MEIOBENTHIC HARPACTICOIDA (CRUSTACEA, COPEPODA) FROM THE DEEP SEA OFF NORTH CAROLINA I. THE GENERA *HEMIMESOCHRA* SARS, *PARANANNOPUS* LANG, AND *CYLINDRONANNOPUS* N. G.[1]

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COULL, B. C. 1973. Meiobenthic Harpacticoida (Crustacea, Copepoda) from the deep sea off North Carolina. I. The genera *Hemimesochra* Sars, *Paranannopus* Lang, and *Cylindronannopus* n. g. *Trans. Amer. Micros. Soc.*, 92: 185–198. This first paper on the deep-sea harpacticoids off North Carolina revises and gives keys to two known genera, *Hemimesochra* Sars and *Paranannopus* Lang. A new species is described in each genus. *H. trisetosa* n. sp. differs from all the previously known species by having three setae on the A_2 exopod and swimming leg setation. *P. atlanticus* n. sp. and *P. philistinus* Por are the only known *Paranannopus* to exhibit 3-segmented A_2 exopods and 1-segmented P_2–P_4 endopods. The two species differ in number of antennal segments and swimming leg setation. A new genus, *Cylindronannopus* n. g., distinct in its body form and lacking the usual sexually dimorphic characters is also described. Possible reasons for this unique dimorphism include a new evolutionary line within the Harpacticoida, intersexuality and morphologically similar females and sub-adult males as known with some amphipods. The low number of males known from the deep-sea literature is discussed and may be a function of misidentifying males as females.

This paper represents the first in a series on deep-sea harpacticoid copepods (>100 m) collected off the eastern United States. Except for my previous works (Coull, 1971, 1972), there are no data available on the deep water Harpacticoida off the United States east coast.[2]

Specific genera or families shall be dealt with in each paper. This will assist future investigators in their systematic search by allowing them to go directly to the taxon in question. Reviews of each taxon will be incorporated in each presentation, and except where publication lag misses new descriptions, the review will update and incorporate all the new forms described.

Sediment samples containing the forms described herewith and those to be discussed in subsequent papers were collected from the R/V EASTWARD of Duke University with a modified Higgins meiobenthic sled at the locations illustrated (Fig. 1).

A station list complete with date, location, depth, and EASTWARD station number is available, upon request, from the author.

Three genera, represented by three species are discussed here. The new species described here were the only ones found in these three genera. Representations of each have been deposited in the Division of Crustacea, United States National Museum (USNM).

The nomenclature, phylogeny, and descriptive terminology used throughout are adopted from Lang (1948, 1965). All figures have been prepared with the aid of a drawing tube. The abbreviations used throughout the paper are: A_1 = antennule, A_2 = antenna, Md. = mandible, Mxl. = maxillula, Mx. = maxilla, Mxp.

[1] I thank the Cooperative Program in Biological Oceanography of Duke University for ship time. Supported by NSF Grant GB-8189. Publication costs, in part, are being met by a grant from the Spencer-Tolles Fund of the American Microscopical Society.

[2] Note added in proof: the very recent work by R. Hamond on some Laophontidae off the coast of North Carolina appeared in the preceding number of this journal, too late for citation in the present paper.

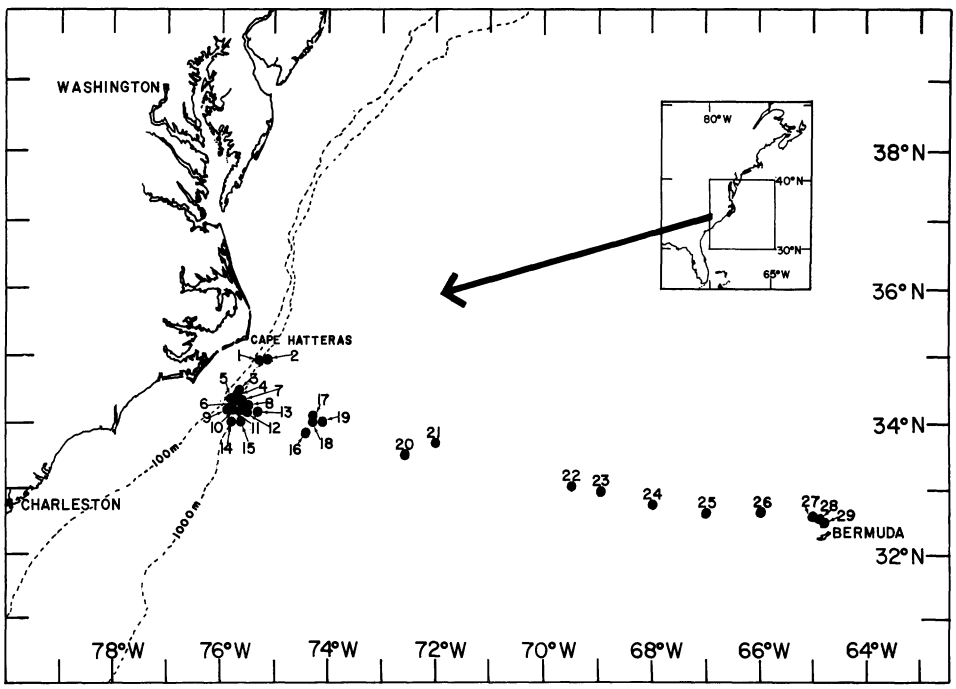


FIG. 1. Area of study with station locations.

= maxillipede, P_1–P_6 = leg 1–leg 6. Total animal measurements refer to the length of the copepod not including the rostrum, antennules, and caudal rami.

Descriptions of Species

Genus *Hemimesochra* Sars, 1920

Since Bodin's (1967) listing of the species in the genus this is the first to be added.

Hemimesochra trisetosa n. sp.

(Figs. 2–13)

Material: 8 ♀♀ (2 ♀♀ Sta. 13 this paper, 2 ♀♀ Sta. 15, 3 ♀♀ Sta. 18, 1 ♀ Sta. 21). Holotype 1 ♀, USNM No. 138437, paratype 2 ♀♀, USNM No. 138438.

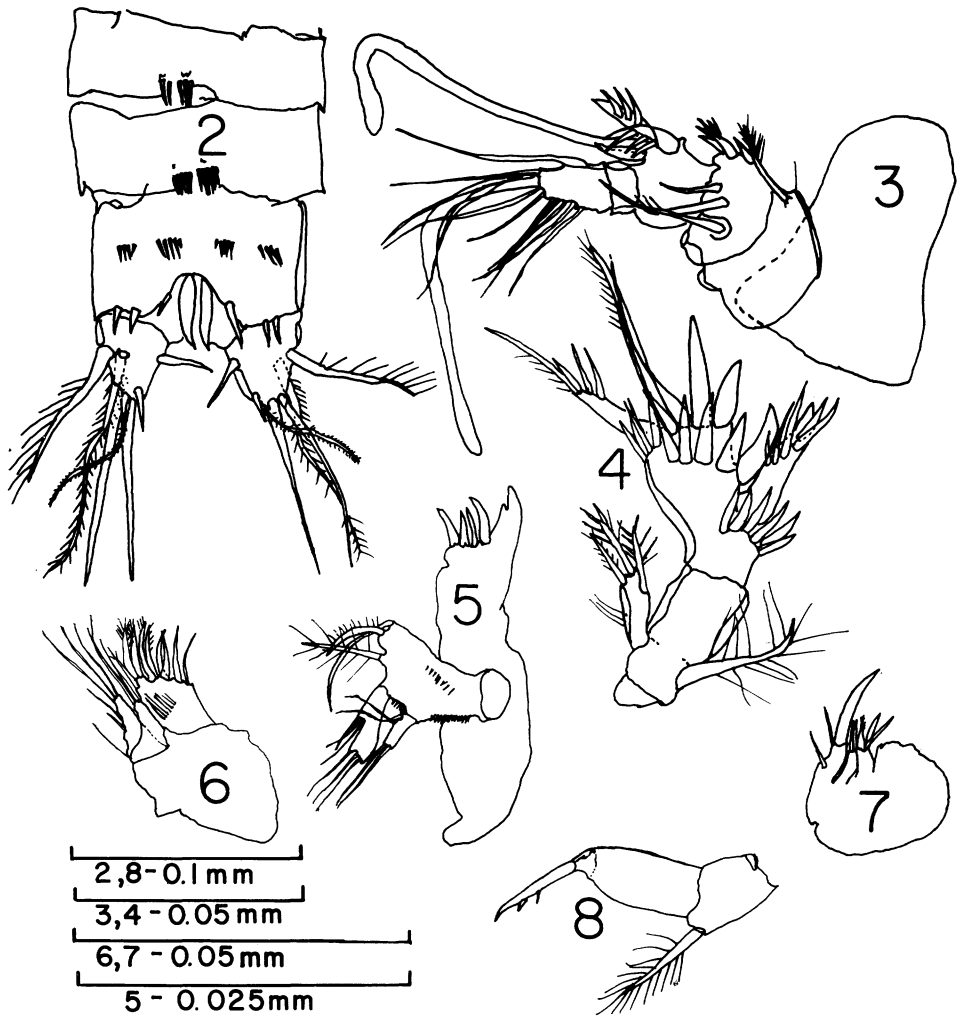
Type locality: EASTWARD Station 14432, 34° 05.0′ N, 74° 16.0′ W, depth 3,940 m.

Description

Female: Based on a non-ovigerous female, 0.49 mm. Body shape of typical generic form; broadened at the cephalothorax and tapering behind. Rostrum broadly rounded (Fig. 3). Abdominal somites and anal operculum ornamented as in Figure 2. Caudal rami (Fig. 2) as long as wide with one lateral, one dorsal, and two terminal setae. Inner margin with two spines; one at ⅓, the other at ⅘ the length.

A_1 (Fig. 3), 5-segmented, aesthetascs on third and fifth segments.

A_2 (Fig. 4), 2-segmented endopod with 1-segmented exopod. Exopod terminally with three setae. Endopod armed with strong spines.



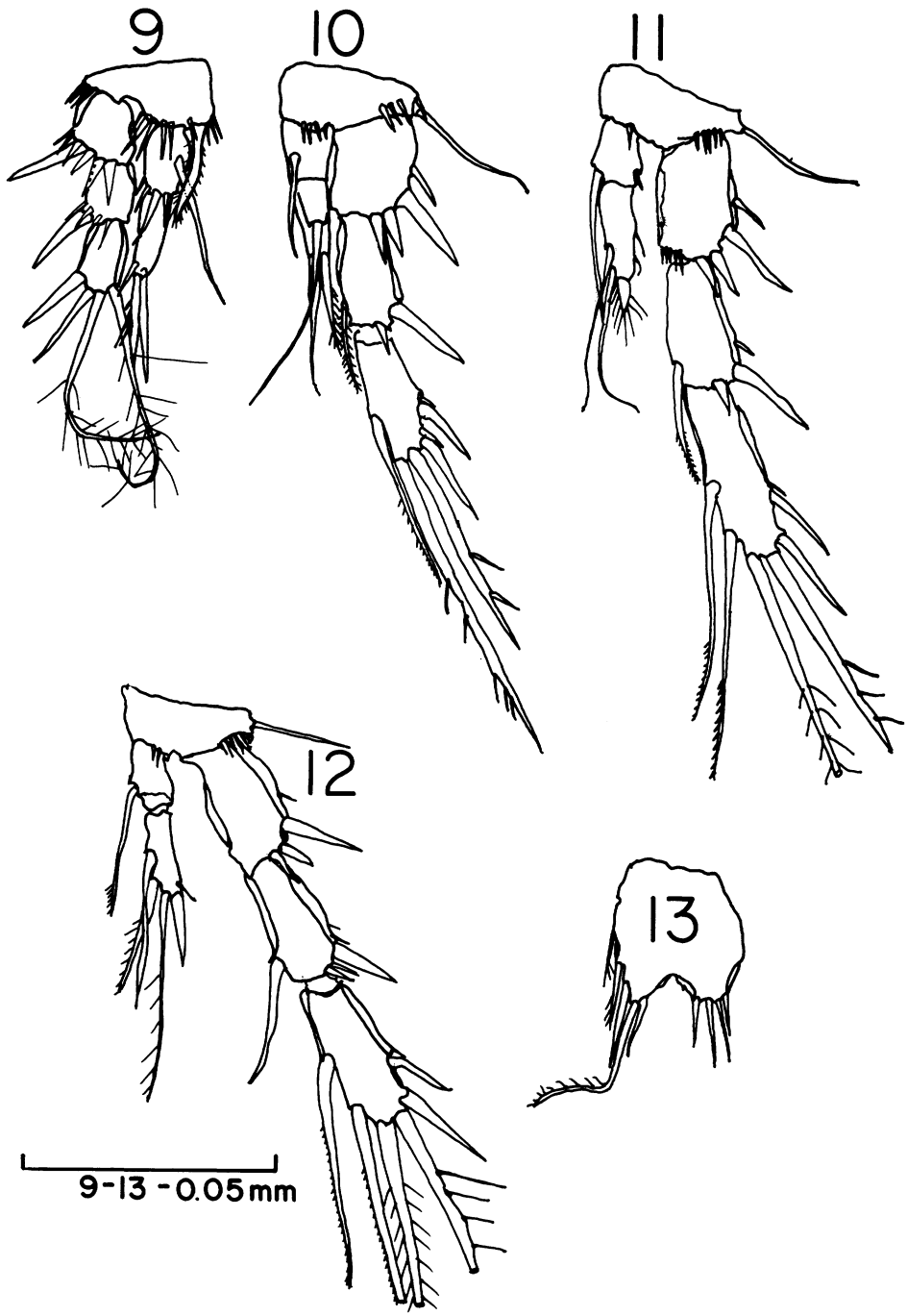
FIGS. 2–8. *Hemimesochra trisetosa* n. sp. ♀. Fig. 2. Last three abdominal somites and caudal rami. Fig. 3. Rostrum and A_1. Fig. 4. A_2. Fig. 5. Md. Fig. 6. Mxl. Fig. 7. Mx. Fig. 8. Mxp.

Md. (Fig. 5), praecoxa with bidentate pars incisiva and four dentate lacinia. Coxa-basis with three plumose setae. Endopod with three inner and three terminal setae. Exopod smaller than endopod with two inner and two terminal setae.

Mxl. (Fig. 6), arthrite of praecoxa with surface spinules and nine terminal setae. Coxa basis and endopod with three terminal setae, exopod reduced to two small setae.

Mx. (Fig. 7), syncoxa with two endites; proximal one with three setae, distal with two. Basis terminally with claw and two small setae. Exopod represented by a single seta.

Mxp. (Fig. 8), basis with strong plumose seta at inner distal corner. Endopod 1-segmented, devoid of ornamentation terminating in a strong claw.



FIGS. 9–13. *Hemimesochra trisetosa* n. sp. ♀. Fig. 9. P_1. Fig. 10. P_2. Fig. 11. P_3. Fig. 12. P_4. Fig. 13. P_5.

P_1(Fig. 9), P_2 (Fig. 10), P_3 (Fig. 11), P_4 (Fig. 12), all with 3-segmented exopods and 2-segmented endopods. Setation as figured and listed below:

Setal formulae for the species of *Hemimesochra*.

	P_2		P_3		P_4	
	Exp.	End.	Exp.	End.	Exp.	End.
H. trisetosa n. sp.	0.1.122	1.210	0.1.222	1.210	0.1.222	1.220
H. clavularis Sars	0.1.123	1.221	0.1.223	1.321	0.1.223	1.221
H. secunda Wells	0.1.123	1.121	0.1.223	1.121	0.1.223	1.121
H. nixe Por	0.1.122	1.221	0.1.222	1.221	0.1.222	1.121
H. nympha Por	0.1.122	1.221	0.1.222	1.221	0.1.222	1.221

P_5 (Fig. 13), baseoendopodite and exopodite fused into a single plate. Baseoendopodite with five setae, exopodite with four.

Male: Unknown.

Etymology: The trivial name *trisetosa* refers to the three setae on the exopod of A_2, and on the terminal segments of the P_2 and P_3 endopods.

Discussion

With the description of *H. trisetosa* there are now five species in the genus (see Lang, 1965, p. 423, for the generic designation). *H. trisetosa* differs from all the other known species in the presence of three setae on the A_2 exopod and setation of the terminal segments of the P_2 and P_3 endopods. *H. trisetosa* is most closely related to *H. nympha* Por (1964a) in antennule segmentation, swimming leg setation, and P_5 fusion. With the few known species, it is difficult to speculate on the generic phylogeny. Perhaps with continued collection of deep-sea specimens more *Hemimesochra* will be found and intra-generic relationships elucidated.

Key to the species of *Hemimesochra*: based on females:

1. A_1 5-segmented 2
   A_1 6-segmented ..... *H. secunda* Wells
2. Benp. and Exp. P_5 fused 3
   Benp. and Exp. P_5 not fused ..... *H. nixe* Por
3. Exp. A_2 with more than one seta 4
   Exp. A_2 with one seta ..... *H. clavularis* Sars[3]
4. Exp. A_2 with two setae; terminal seg. end. P_2–P_3 with five setae ..... *H. nympha* Por
   Exp. A_2 with three setae, terminal seg. end. P_2–P_3 with three setae ..... *H. trisetosa* n. sp.

Genus *Paranannopus* Lang, 1936

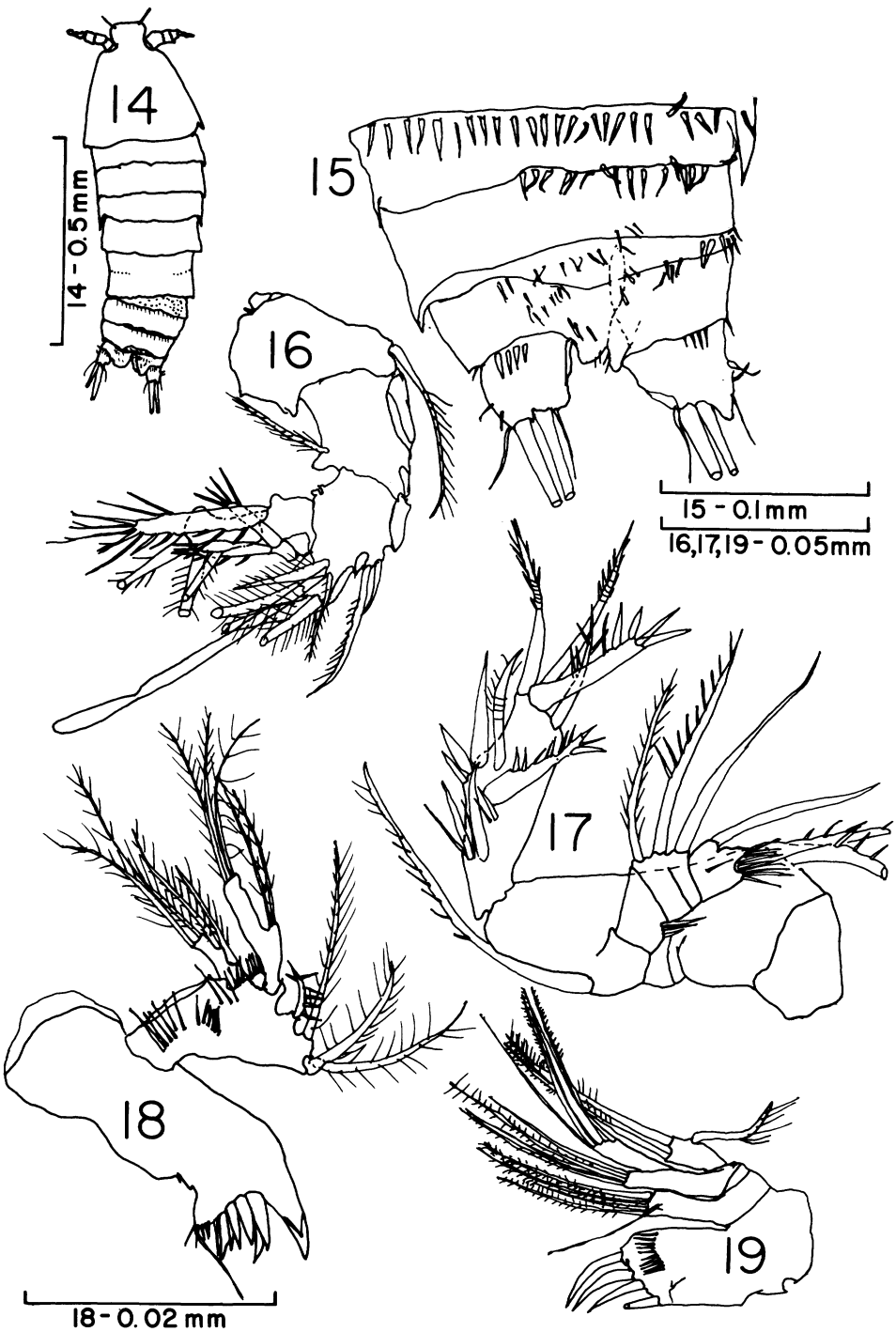
Since Por's (1964b) revision of the genus, the following species have been added: *P. echinipes* and *P. minutus* Smirnov, 1946, *P. caheti* Soyer, 1964, *P. triarticulatus* and *P. langi* Wells, 1965.

Paranannopus atlanticus n. sp.
(Figs. 14–26)

Material: 8 ♀♀ (3 ♀♀ Sta. 10 this paper, 3 ♀♀ Sta. 13, 1 ♀ Sta. 15, 1 ♀ Sta. 18). Holotype 1 ♀, USNM No. 138439, paratype 1 ♀, USNM No. 138440.

Type locality: Eastward Station 11823, 34° 09.0′ N, 75° 54.0′ W, depth 500 m.

[3] See Por (1964a, p. 254) for analysis of P_5 fusion in *H. clavularis*.



FIGS. 14–19. *Paranannopus atlanticus* n. sp. ♀. Fig. 14. Habitus. Fig. 15. Last three abdominal somites and caudal rami. Fig. 16. A_1. Fig. 17. A_2. Fig. 18. Md. Fig. 19. Mxl.

Description

Female: Based on a non-ovigerous female, length 0.76 mm. Body short, stout as normal for the genus (Fig. 14). Abdominal somites with rows of coarse spinules ventrally (Fig. 15). Rostrum large, broad, and plate-like with one seta on each side of a rounded apex (Fig. 14). Caudal rami slightly longer than wide with two principal terminal setae (Fig. 15).

A_1 (Fig. 16), 5-segmented and short. Many pennate setae. Aesthetasc on segment 3.

A_2 (Fig. 17), 2-segmented, with 3-segmented exopod bearing six setae. Terminal endopod segment with six setae, four of which are heavily spined.

Md. (Fig. 18), praecoxa with bidentate pars incisiva, six dentate lacinia, and several small setae and spines. Coxa-basis irregularly indented with surface spines and four plumose terminal setae. Endopod with two juxtaposed inner plumose setae and three terminal plumose setae. Exopod shorter than endopod with two inner and two terminal plumose setae.

Mxl. (Fig. 19), arthrite of praecoxa with surface row of spinules and four terminal claw-like setae. Coxa-basis and endopod all with four terminal setae. Exopod terminally with two setae and laterally with one.

Mx. (Fig. 20), syncoxa with three endites, the proximal one is broadened and bears three quilled-shaped plumose setae. Basis terminally with claw. Exopod represented by four setae.

Mxp. (Fig. 21), basis with strong spinulose seta at outer distal corner. Endopod with two rows of spinules terminating in a claw.

P_1 (Fig. 22), basis spinulose with strong basis setae on both sides. Exopod 3-segmented, endopod 2-segmented. Setation as figured.

P_2 (Fig. 23), P_3 (Fig. 24), P_4 (Fig. 25) all with 3-segmented exopods and 1-segmented endopods. Setation as figured and listed below:

Setal formula—*Paranannopus atlanticus* n. sp.

	Exp.	End.
P_1	0.0.023	1.210
P_2	1.1.123	.020
P_3	1.1.123	.111
P_4	1.1.123	.110

P_5 (Fig. 26), both segments fused with a total of six setae.

Male: Unknown.

Etymology: The specific name refers to the Atlantic basin from which it was collected.

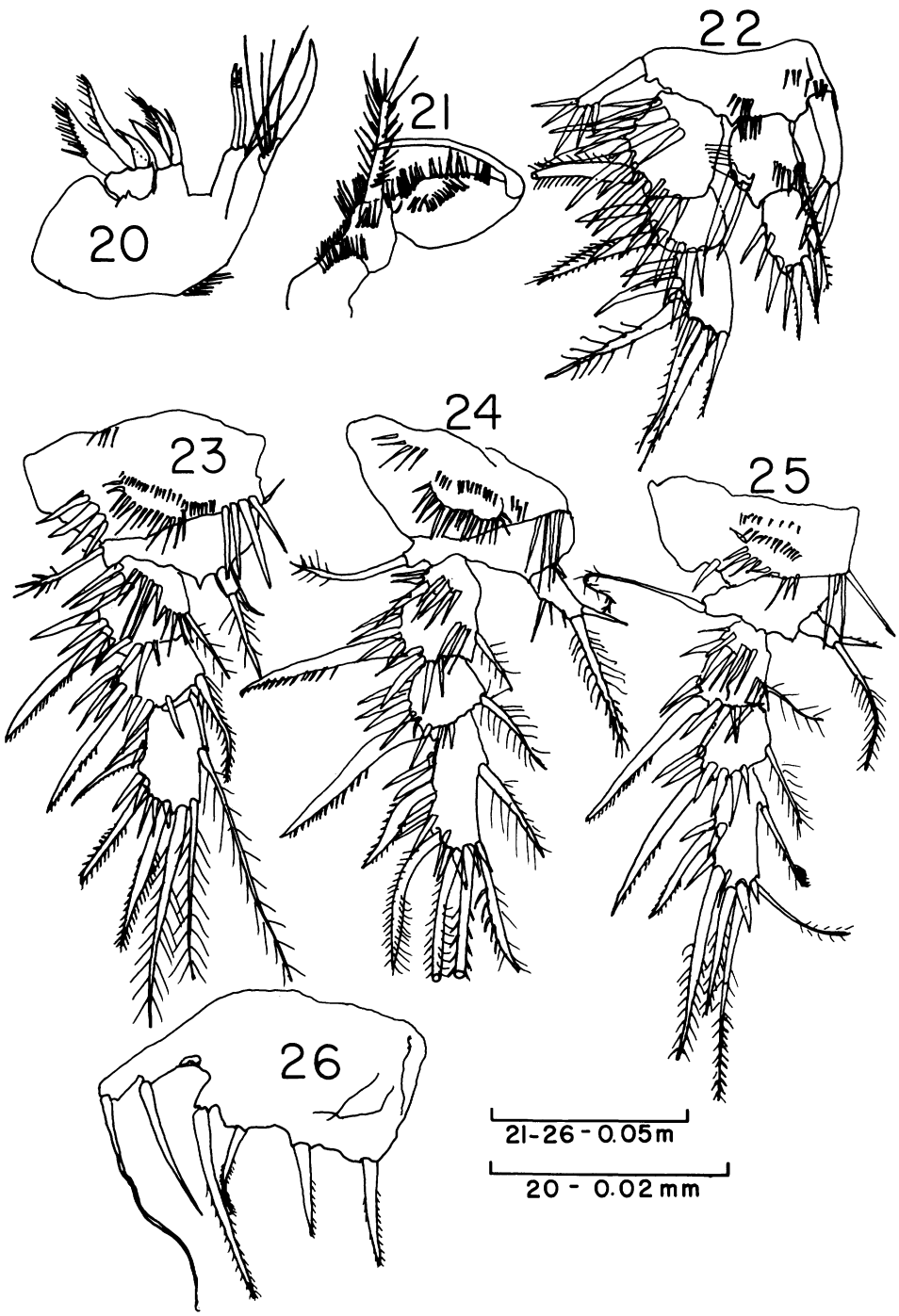
Discussion

Only two species in the genus exhibit the combination 1-segmented P_2–P_4 endopods and a 3-segmented A_2 exopod: *P. philistinus* Por and *P. atlanticus* n. sp. The two species are easily separable on the number of antennular segments (five in *P. atlanticus* and six in *P. philistinus*) and setal formulae of the P_2 and P_3 endopods (*P. atlanticus* has two and three setae, respectively, whereas *P. philistinus* has three and one setae, respectively). A key to the genus is given below:

Key to the species of *Paranannopus*[4]

1. End. P_2–P_4 absent 2
   End. P_2–P_4 2-segmented 3

[4] *P. wellsi* Soyer is not included as it has yet to be published and is only known from its listing in Soyer (1970).



FIGS. 20–26. *Paranannopus atlanticus* n. sp. ♀. Fig. 20. Mx. Fig. 21. Mxp. Fig. 22. P_1. Fig. 23. P_2. Fig. 24. P_3. Fig. 25. P_4. Fig. 26. P_5.

End. P_2–P_4 1-segmented 5
2. Exp. A_2 1-segmented, benp. & exp. P_5 separate ..... *P. abyssi* Sars
Exp. A_2 2-segmented, P_5 fused ..... *P. caheti* Soyer
3. Exp. A_2 1-segmented ..... *P. sarsi* Lang
Exp. A_2 2-segmented ..... *P. bahusiense* Por
Exp. A_2 3-segmented 4
4. Terminal segment P_4 End. with five setae ..... *P. langi* Wells
Terminal segment P_4 End. with two setae ..... *P. triarticulatus* Wells
5. A_1 5-segmented 6
A_1 6-segmented ..... *P. philistinus* Por
6. End. P_3 with two setae 7
End. P_3 with three setae ..... *P. atlanticus* n. sp.
7. Terminal seg. Exp. P_4 with seven setae ..... *P. minutus* Smirnov
Terminal seg. Exp. P_4 with five setae ..... *P. echinatus* Smirnov

Cylindronannopus n. g.

The generic designation coincides with that of its sole and type species and must, therefore, be considered preliminary.

Remarks

Cylindronannopus n. g. represents a most unique position in the family. It harbors many characteristics common to *Paranannopus* yet its elongate and cylindrical body shape suggest affinities with the interstitial Cylindropsyllidae. The endopod segmentation of the swimming legs does not agree with the generic designation of *Paranannopus*, but these characters appear to vary within the genus (see key to *Paranannopus*) and are not good generic characters.

The body shape, then, is the most distinguishing characteristic. If the body were short and stout as typical for *Paranannopus*, I should not hesitate to include it in this genus. However, to include such a distinctly shaped species in a genus well known for its characteristic body shape would only serve to confuse future systematists, and thus a new genus is erected to incorporate it.

Cylindronannopus primus n. g., n. sp.
(Figs. 27–41)

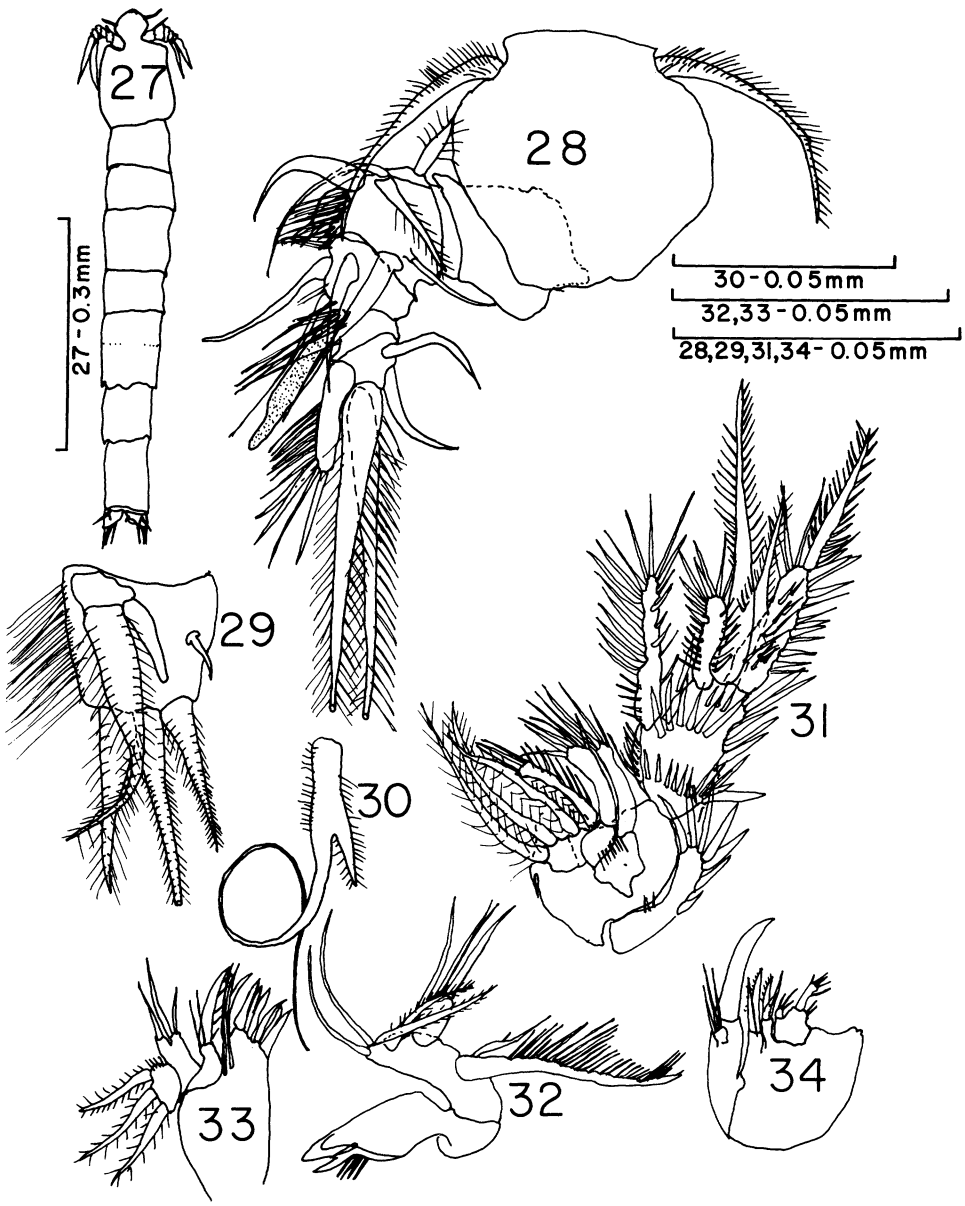
Material: 12 ♀♀, 1 ♂ (9 ♀♀, 1 ♂ Sta. 13 this paper, 3 ♀♀ Sta. 18).

Holotype: 1 ♀, USNM No. 138441; paratype 1 ♀, USNM No. 138442.

Type locality: Eastwood Station 14427, 34° 14.0′ N, 75° 20.0′ W, depth 3,000 m.

Description

Female: Based on a non-ovigerous female, 0.61 mm. Body narrow and elongate, tapering in form characteristic of the family Cylindropsyllidae (Fig. 27). Somites devoid of ornamentation but remainder of body parts heavily spinulose. Genital and penultimate somites double the length of the others. Anal operculum inconspicuous. Rostrum (Figs. 27–28) almost circular with finely pubescent setae arising on either side of the apex. Caudal rami (Fig. 29) slightly broader than long (ratio of 2.8/2.5). Outer margin covered with fine, long, hair-like setules. Surface knob at base with one annulated outer seta and a short inner bare one. One small median seta at ½ the length. Terminally there are three setae, all semi-annulated and finely setose; the middle one is longest. The middle seta is not the same. Of the 13 individuals examined the median terminal seta of three

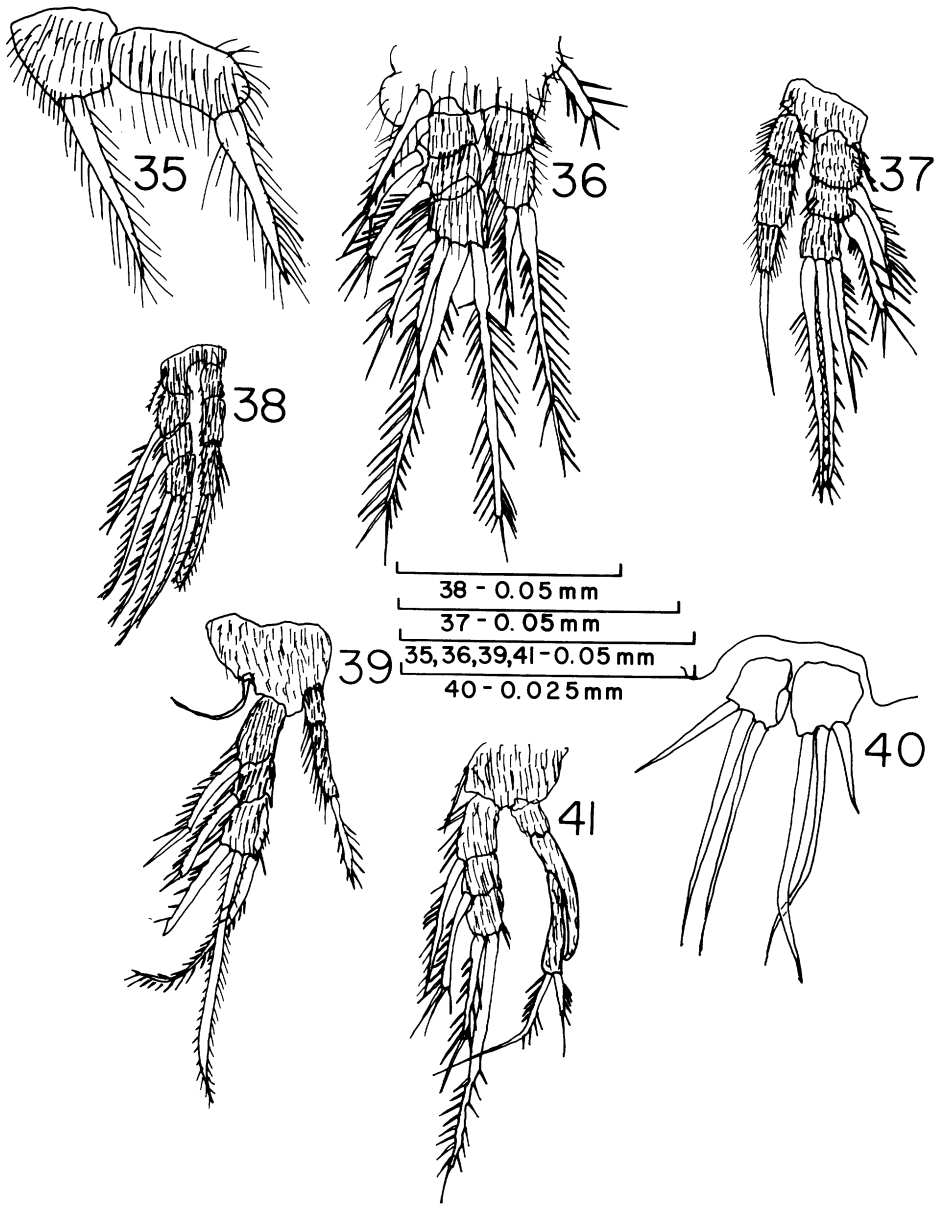


FIGS. 27–34. *Cylindronannopus primus* n. g., n. sp. ♀. Fig. 27. Habitus. Fig. 28. Rostrum and A_1. Fig. 29. Caudal ramus, dorsal view. Fig. 30. Median terminal caudal seta, lateral view. Fig. 31. A_2. Fig. 32. Md. Fig. 33. Mxl. Fig. 34. Mx.

specimens was bifid (Fig. 30). The dorsal bifurcation is extremely long and terminates in a hair-like lash (Fig. 30).

A_1 (Fig. 28), 5-segmented, aesthetasc on segment three. Strong and heavily spinulose as figured.

A_2 (Fig. 31), endopod 2-segmented with allobasis, heavily spinulose and



FIGS. 35–41. *Cylindronannopus primus* n. g., n. sp. Fig. 35. Mxp.—♀. Fig. 36. P_1—♀. Fig. 37. P_2—♀. Fig. 38. P_3—♀. Fig. 39. P_4—♀. Fig. 40. P_5—♀. Fig. 41. P_5—♂.

terminally with strong spinulose setae. Exopod 3- (indistinctly 4-) segmented with six setae.

Md. (Fig. 32), praecoxa with tridentate pars-incisiva and four dentate lacinia. Coxa-basis with four plumose setae. Endopod rounded with three setae. Exopod represented by single strong spinulose seta.

Mxl. (Fig. 33), arthrite of praecoxa with two surface setae and seven terminal claw-like setae. Coxa terminating in claw-like seta and two small setae. Basis

plain with three terminal setae. Exopod missing, endopod spatulate with three terminal plumose setae.

Mx. (Fig. 34), syncoxa with three endites. Distad one spatulate with two small and two spinulose setae. Basis with one claw. Endopod with three setae.

Mxp. (Fig. 35), entire structure finely spinulose. Basis with plumose seta at inner distal corner. Endopod 1-segmented terminating in strong plumose seta.

P_1 (Fig. 36), 3-segmented exopod, 2-segmented endopod. All segments and setae spinulose. Setation as figured and listed below.

P_2 (Fig. 37), P_3 (Fig. 38), both with 3-segmented exopods and endopods. Setation as figured and listed below.

P_4 (Fig. 39), exopod 3-segmented, endopod 2-segmented. Setation as figured and listed below.

Setal formula—*Cylindronannopus primus* n. g., n. sp.

	Exp.	End.
P_1	0.0.022	0.020
P_2	0.0.021	0.0.010
P_3	0.0.021	0.0.020
P_4	0.0.021	0.010

P_5 (Fig. 40), baseoendopodite and exopodite fused into a single plate on each side with three terminal non-plumose setae each.

P_6—Absent.

Male: 0.49 mm. Exactly the same as the female in all aspects except the P_3, size, and genital field. P_3 (Fig. 41), both rami 3-segmented. The exopod with but two terminal setae (the female has three). Second endopodite segment modified into long claw-like outer extension, reaching ⅘ the length of the segment.

The genital field of the male is more striking than that of the female in that an internal spermatophore is present in the male as well as a single plate P_6 with a total of four setae. No distinctive genital field is apparent in the female.

Discussion

The generic affinities have previously been discussed in the remarks. The most puzzling feature of *C. primus* n. g., n. sp. is the lack of a sexually dimorphic A_1 and P_5. With but one male specimen it is difficult to assess the significance of the missing A_1 and P_5 dimorphism but three possibilities are suggested: (1) a new line of evolution within the Harpacticoida where A_1 and P_5 sexual dimorphism are absent, similar to the Isokarandria of the Calanoida, where no A_1 modification appears (Sars, 1903) and *Hemimesochra nixe* Por (1964a) where no P_5 modification occurs; (2) intersexuality, where an animal is neither male nor female, but an intermediate with female characters dominating (see Charniaux-Cotton, 1960 for crustacean intersexes); or, (3) morphologically similar females and sub-adult males, a common case in benthic amphipods where the characteristic male morphology is reached only at the last molt. In this case sub-adult males are often misidentified as females (see Mills, 1967 for discussion).

I doubt the sub-adulthood concept is relevant to the male *C. primus* as the presence of the internal spermatophore is typically an adult character. The dimorphism of the genital field and P_3 in the male *C. primus*, along with the retention of the female characters on the remainder of the body, presents a strong case for intersexuality; thus I suggest the possibilities of a new evolutionary line and intersexuality as the most feasible.

Related to my findings of this unique male is the previously reported dominance of female Harpacticoida in the deep sea. Several authors have listed and described deep-sea harpacticoids, and females always are more abundant than

TABLE I
Summary of sex ratio data on deep-sea Harpacticoida

Author	Location of collection	No. females	No. males	Ratio female/male
Bodin (1968)	France—Atlantic	25	8	3.13
Por (1964c)	Israel—Mediterranean	71	4	17.75
Por (1965)	Norway	59	11	5.36
Por (1969)	Indian Ocean	40	7	5.71
Smirnov (1946)	Arctic Ocean	73	7	18.25
Soyer (1969)	France—Mediterranean	120	5	24.00
Coull (present study and unpubl. data)	U. S. Atlantic	589	107	5.50

males. A summary of female/male ratios for deep-sea Harpacticoida (>100 m) is given in Table I. If one only looks for the commonly regarded sexually dimorphic characters (A_1, P_5) and uses these for sex determination, the reported sex ratio may not be a true measure of the sexual distribution. If, as in *C. primus*, the usual sexually dimorphic characters are absent, or an "intersex" organism is present, then the low abundance of males in the deep sea may be a function of misidentifying males as females as Mills (1967) has previously pointed out with the amphipods.

Obviously, the "intersex," sub-adult male hypothesis needs to be examined in more detail and, for the present, must be regarded as speculation. Hopefully, with more careful examination and continued collection of deep-sea harpacticoids, the hypothesis can be fully tested.

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MEIOBENTHIC HARPACTICOIDA (CRUSTACEA, COPEPODA) FROM THE DEEP SEA OFF NORTH CAROLINA II. THE FAMILY CERVINIIDAE SARS, LANG[1]

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COULL, B. C. 1973. Meiobenthic Harpacticoida (Crustacea, Copepoda) from the deep sea off North Carolina II. The family Cerviniidae Sars, Lang. *Trans. Amer. Micros. Soc.,* 92: 198–208. This second paper on the deep-sea harpacticoids off North Carolina deals exclusively with the family Cerviniidae. Seven species, including two new to science, were collected. The new species, *Cerviniella hamata* n. sp. and *Cerviniella bodini* n. sp., differ from the known species primarily in mouthpart setation and swimming leg segmentation and setation. Both new species possess a P_4 endopodite and along with *C. brodaskayae* Por are the only known species to do so. A table with salient morphological features and a key to the genus is given. A brief description of *Eucanuella* aff. *reticulata* Soyer is also given.

As part of my continuing study of North Carolinian deep-sea harpacticoids, this paper deals exclusively with the family Cerviniidae. Present knowledge of deep-sea harpacticoids is restricted to a few geographically isolated examples and except for Part I of this series, there is nothing known of the deep (>100 m) fauna off the United States east coast. The cerviniids have long been recognized as an exclusively deep-sea group, and their occurrence on the Carolinian slope and Hatteras abyssal plain was to be expected. Their squat body shape, characteristic spade-shaped appendages, and spiny processes make them ideally suited for a burrowing life in abyssal muds (see Figs. 9–12 and 21–24 of swimming legs).

I collected seven species of Cerviniidae, two of which are new and described below. Table I lists the North Carolinian cerviniids. The station locations, collecting methods, preparation, and terminology used throughout are the same as in Part I of this series (Coull, 1973).

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