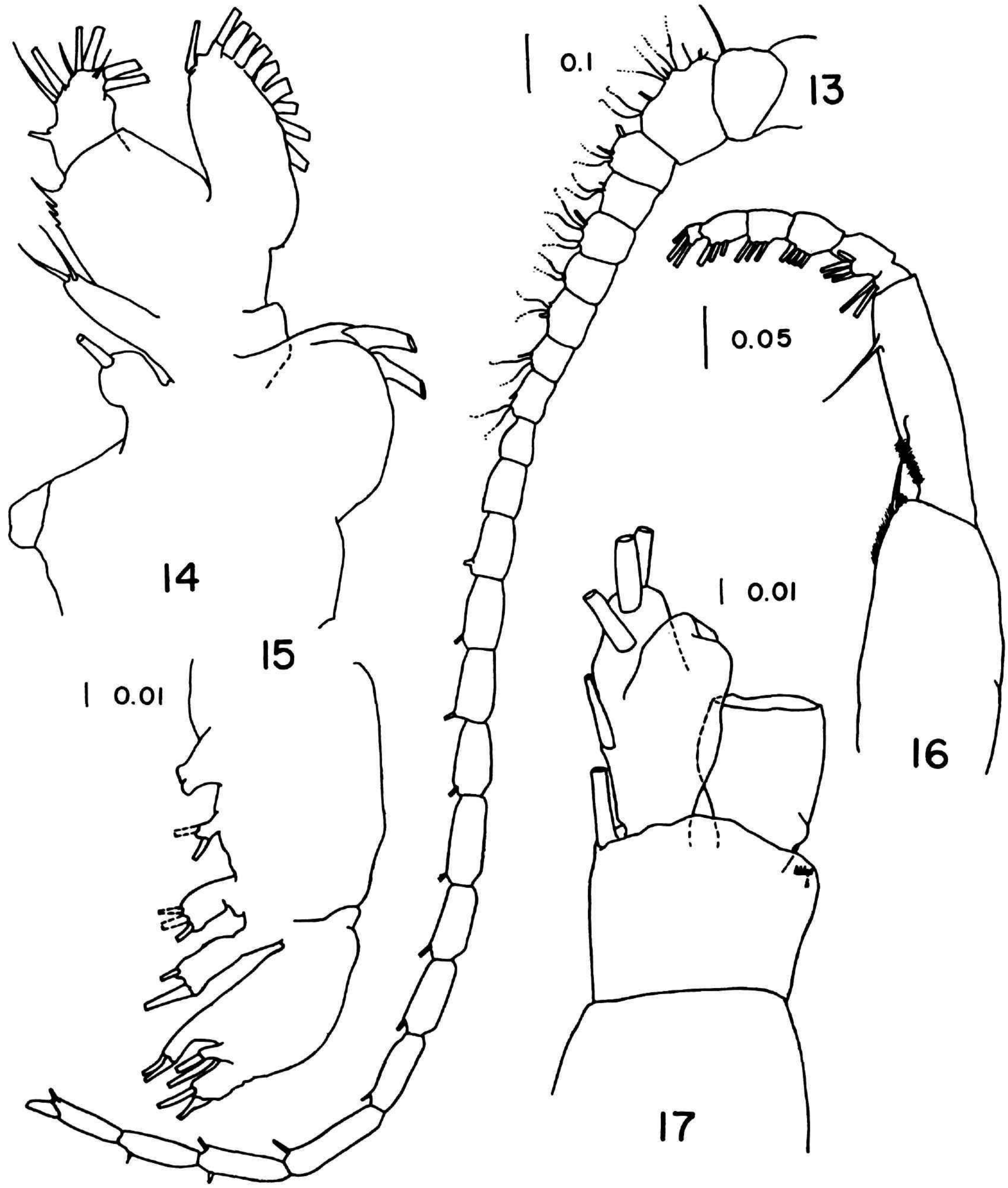
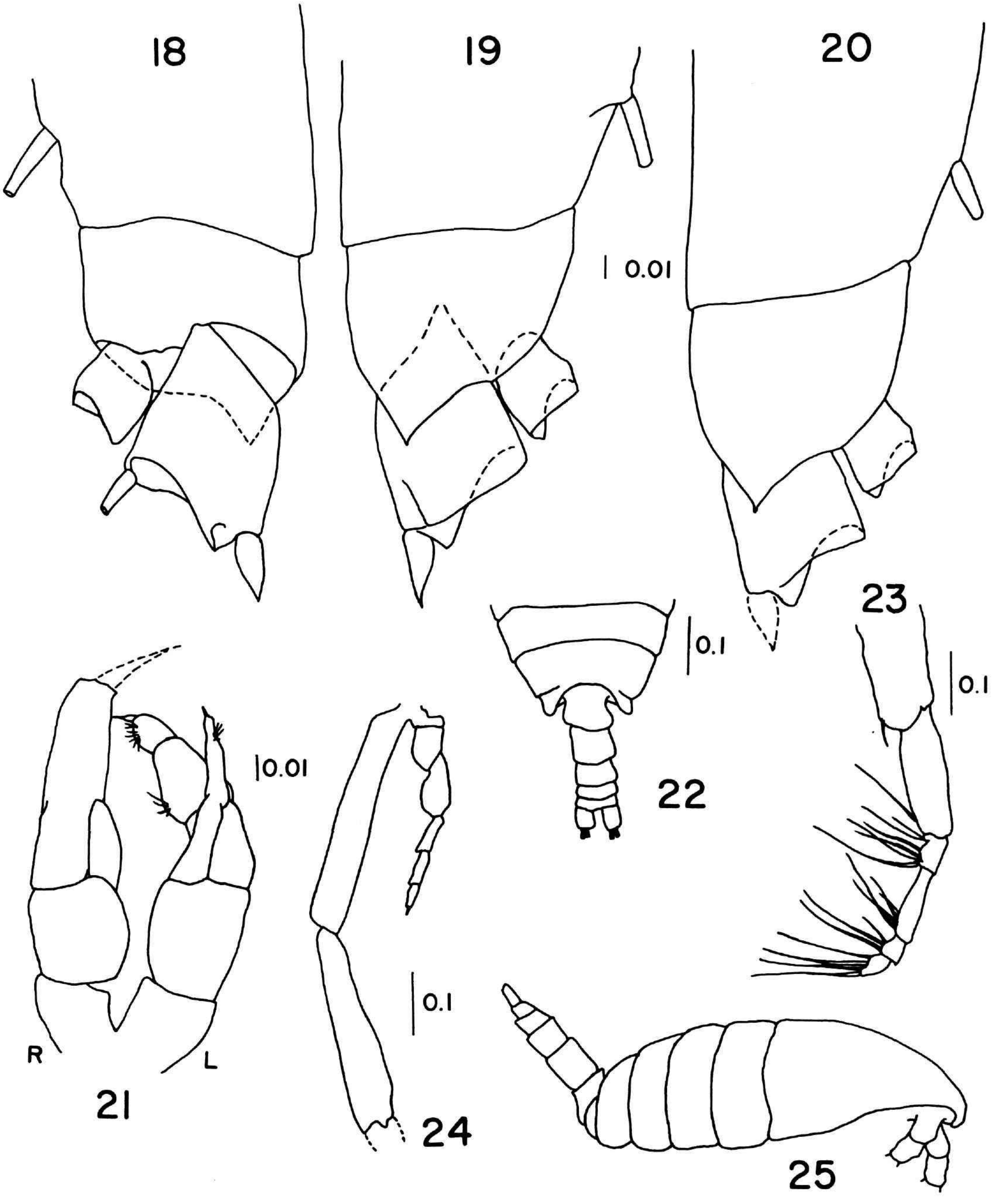


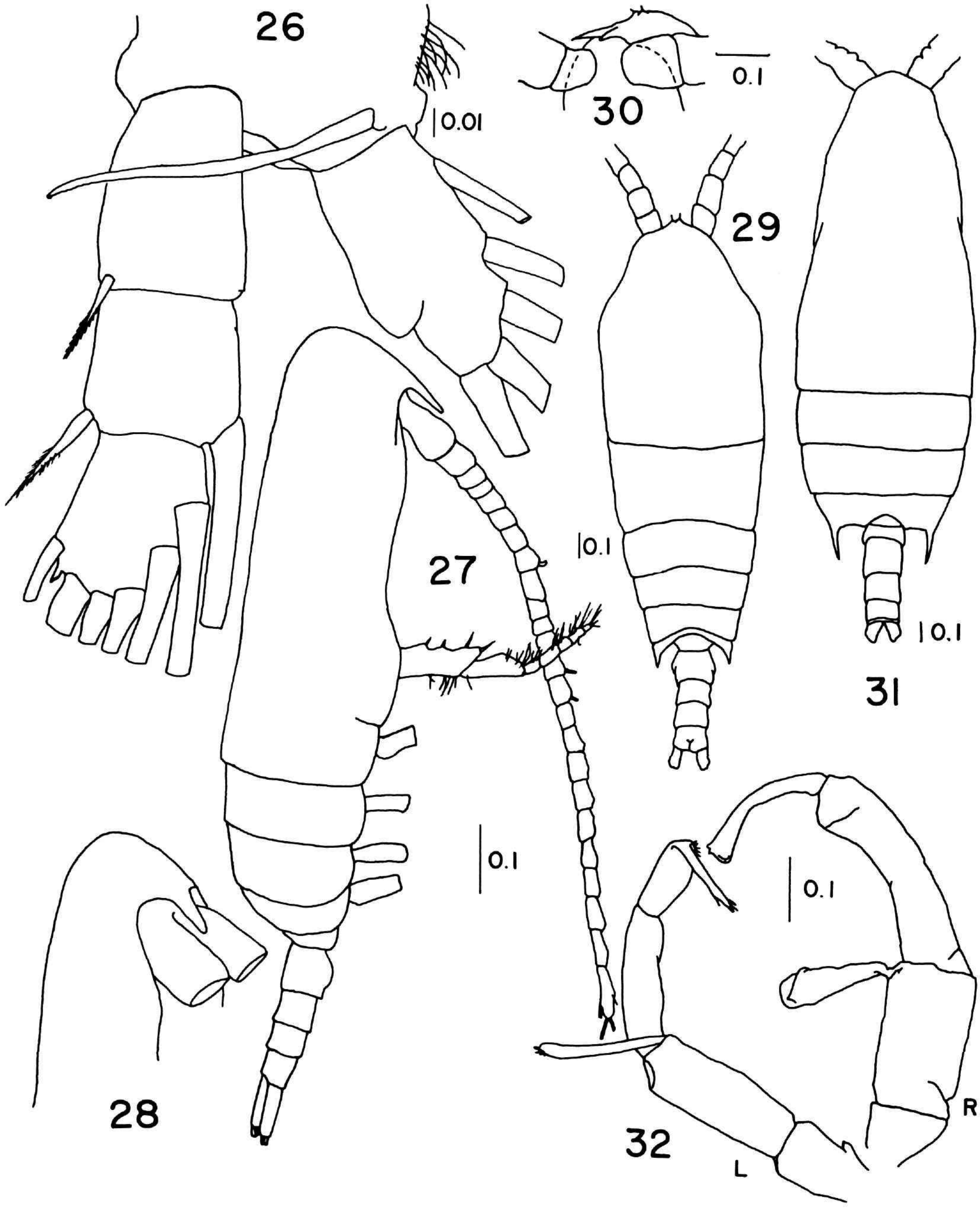
FIGURES 5–12.—*Mimocalanus sulcifrons,* new species, male: 5, adult, lateral view; 6, anterior end of head, ventral view; 7, anterior end of head, dorsal view; 8, adult, dorsal view; 9, male fifth legs; 10, gnathal lobe of mandible; 11, mandibular palp; 12, second antenna.



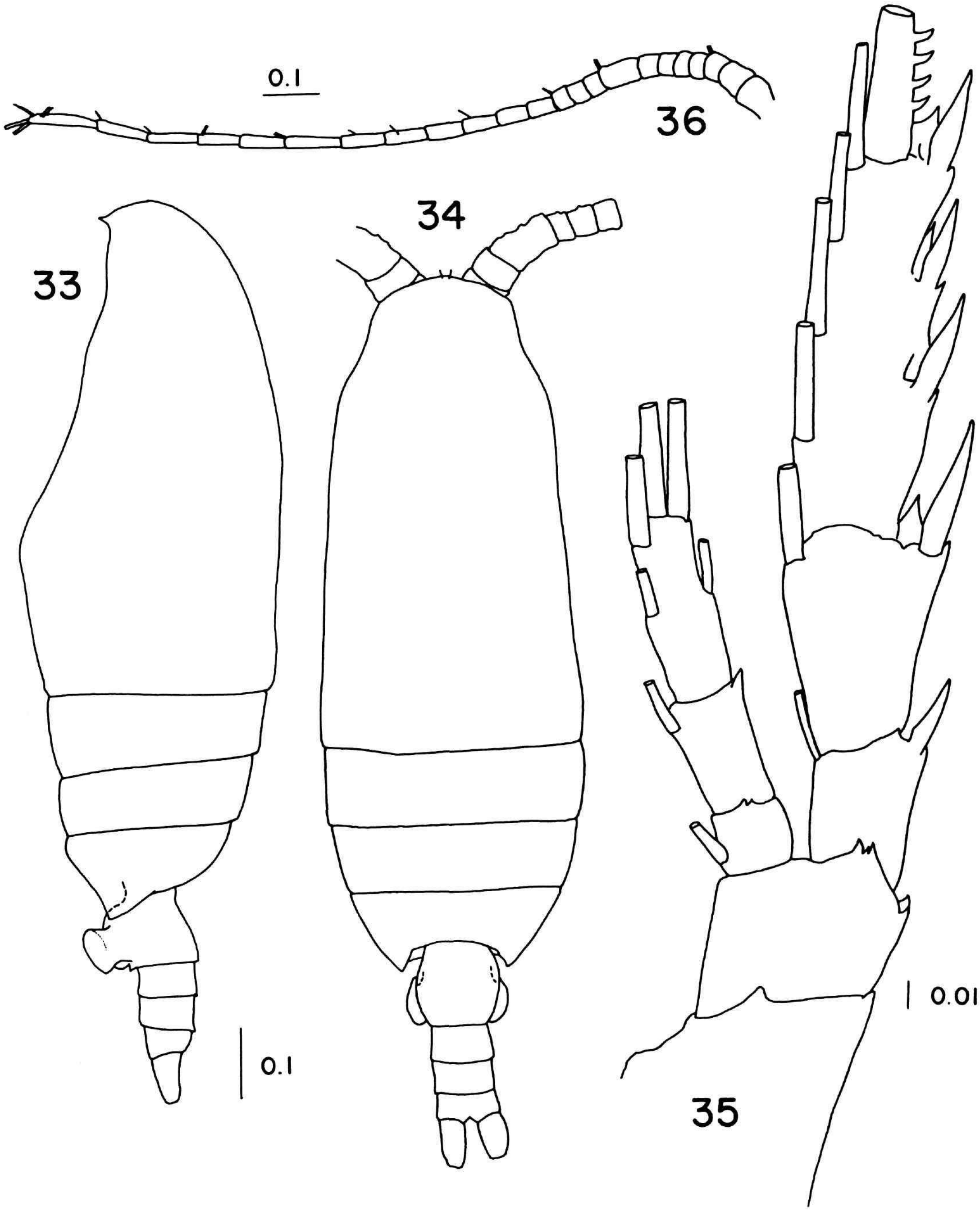
FIGURES 13–17.—*Mimocalanus sulcifrons,* new species, male: 13, first antenna; 14, first maxilla; 15, second maxilla; 16, maxilliped; 17, first leg, last 2 exopod segments missing.



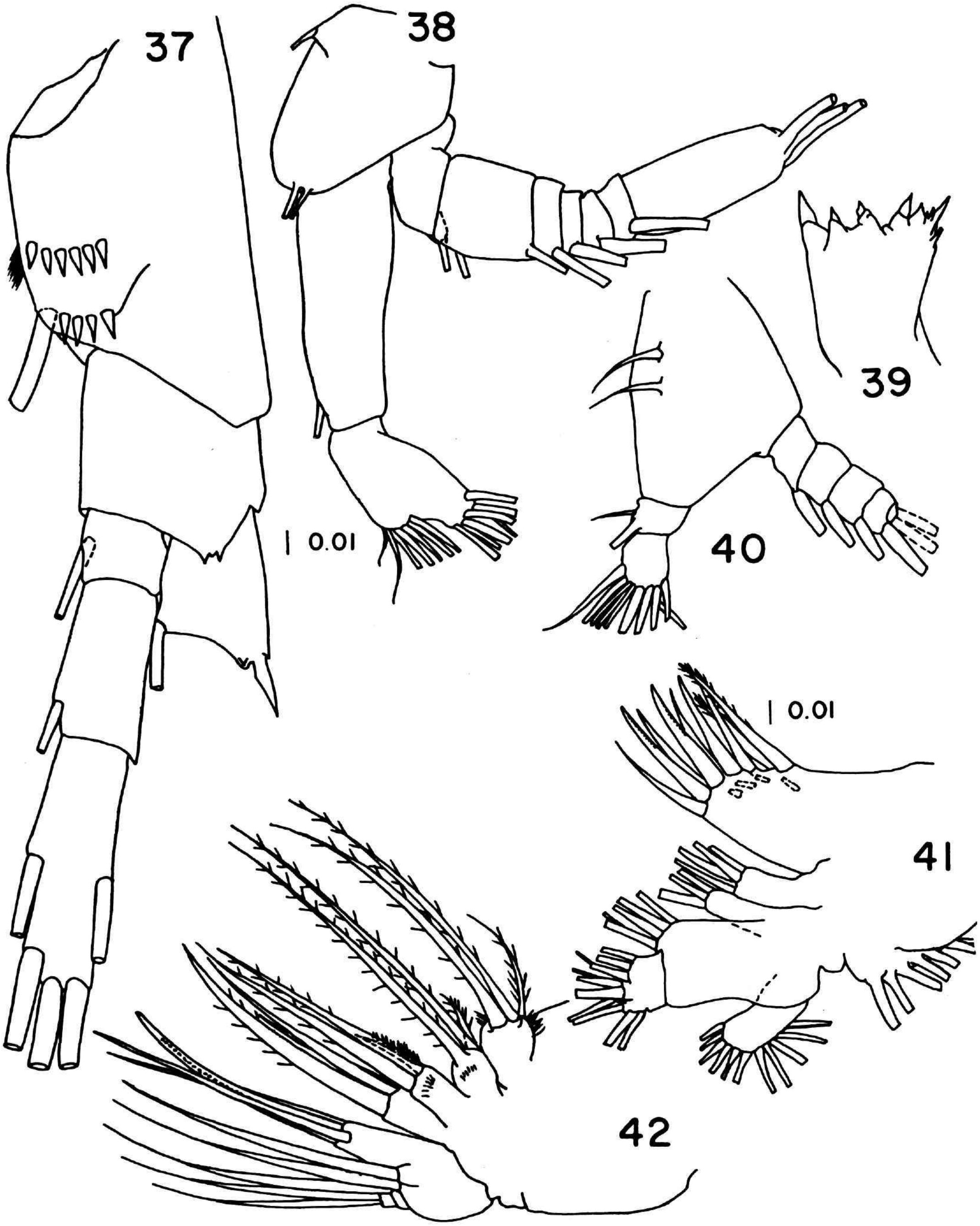
FIGURES 18–25.—*Mimocalanus sulcifrons*, new species, male: 18, second leg, rest of endopod and exopod missing; 19, third leg, rest of endopod and exopod missing; 20, fourth leg, rest of endopod and exopod missing. *Monacilla typica*, male: 21, fifth legs, terminal spine on right exopod missing; 22, posterior half of prosome, urosome, dorsal view. *Spinocalanus* species, male: 23, maxilliped; 24, fifth legs, terminal segments of right fifth leg missing; 25, adult male, lateral view.



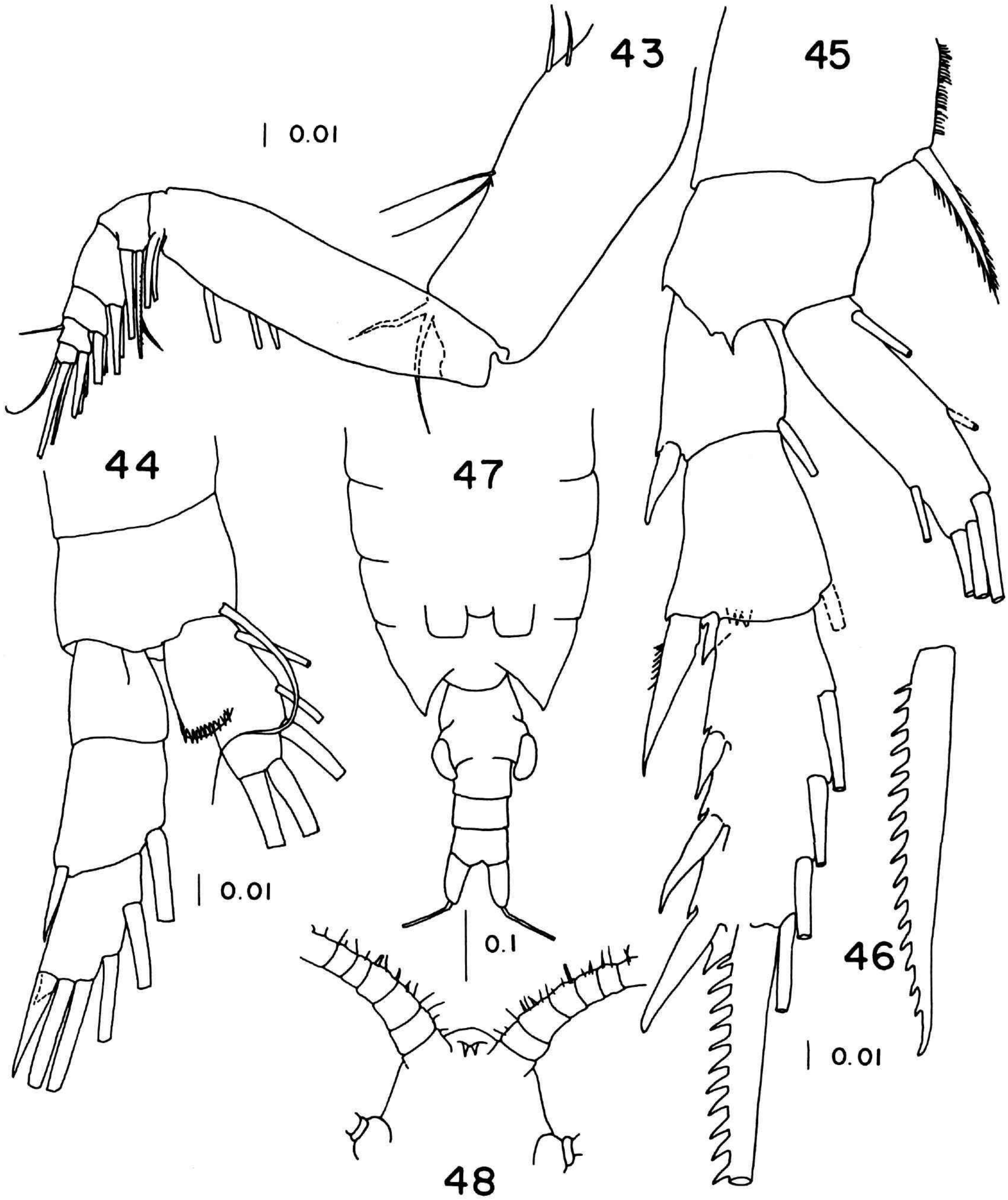
FIGURES 26–32.—*Spinocalanus* species, male: 26, first leg. *Teneriforma naso,* female: 27, adult, lateral view; 28, anterior portion of head. *Aetideopsis retusa,* female: 29 adult, dorsal view; 30, anterior portion of head, ventral view. *Gaidius tenuispinus,* male: 31, adult, dorsal view; 32, fifth legs.



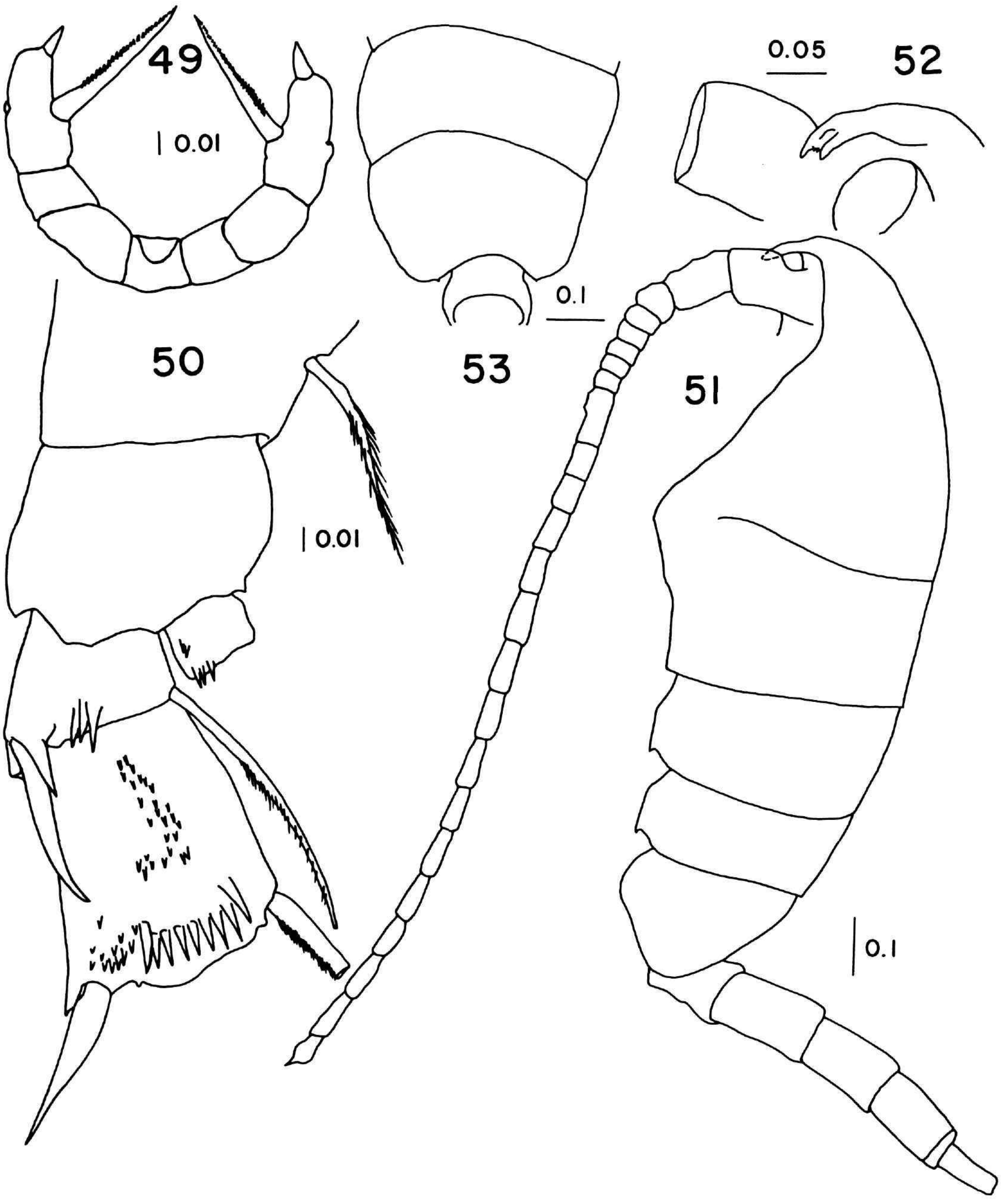
FIGURES 33–36.—*Paivella naporai*, new species, female: 33, adult, lateral view; 34, adult, dorsal view; 35, third leg; 36, first antenna.



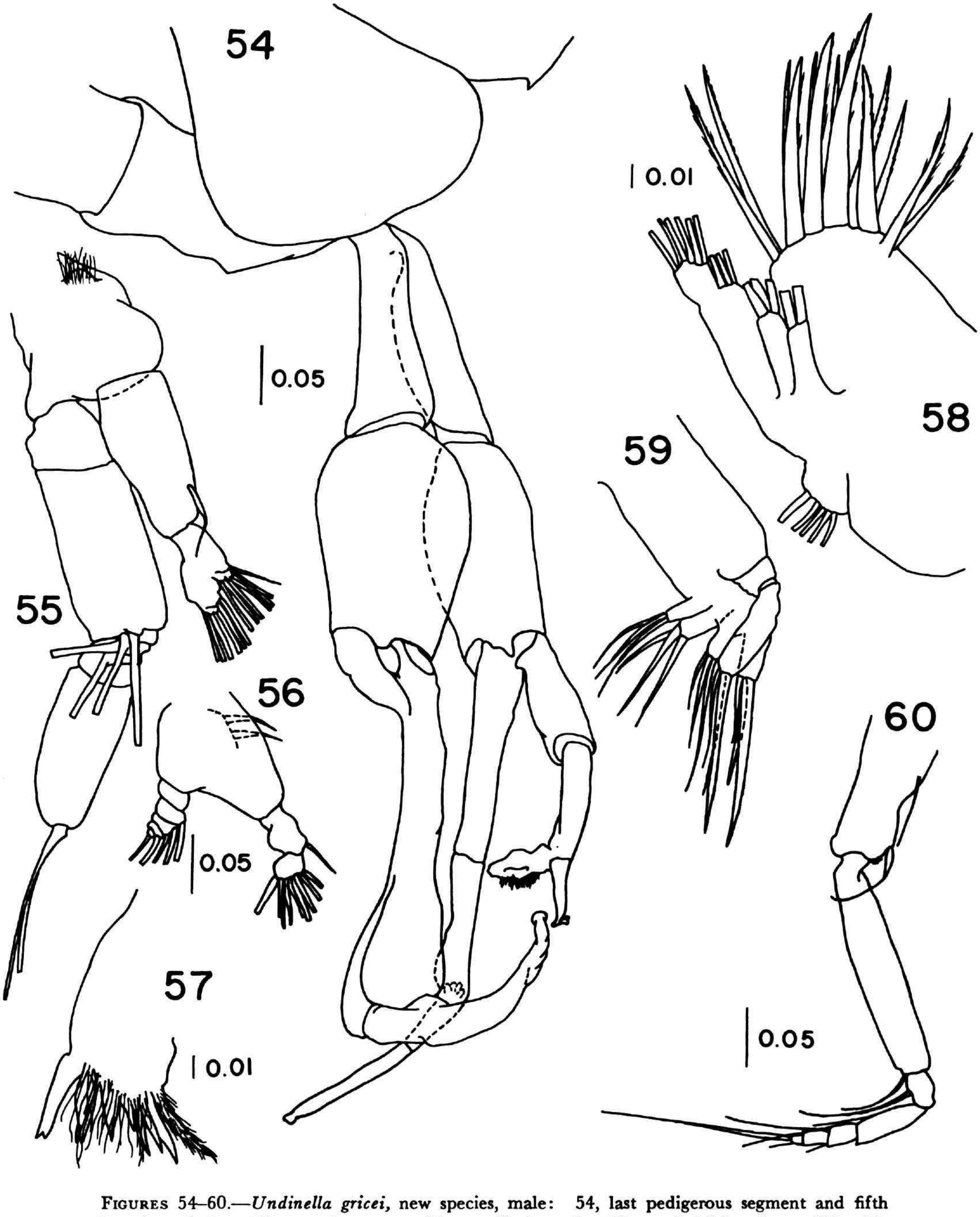
FIGURES 37–42.—*Paivella naporai*, new species, female: 37, fourth leg, last 2 segments of exopod omitted; 38, second antenna; 39, gnathal lobe of mandible; 40, mandibular palp; 41, first maxilla; 42, second maxilla.



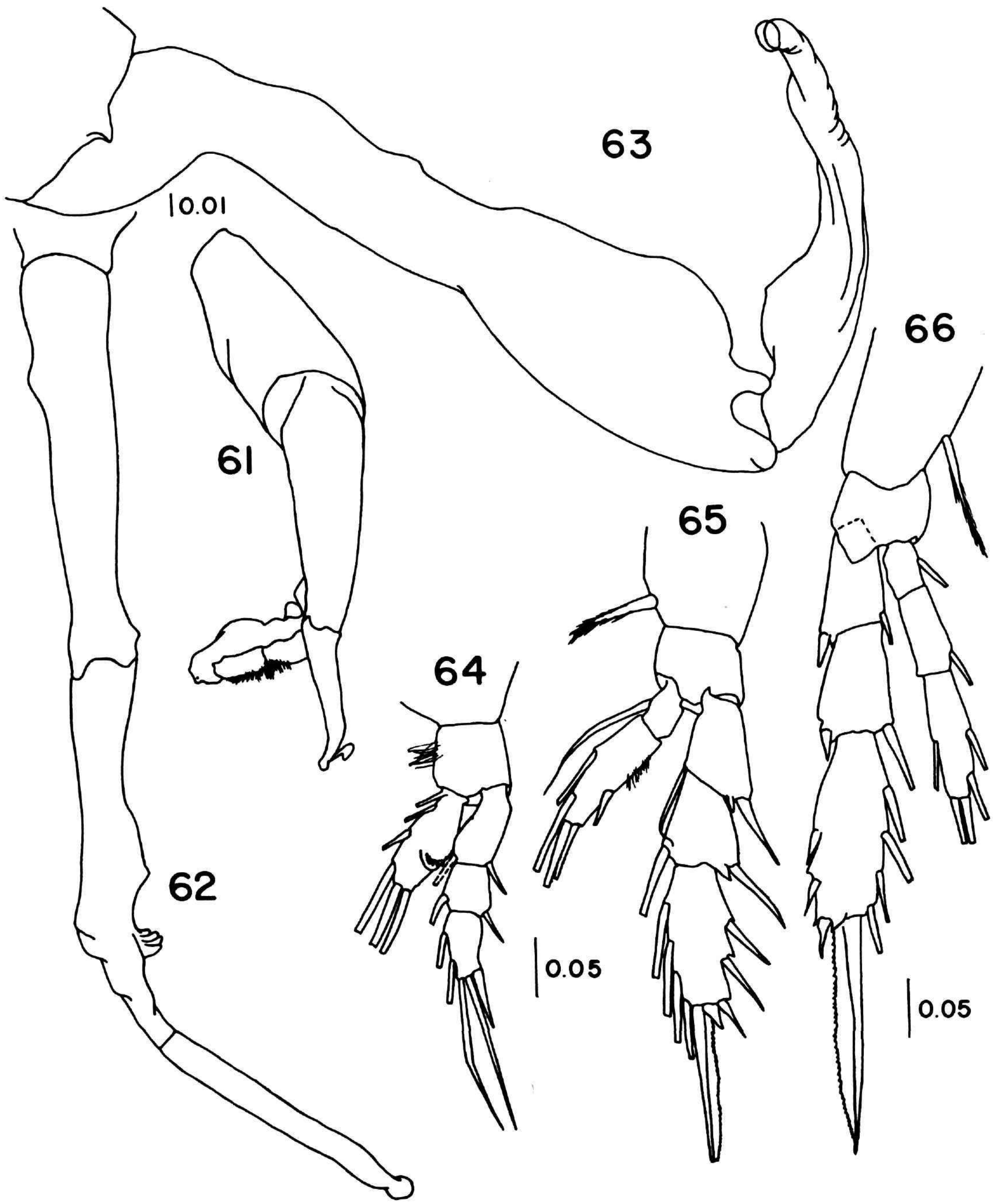
FIGURES 43–48.—*Paivella naporai*, new species, female: 43, maxilliped; 44, first leg; 45, second leg; 46, complete terminal spine, second leg; 47, posterior portion of prosome, urosome, ventral view; 48, anterior portion of head, ventral view.



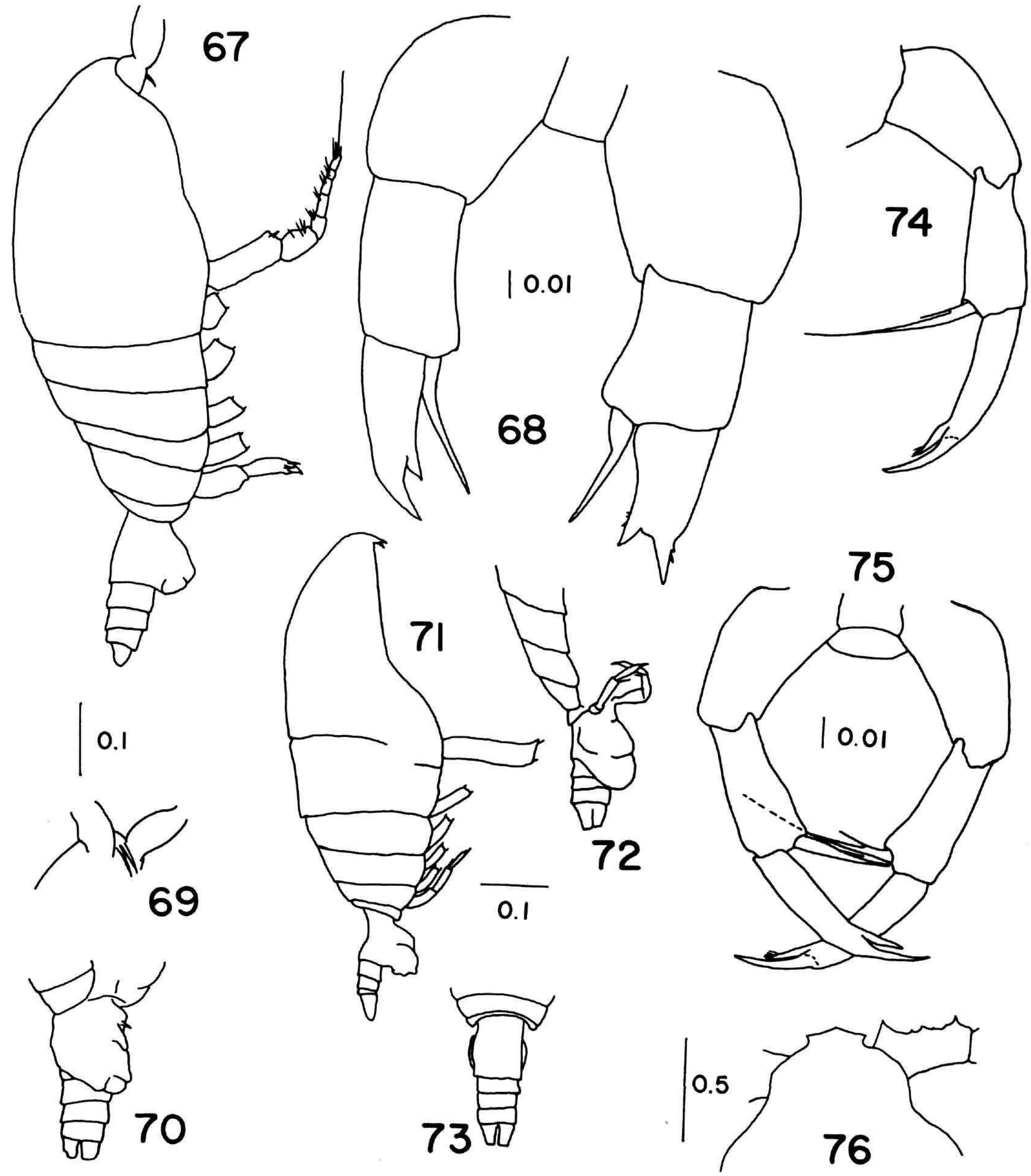
FIGURES 49–53.—*Scolecithricella timida,* female: 49, fifth legs; 50, second leg, segments 2, 3 of endopod and segment 3 of exopod missing. *Undinella gricei,* new species, male: 51, adult, lateral view; 52, rostrum; 53, posterior portion of cephalothorax, dorsal view.



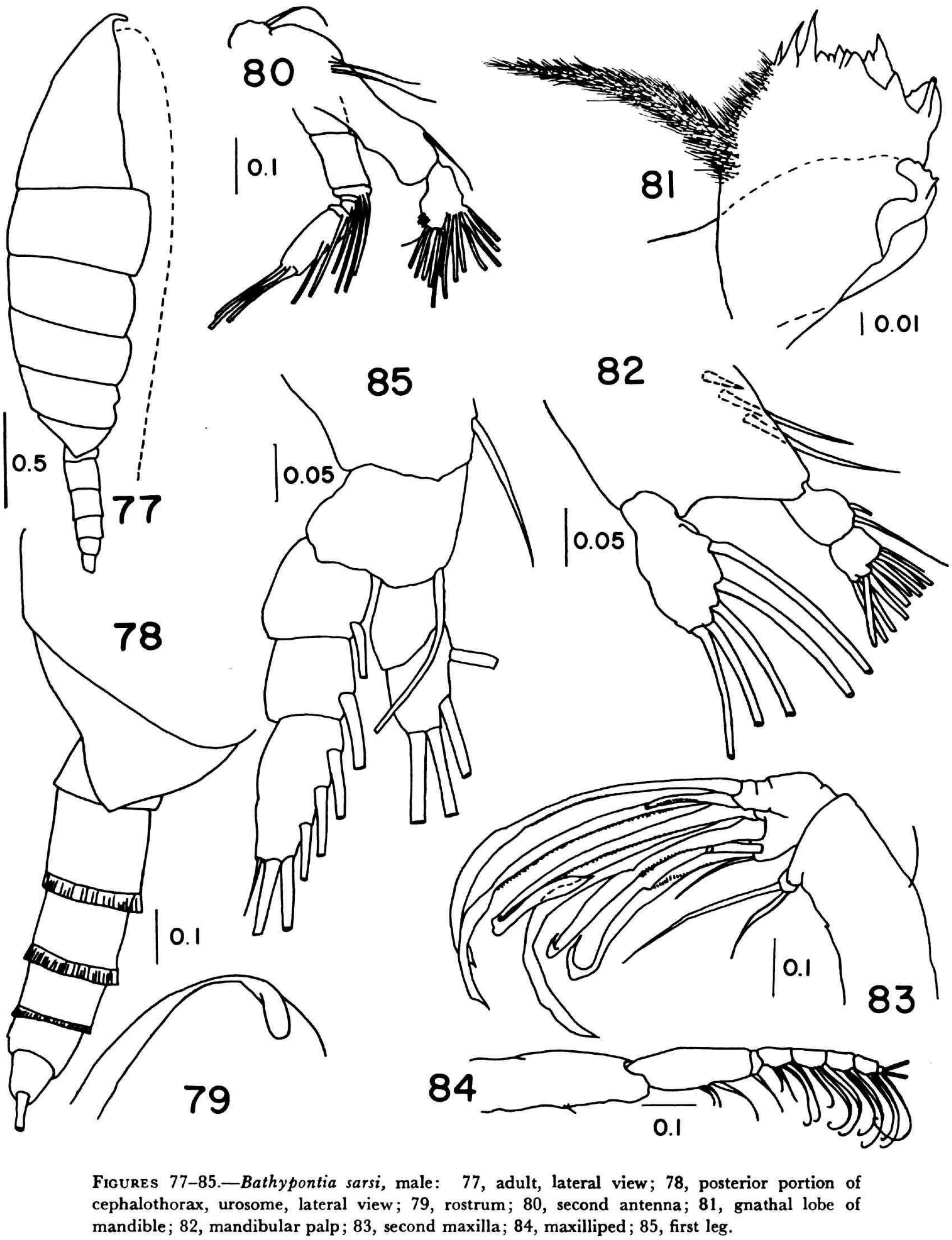
FIGURES 54–60.—*Undinella gricei,* new species, male: 54, last pedigerous segment and fifth legs, lateral view; 55, second antenna; 56, mandibular palp; 57, gnathal lobe of mandible; 58, first maxilla; 59, second maxilla; 60, maxilliped.



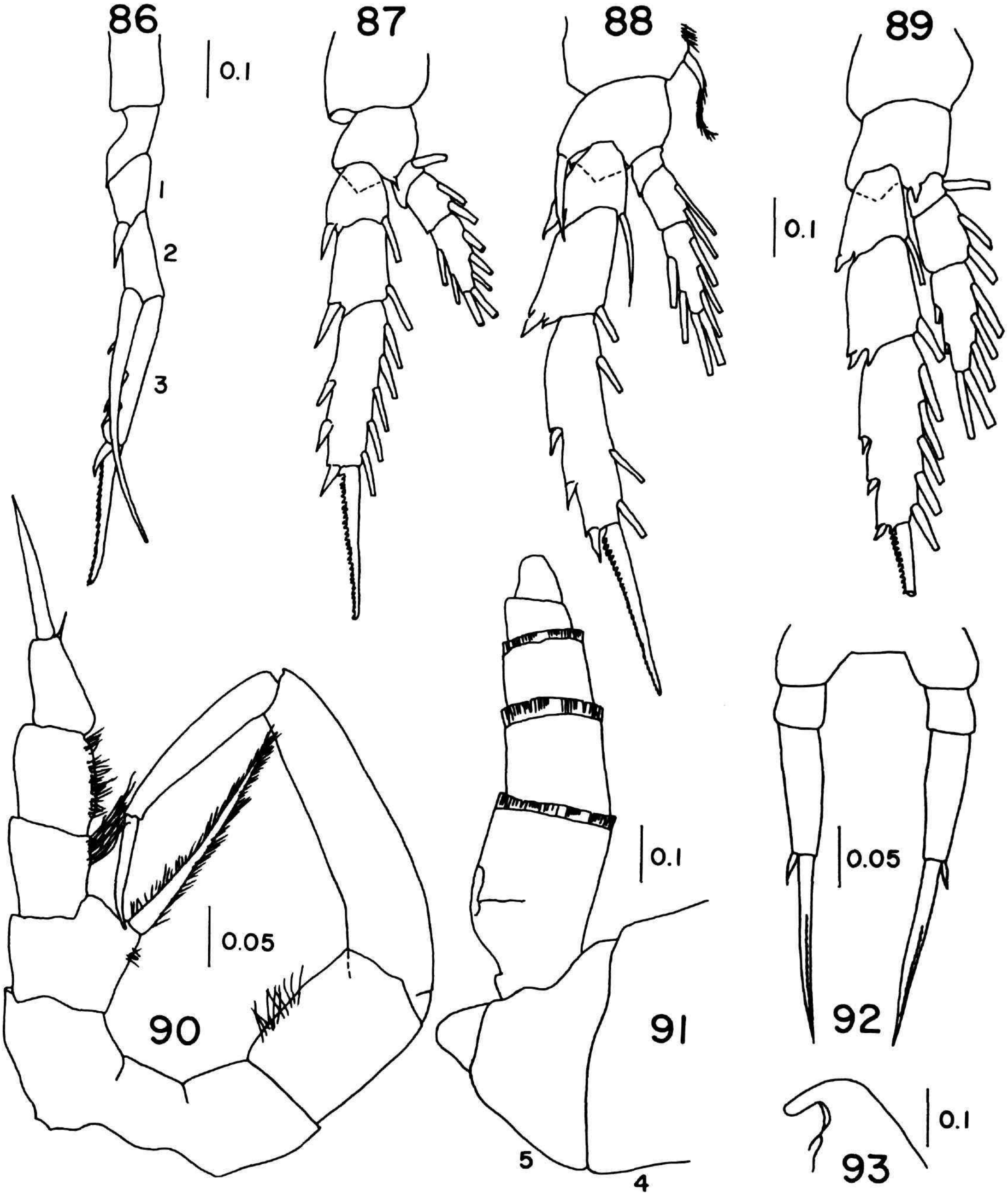
FIGURES 61–66.—*Undinella gricei,* new species, male: 61, exopod of left fifth leg; 62, endopod of left fifth leg; 63, right fifth leg; 64, first leg; 65, second leg; 66, fourth leg.



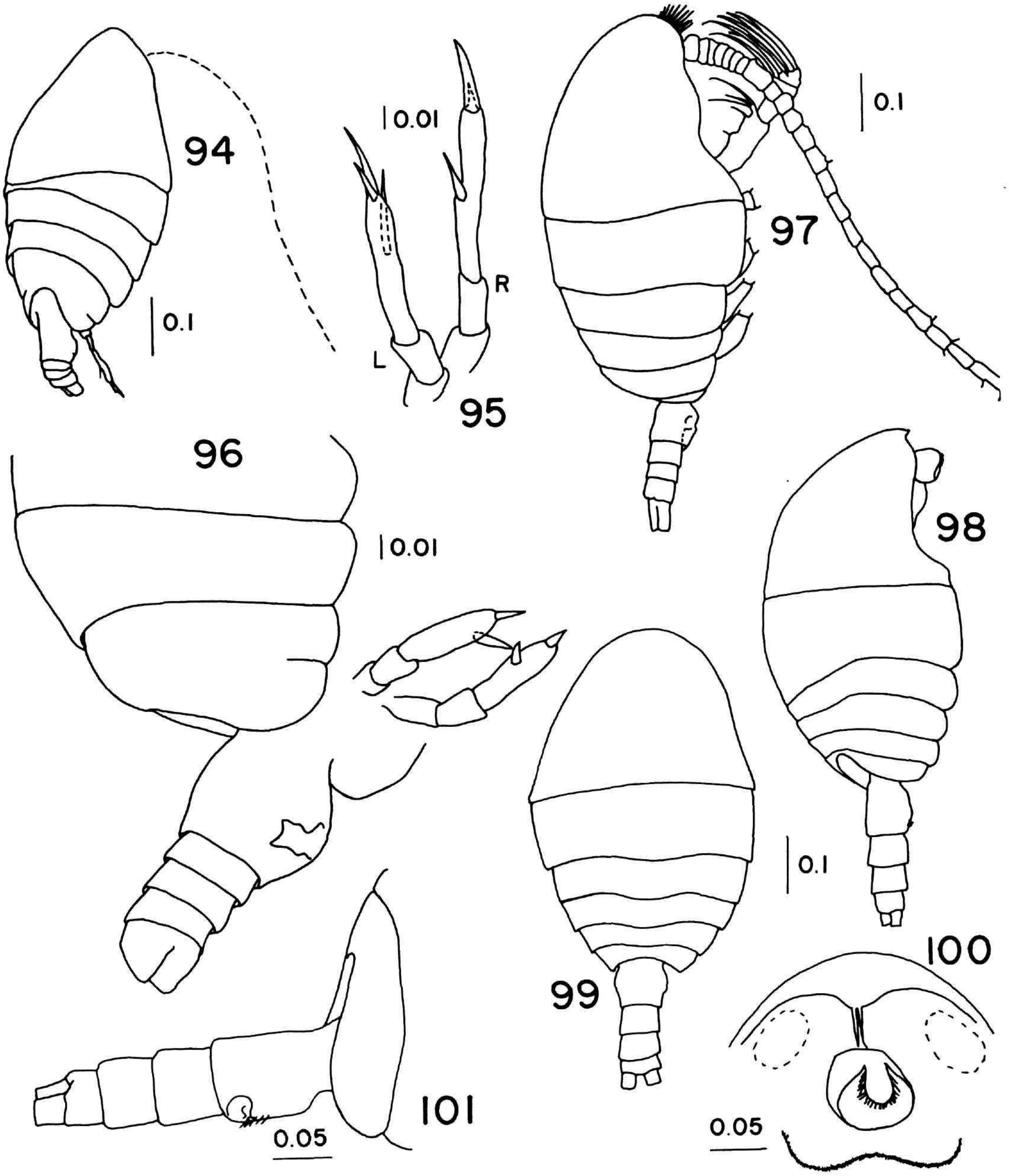
FIGURES 67–76.—*Temoropia mayumbaensis,* female with "thickened" fifth legs: 67, adult, lateral view; 68, fifth legs, "thickened" type; 69, rostrum; 70, urosome, three-quarter ventral view. *Temoropia mayumbaensis,* female with "slender" fifth legs: 71, adult, lateral view; 72, urosome and fifth legs; 73, urosome, dorsal view; 74, right fifth leg; 75, fifth legs. *Metridia princeps,* juvenile: 76, anterior portion of head, dorsal view.



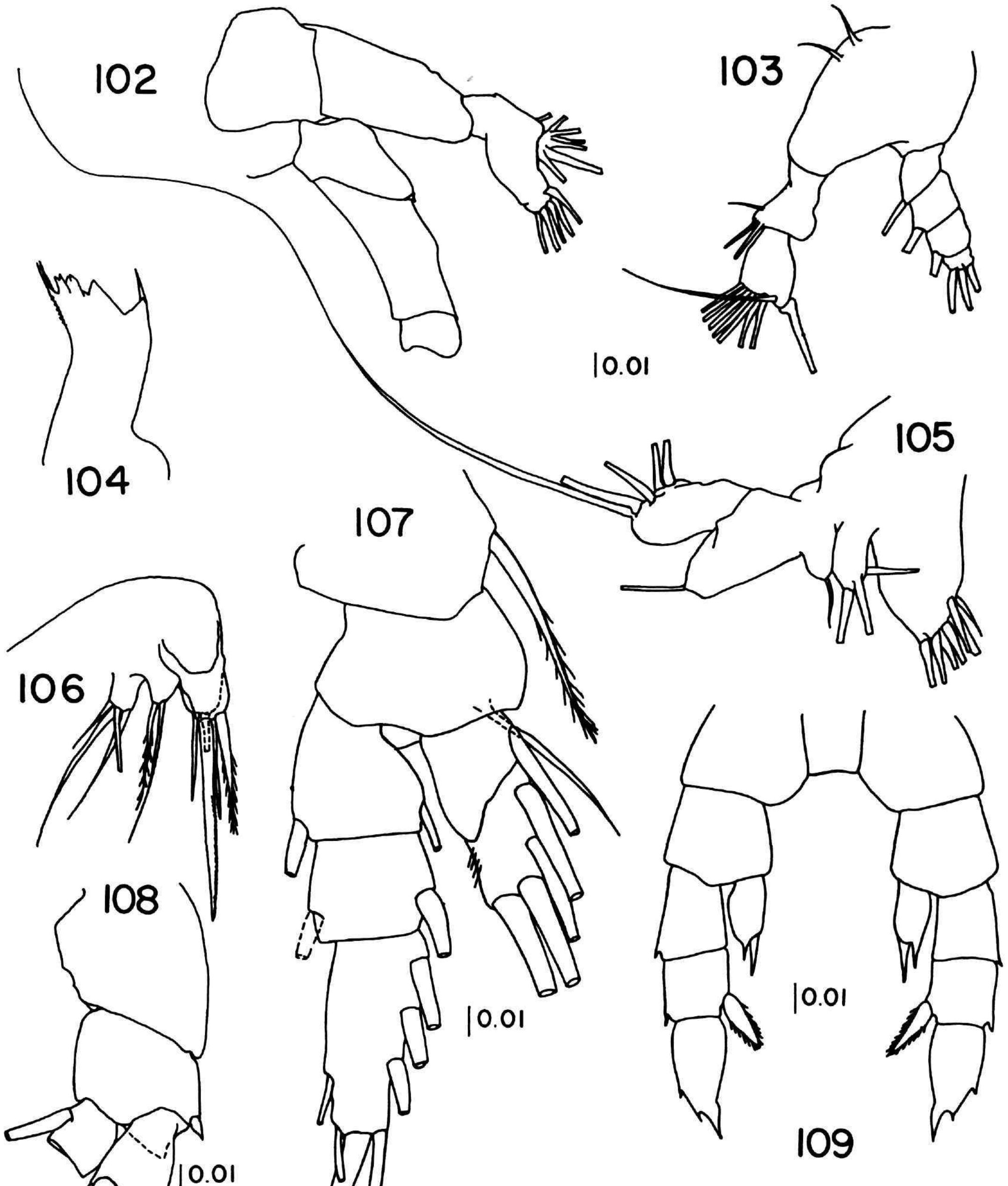
FIGURES 77–85.—*Bathypontia sarsi,* male: 77, adult, lateral view; 78, posterior portion of cephalothorax, urosome, lateral view; 79, rostrum; 80, second antenna; 81, gnathal lobe of mandible; 82, mandibular palp; 83, second maxilla; 84, maxilliped; 85, first leg.



FIGURES 86–93.—*Bathypontia sarsi,* male: 86, right second leg, lateral view; 87, left second leg; 88, third legs; 89, fourth legs; 90, fifth legs. *Bathypontia* species: 91, posterior portion of cephalothorax, urosome, lateral view; 92, fifth legs; 93, rostrum, lateral view.



FIGURES 94–101.—*Temorites discoveryae,* female (0.64 mm): 94, adult, three-quarter dorsal view; 95, fifth legs. *Temorites discoveryae,* female (0.56 mm): 96, posterior portion of cephalothorax, urosome, fifth legs. *Foxtonia barbatula,* female: 97, adult, lateral view. *Zenkevitchiella tridentae,* new species, female: 98, adult, lateral view; 99, adult, dorsal view; 100, anterior portion of head, ventral view; 101, fifth pedigerous segment, urosome, lateral view.



FIGURES 102–109.—*Zenkevitchiella tridentae,* new species, female: 102, second antenna, last 4 segments of exopod missing; 103, mandibular palp; 104, gnathal lobe of mandible; 105, first maxilla; 106, second maxilla, terminal segment missing; 107, first leg; 108, third leg, segments 2, 3 of endopod and exopod missing; 109, fifth legs.

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