



New species of Cirratulidae (Annelida, Polychaeta) from abyssal depths of the Clarion-Clipperton Fracture Zone, North Equatorial Pacific Ocean

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Abstract

Abyssal polychaetes of the family Cirratulidae were collected as part of reconnaissance and benthic impact experimental surveys at Clarion-Clipperton Fracture Zone manganese nodule sites in 1984 and 1993–1994. All specimens were collected from the 4500–4900 m depth range. Twelve species of Cirratulidae were identified, of which 11 are new to science. *Aphelochaeta abyssalis* n. sp., *A. clarionensis* n. sp., *A. clippertonensis* n. sp., *A. spargosis* n. sp., *A. tanyperistomia* n. sp., *A. wilsoni* n. sp., *Caulleriella bathytata* n. sp., *Chaetozone akaina* n. sp., *C. grasslei* n. sp., *C. truebloodi* n. sp. and *Tharyx hessleri* n. sp. Most of these species are small deposit-feeding threadlike worms that reside in the upper 5 cm of the sediment and represent a unique assemblage of abyssal taxa.

Key words: *Aphelochaeta*, *Caulleriella*, *Chaetozone*, *Kirkegaardia*, *Tharyx*, new species, deep sea

Introduction

Records of Cirratulidae from abyssal depths exceeding 3500 m are rare and in most cases specimens were identified as previously described shelf and slope species that had been reported from other parts of the world (e.g. Hartman 1965, 1967, 1971; Hartman & Fauchald 1971). Recent reports of abyssal cirratulids from off western South America and Antarctica based on results of older and more recent expeditions have yielded numerous new species (Blake 2016, 2018). These studies and results of other surveys suggest that cirratulids are one of the more abundant families of polychaetes in abyssal benthic habitats.

Owing to the occurrence of manganese nodules in the northern Equatorial Pacific Ocean in the vicinity of the Clarion-Clipperton Fracture Zone (CCFZ), numerous efforts have been made over the past 35 years to survey the site, collect samples of the biota, and to conduct experiments intended to determine the impact of mining for mineral deposits in these abyssal sites (Wilson & Hessler 1987). There have, however, been few publications describing benthic polychaetes from these sites. The present paper reports on cirratulid polychaetes collected from the CCFZ as part of the ECHO-I survey conducted in 1984 (Spiess *et al.* 1984, Wilson & Hessler 1987) and the Benthic Impact Experiment (BIE) conducted in 1993–1994 (Trueblood & Ozturgut 1997; Trueblood *et al.* 1997). Wilson (2017) recently reported benthic community parameters from the Echo-I and related surveys.

The present study reports on twelve species of bitentaculate Cirratulidae from the CCFZ. Eleven species in four genera are new to science: *Aphelochaeta* (6), *Caulleriella* (1), *Chaetozone* (3), and *Tharyx* (1). *Kirkegaardia fragilis* Blake, 2016 was previously described (Blake 2016). All species encountered are from abyssal depths of 4500–4900 m. The following species are included in this study:

Aphelochaeta abyssalis n. sp.

Aphelochaeta clarionensis n. sp.

Aphelochaeta clippertonensis n. sp.

Aphelochaeta spargosis n. sp.

Aphelochaeta tanyperistomia n. sp.

Aphelochaeta wilsoni n. sp.

Caulleriella bathytata n. sp.
Chaetozone akaina n. sp.
Chaetozone grasslei n. sp.
Chaetozone truebloodi n. sp.
Kirkegaardia fragilis Blake, 2016
Tharyx hessleri n. sp.

Material and methods

Materials examined as part of this study. The samples on which this study is based were collected as part of the ECHO-I survey of the National Oceanic and Atmospheric Administration (NOAA), Deep Ocean Mining Environmental Study (DOMES) Site C, led by Dr. Robert R. Hessler (Spiess *et al.* 1984) and the NOAA BIE surveys led by Dr. Dwight D. Trueblood (Trueblood & Ozturgut 1997; Trueblood *et al.* 1997).

The CCFZ is an enormous rectangular area between the Clarion and Clipperton fractures (120°–160°W) south and east of the Hawaiian Islands towards the East Pacific Rise and encompasses an area almost as wide as the continental United States. The center of DOMES site C is located at approximately 14°40'N, 125°25'W at an average depth of about 4500 m. The center of the BIE site is located at approximately 15°56'N, 128°36'W at an average depth of about 4870 m. The two sites are approximately 350 km apart.

Benthic samples from both surveys were collected with a 0.25 m² box core. For the ECHO-I survey the entire box was sampled to a depth of 10 cm. The overlying water was retained and sieved; the sediment was collected in layers of 0–1, 1–5, and 5–10 cm depths and processed separately. All samples were sieved through a 300- μ m-mesh screen. For the BIE project, the box core was divided into 25 (10 x 10 x 50 cm) subcores of which the upper 10 cm was retained. Each of these subcores was separated into 0–2, 2–5, and 5–10 cm fractions and sieved separately, also through a 300- μ m-mesh sieve. For both surveys, nodules found on the surface were separately examined for attached fauna. Samples from both surveys were preserved in 4% buffered formalin and later rinsed with fresh water and preserved in 80% ethanol (ETOH).

The ECHO-I polychaete collections were originally given provisional identifications by Dr. Kirk Fitzhugh, now Curator of Polychaetes at the Los Angeles County Museum of Natural History (LACM-AHF). The BIE collections were sorted by Cove Corporation as part of a contract with NOAA. Identifications of the polychaete collections were by this author and Dr. Brigitte (Hilbig) Ebbe, both under subcontract to Cove Corporation.

Cirratulids obtained from the ECHO-I survey are archived with the LACM-AHF and the BIE samples are deposited in the National Museum of Natural History, Smithsonian Institution (USNM).

Morphological observations. All specimens were examined with light microscopy using a Wild M-5 stereomicroscope and a Zeiss RA research microscope equipped with phase contrast and Nomarski differential interference optics. Photomicrographs were taken with a Nikon D7100 camera mounted on both the stereo- and compound microscopes. Some specimens were stained with a solution of Shirlastain A in water to highlight difficult-to-see surficial morphology. Some specimens were stained with a saturated solution of Methyl Green (MG) in 70% ETOH in order to elucidate distinct staining patterns of subdermal glands evident on some species. Both stains dissipate completely in ETOH. Line drawings were developed in pencil using a drawing tube or *camera lucida* on the Zeiss RA and later transferred to Mylar and inked.

Abbreviations used on figures: anC, anal cirrus; br, branchiae; dCr, dorsal crest; dT, dorsal tentacle; hB, heart body; int, intestine; mo, mouth; nuO, nuchal organ; ova, egg or oocyte; pap, papilla; paPd, palpode; per, peristomium; pig, pigment; pr, prostomium; prob, proboscis; pyg, pygidium; vGr, ventral groove.

Taxonomic Account

Family Cirratulidae Ryckholt, 1851

Genus *Aphelochaeta* Blake, 1991

Type-species: *Tharyx monilaris* Hartman, 1960. Original designation by Blake (1991).

Diagnosis. (after Blake 2018). Prostomium conical to rounded; peristomium elongate with pair of grooved dorsal tentacles arising either on or anterior to setiger 1. Anterior segments often expanded, crowded or uncrowded; abdominal segments sometimes beaded or moniliform in appearance; setae simple capillaries lacking distinct serrations using light microscopy but distinct fibrils may be visible using SEM; posterior end frequently expanded, tapering to a simple pygidial lobe.

Remarks. As part of a revision of the genus *Tharyx*, Blake (1991) assigned bitentaculate cirratulid species having only simple, non-serrated capillary setae to a new genus, *Aphelochaeta*. The absence of setae other than simple capillaries means that systematists are required to use body shape, details of the pre-setiger region, origin of the dorsal tentacles and anterior branchiae, presence or absence of dorsal and ventral grooves and ridges, form of the posterior end, nature of the pygidium, and Methyl Green staining patterns to identify species. Blake (2018) reviewed a wide range of morphological details that are available within the genus, but species of *Aphelochaeta* are the most difficult of the bitentaculate cirratulids to identify.

In the present study, six species of *Aphelochaeta* have been identified. Most specimens are long and threadlike, but, fortunately, each species has a distinct set of characters that makes identifications possible if the specimens are in good condition. There are differences in the size and configuration of the pre-setiger region including presence or absence of annular rings on the peristomium, differences in the placement of the dorsal tentacles and first branchiae, development of parapodia, and MG staining patterns.

Aphelochaeta abyssalis new species

Figure 1

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Tharyx sp. B: Wilson & Hessler 1987: Appendix E (in part).

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion-Clipperton Fracture Zone, ECHO I, DOMES Site C, R/V *Melville* cruise, coll. R. Hessler, 0.25 m² Sandia box core, Sta. H358, 0–1 cm fraction, 23 Jun 1983, 14°42.1930'N, 125°24.2556'W, 4516 m, **holotype** (LACM-AHF Poly 11255); Sta. H354, 1–5 cm fraction, 18 Jun 1983, 14°41.8091'N, 125°24.2202'W, 4514 m, 1 **paratype** (LACM-AHF Poly 11256).—NOAA BIE Project site, Sta. DDT-4-93, veg. 13, 0–2 cm fraction, 11 Aug 1993, 12°55.595'N, 128°35.943'W, 4861 m, 1 specimen (USNM 1557529).

Description. A small, elongate, slender species, with body cylindrical in cross section and lacking dorsal and ventral grooves; all segments narrow, wider than long throughout with no obvious separation of body into defined regions except for anterior 10–12 segments bearing weakly developed parapodial shoulders (Fig. 1A); posterior segments not expanded (Fig. 1B). Holotype complete, 4.0 mm long, 0.275 mm across anterior segments, with about 73 setigerous segments. Color in alcohol opaque white; black peristomial pigment spots extending across venter posterior to ventral lip of mouth with a few spots extending dorsally to lateral margin of peristomium (Fig. 1A). Holotype with body wall of mid-body segments ruptured, intestinal lobes with fine silt particles emergent.

Prostomium triangular, merging with peristomium; narrowing anteriorly to pointed apex (Fig. 1A); eyespots absent; nuchal organs not observed. Peristomium as wide as long, with smooth dorsal and lateral surface; merging seamlessly with dorsal margin of setiger 1 (Fig. 1A); annular grooves not apparent except on ventral surface; dorsal crest absent. Dorsal tentacles arising from posterior margin of peristomium (Fig. 1A); first pair of branchiae on setiger 1 dorsal to notosetae; subsequent branchiae in similar position (Fig. 1A). Branchiae or their stubs and scars most apparent in anterior 10–15 setigers; a few observed in middle and posterior segments.

Parapodia reduced, with setae appearing to arise directly from body wall. All setae long capillaries providing a bristled appearance to body (Fig. 1A–B). Notosetae numbering 6–10 capillaries including 1–2 long, natatory-like setae along most of body; neurosetae numbering 4–6 capillaries per fascicle along most of body.

Posterior 2–3 segments narrowing to conical pygidial lobe (Fig. 1B).

Methyl Green stain. No pattern, de-stains rapidly.

Etymology. The epithet is from the Latin *abyssus*, for bottomless pit or the deep sea and represents the occurrence of this species in abyssal depths of the ocean.

Remarks. *Aphelochaeta abyssalis* n. sp. differs from other congeners at the CCFZ in having a long, thin, body

with no expanded segments and with all segments narrow but wider than long throughout. The peristomium is relatively short, smooth, and with no evidence of annular rings, grooves, or dorsal crest.

The presence of rows of transverse black pigment spots on the venter and lateral margin of the peristomium posterior to the lower lip of the mouth on *A. abyssalis* n. sp. is similar that found in *A. dearborni* Blake, 2018, a widespread Antarctic shelf species that ranges to a depth of about 1510 m and *Aphelochaeta* sp. 1, an undescribed deep-water continental slope species that occurs off northern California (Blake, unpublished). However, both of these latter species are larger, more robust cirratulids with expanded anterior segments, prominent peristomial rings or annuli, and an extra pair of branchiae on either the peristomium or the anterior margin of setiger 1 (Blake 2018; unpublished observations). See additional comparative comments with *A. clarionensis* n. sp. (below).

Distribution. Abyssal Pacific Ocean, 4514–4861 m.

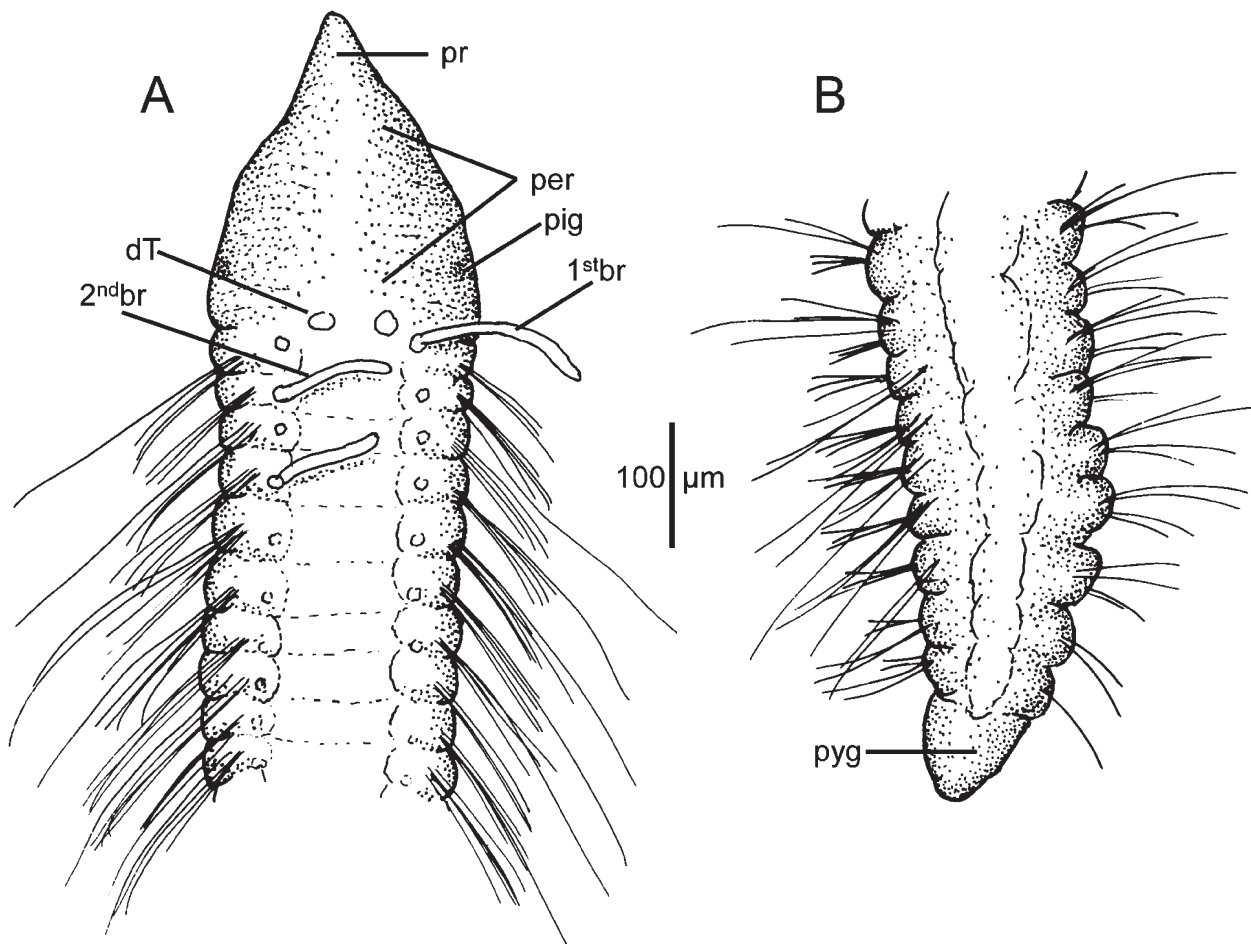


FIGURE 1. *Aphelochaeta abyssalis* n. sp. Holotype (LACM-AHF Poly 1255): A, anterior end, dorsal view; B, posterior end, dorsal view.

Aphelochaeta clarionensis new species

Figure 2

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Tharyx sp. C: Wilson & Hessler 1987: Appendix E (in part).

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion-Clipperton Fracture Zone, ECHO I, DOMES Site C, R/V *Melville* cruise, coll. R. Hessler, 0.25 m² Sandia box core, Sta. H358, 0–1 cm fraction, 23 Jun 1983, 14°42.1930'N, 125°24.2556'W, 4516 m, **holotype** (LACM-AHF Poly 11257); Sta. H356, top water from box core, 12 Jun 1983, 14°42.4541'N, 125°24.2664'W, 4518 m, 1 **paratype** (LACM-AHF Poly 11258).

Description. A moderately sized species, holotype complete, in two parts, collectively measuring 11 mm long, 0.52 mm across anterior segments, 0.48 mm across posterior segments, with 81 setigerous segments. Body more or less cylindrical throughout with dorsum low, rounded and venter weakly flattened along entire body; with mid-

ventral longitudinal ridge line evident at ventral midpoint of each segmental ring. All body segments narrow, wider than long; anterior segments crowded, about seven times wider than long (Fig. 2A); posterior segments about three times wider than long (Fig. 2B). Color in alcohol light tan; pigment spots absent.

Prostomium short, semi-circular, broadly rounded on anterior margin; eyespots absent; nuchal grooves narrow slits on posterior lateral margin. Peristomium longer than wide, narrowing anteriorly, divided into two annular rings (Fig. 2A); first anterior ring shorter and narrower than posterior ring; second ring about 2.5 times longer than first ring, with dorsum elevated into an oval-shaped crest (Fig. 2A); dorsal tentacles arising from posterior margin at anterior border with setiger 1 (Fig. 2A). First pair of branchiae arising posterior to dorsal tentacles on setiger 1, dorsal to notosetae; subsequent branchiae occurring in same position on following setigers (Fig. 2A). Branchiae mostly missing, limited to stumps or scars but occurring along entire body, short when present.

Parapodia reduced, with setae arising directly from body wall; anterior parapodia not producing shoulders. Setae all long capillaries with extra-long natatory-like notosetae present along most of body. Anterior notosetae numbering 12–14 per fascicle; neurosetae 8–10 per fascicle.

Pygidium with a short lobe ventral to anal opening (Fig. 2B).

Methyl Green stain. Stain producing pattern in pre-setiger region. Posterior half of prostomium stained, followed by two unstained areas on anterior of first peristomial ring; posterior half of first ring with stained wedge producing a clear area in first half of ring behind stain on prostomium. Second peristomial ring with two diffuse bands extending laterally and ventrally. Rest of body staining lightly with no pattern.

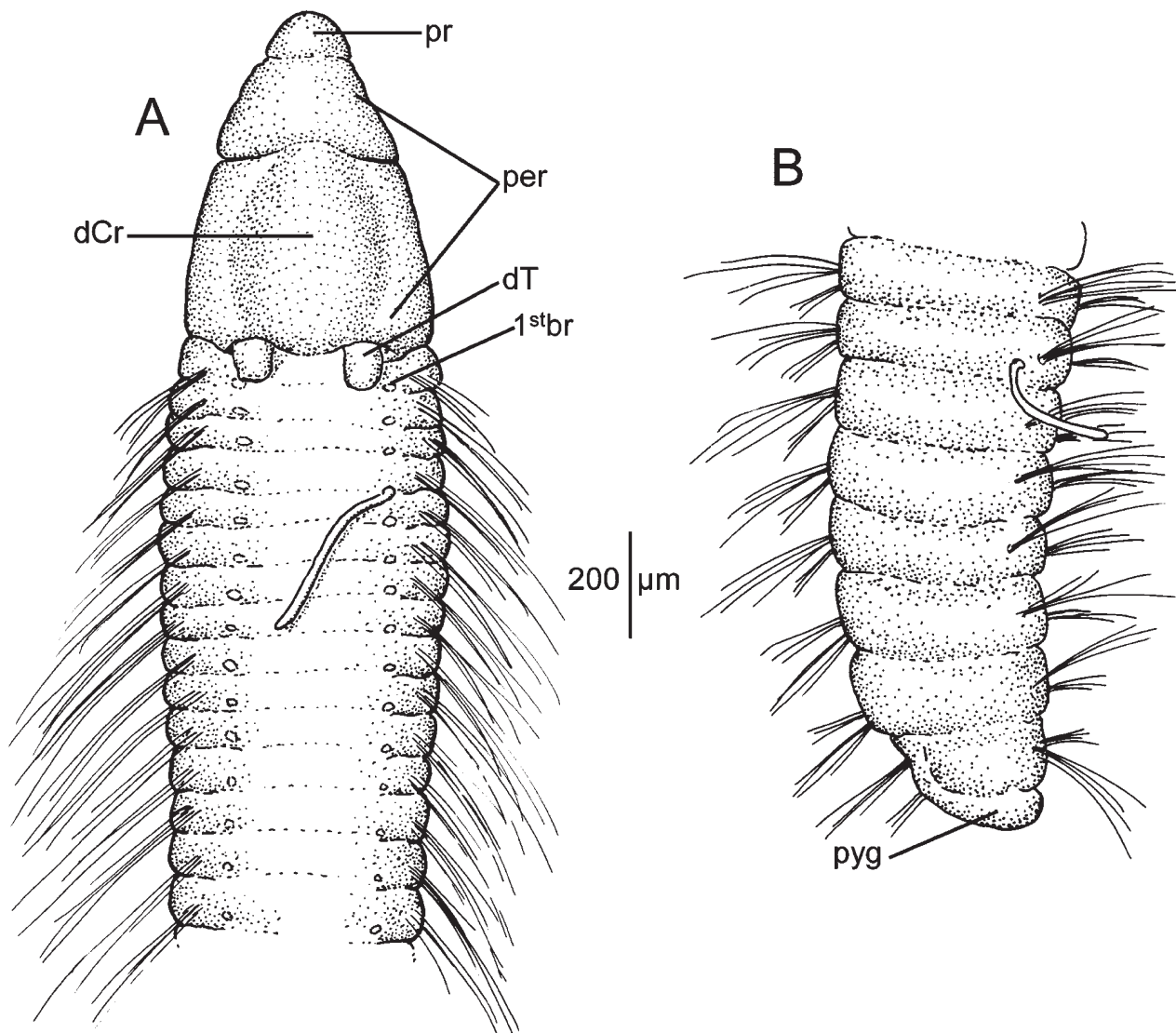


FIGURE 2. *Aphelochaeta clarionensis* n. sp. Holotype (LACM-AHF Poly 1257): A, anterior end, dorsal view; B, posterior end, dorsolateral view.

Etymology. The name *clarionensis* is taken from the first part of the name of the Clarion-Clipperton Fracture Zone where the species was collected.

Remarks. By having all body segments narrow, but distinctly wider than long, and with the first branchiae arising from setiger 1, *Aphelochaeta clarionensis* n. sp. is most similar to *A. abyssalis* n. sp. found in the same and adjacent samples. *Aphelochaeta clarionensis* n. sp., however, differs from *A. abyssalis* n. sp. in having the prostomium short and rounded instead of longer, triangular and pointed apically, and having the peristomium divided into two distinct annular rings with a large prominent dorsal crest instead of the peristomium being smooth with no annular rings or dorsal crest. In addition, *A. clarionensis* n. sp. has a MG pattern in the pre-setiger region instead of no staining pattern at all.

Globally, most species of *Aphelochaeta* are known from intertidal zones or shelf depths and have the first pair of branchiae arising from the peristomium lateral to or in close proximity with the dorsal tentacles or, if the first branchiae do arise from setiger 1, there is usually a second pair of branchiae present on the same setiger (Blake 1996, 2018; Dean & Blake 2016; Choi *et al.* 2018; Blake & Magalhães 2019). Further, for most of these shallow-water species, the posterior end is enlarged or expanded and moniliform segments are often present. Thus, *A. abyssalis* n. sp. and *A. clarionensis* n. sp. differ from the majority of known *Aphelochaeta* species, including other abyssal species described in this study, by the arrangement of the anterior branchiae and by having narrow segments present along the entire body.

Distribution. Abyssal Pacific Ocean, 4516–4518 m.

Aphelochaeta clippertonensis new species

Figures 3–4

urn:lsid:zoobank.org:act:CE40005E-0928-44AA-B800-57903EDFCB0F

Tharyx sp. C: Wilson & Hessler 1987: Appendix E (in part).

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion-Clipperton Fracture Zone, NOAA BIE Project site, Sta. DDT-9-93, veg. 13, 5–10 cm fraction, 03 Sep 1993, 12°56.280'N, 128°35.440'W, 4860 m, **holotype** (USNM 1557530); Sta. DDT 2-93, veg 20, 2–5 cm fraction, 10 Aug 1993, 12°56.166'N, 128°35.520'W, 4869 m, 1 specimen (USNM 1557532); Sta. DDT 5-93, veg 14, 2–5 cm fraction, 13 Aug 1993, 12°56.566'N, 128°35.408'W, 4870 m, 1 **paratype** (USNM 1557533); Sta. DDT 6-93, veg 13, 0–2 cm fraction, 01 Sep 1993, 12°55.780'N, 128°35.881'W, 4858 m, 1 specimen (USNM 1557534); Sta. DDT-8-93, veg. 24, 0–2 cm fraction, 02 Sep 1993, 12°55.633'N, 128°36.011'W, 4843 m, 1 **paratype** (USNM 1557531).—ECHO I, DOMES Site C, R/V *Melville* cruise, coll. R. Hessler, 0.25 m² Sandia box core, Sta. H350, 1–5 cm fraction, 14 Jun 1983, 14°38.1226'N, 125°26.8208'W, 4506 m, 1 **paratype** (LACM-AHF Poly 11259).

Description. A small, elongate, threadlike species. Holotype complete, 4.0 mm long, 0.3 mm wide across anterior segments with 20 setigers; paratype from Sta. DDT-5-93 complete, 1.83 mm long, 0.213 mm wide with 16 setigers. Body slightly expanded in anterior and far posterior segments (Figs. 3A–B, 4A–C), but generally consistently narrow along entire body. Individual segments visibly separated from one another by setal fascicles; segmental furrows poorly developed (Fig. 3A–B); no moniliform segments. Parapodial shoulders not apparent in anterior segments or elsewhere along body. First 6–8 segments narrow, about three times wider than long (Figs. 3A, 4A, C); middle body segments longer, about 1.5 times as wide as long (Fig. 4C); posterior segments longer, about 1.8 times as wide as long (Figs. 3B, 4B). Dorsal and ventral grooves absent. Paratype from Sta. H350 with posterior segments bearing elongate embryos, two per segment, each approximately 85 µm long and 35 µm wide (Fig. 4D). Each embryo composed of numerous cells, but not differentiated. Color in alcohol opaque white.

Pre-setiger region narrow, tapering from setiger 1 to tip of prostomium, about 1.5 times longer than wide (Figs. 3A, 4A). Prostomium triangular, tapering to pointed apex; eyespots absent; nuchal organs not observed; proboscis with thin papillated epidermis, everted on holotype (Figs. 3A, 4A). Peristomium with three weakly developed annular rings only evident laterally by shallow furrows; dorsal surface smooth with no separate dorsal crest (Fig. 3A). Dorsal tentacles present on anterior border of third peristomial ring (Figs. 3A, 4A–B); first pair of branchiae present posterior to tentacles at anterior border with setiger 1 (Figs. 3A, A–B). Second pair of branchiae on setiger 1 dorsal to notosetae; subsequent branchiae in similar location on following segments (Fig. 3A). Most branchiae missing but evident as stubs or scars through about setiger 10.

Parapodia poorly developed throughout, with podial lobes reduced and with setae emerging directly from body

wall. All setae thin capillaries. Notosetae 7–8 per fascicle on first 5–6 setigers, then reduced to 3–5 per fascicle over next 5–6 setigers; posterior setigers with 1–2 long natatory-like capillaries (Figs. 3B, 4C); neurosetae of anterior setigers similar to notosetae, numbering 6–8 per fascicle, then reduced to 3–4 in following segments; posterior segments with 1–2 capillaries where long notosetae occur. Individual capillaries thin, with no marginal fibrils evident in light microscopy.

Posterior end terminating in simple conical-shaped pygidium bearing numerous minute papillae (Figs. 3B, 4C).

Methyl Green stain. No pattern.

Etymology. The name *clippertonensis* is taken from the second part of the name of the Clarion-Clipperton Fracture Zone where the species was collected.

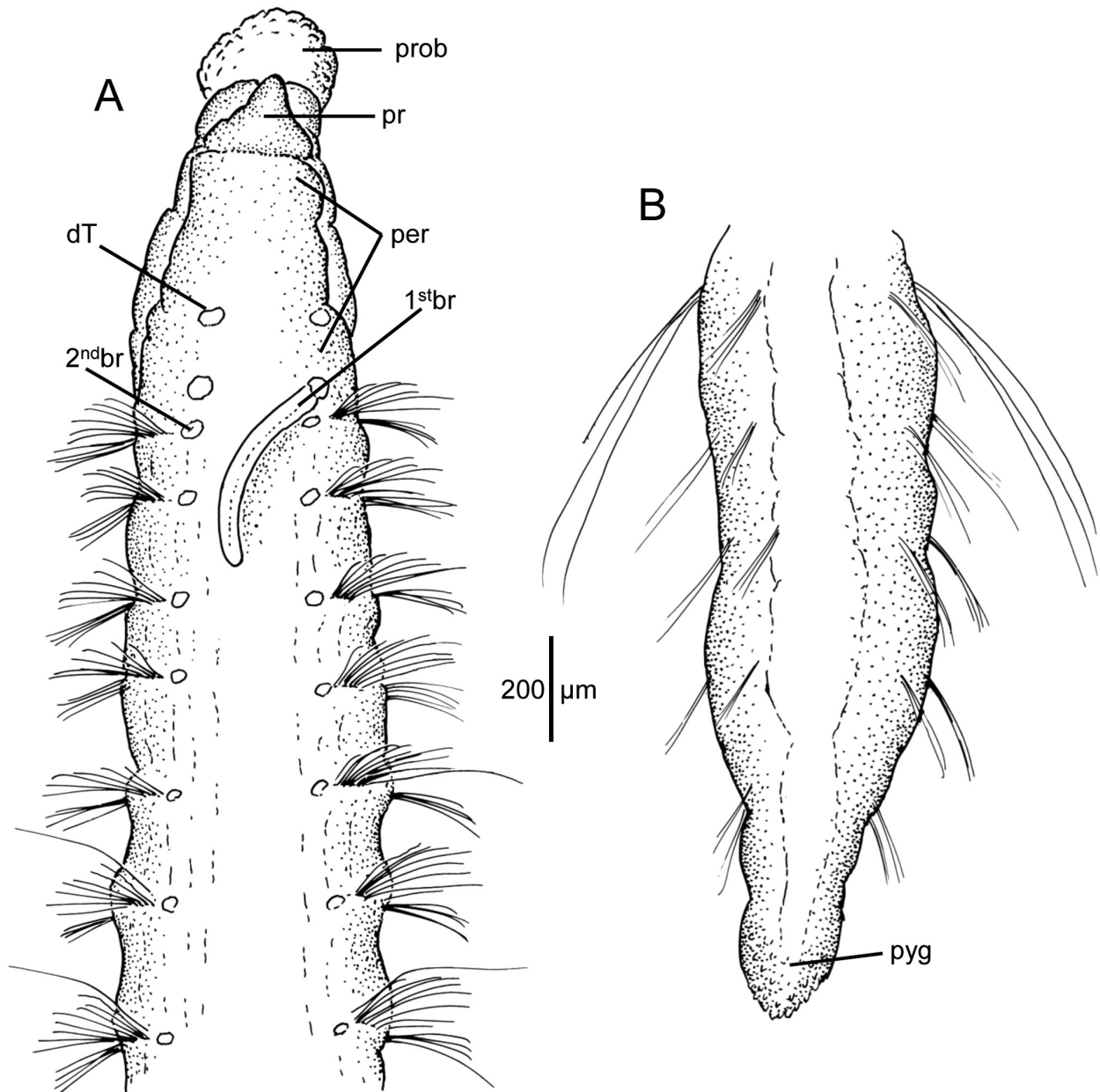


FIGURE 3. *Aphelochaeta clippertonensis* n. sp. Holotype (USNM 1557530): A, anterior end, dorsal view; B, posterior end, dorsal view.

Remarks. *Aphelochaeta clippertonensis* n. sp. is one of several small bitentaculate cirratulids from abyssal sediments in the Clarion-Clipperton Fracture Zone with a slender threadlike body. Among species of *Aphelochaeta* identified in this project, *A. clippertonensis* n. sp. is the only one to have reduced segmental furrows that result in the individual segments being defined only by the location of setal fascicles. Other species in this study have individual

segments well defined with segmental furrows and distinctly separate from one another along the body. An exception is the paratype from Sta. H350 that has elongate brooding embryos within segments in the posterior half of the body producing segments that appear swollen, lumpy, and rounded (Fig. 4D). There appear to be two embryos per segment that are similar in appearance to eggs and embryos observed for *Tharyx moniliformis* Blake, 2018 from slope and abyssal depths in the Weddell Sea, Antarctica. These observations suggest that deep-sea cirratulids have evolved viviparity or other means of brooding as part of their life cycles.

Distribution. Abyssal Pacific Ocean, 4506–4870 m.

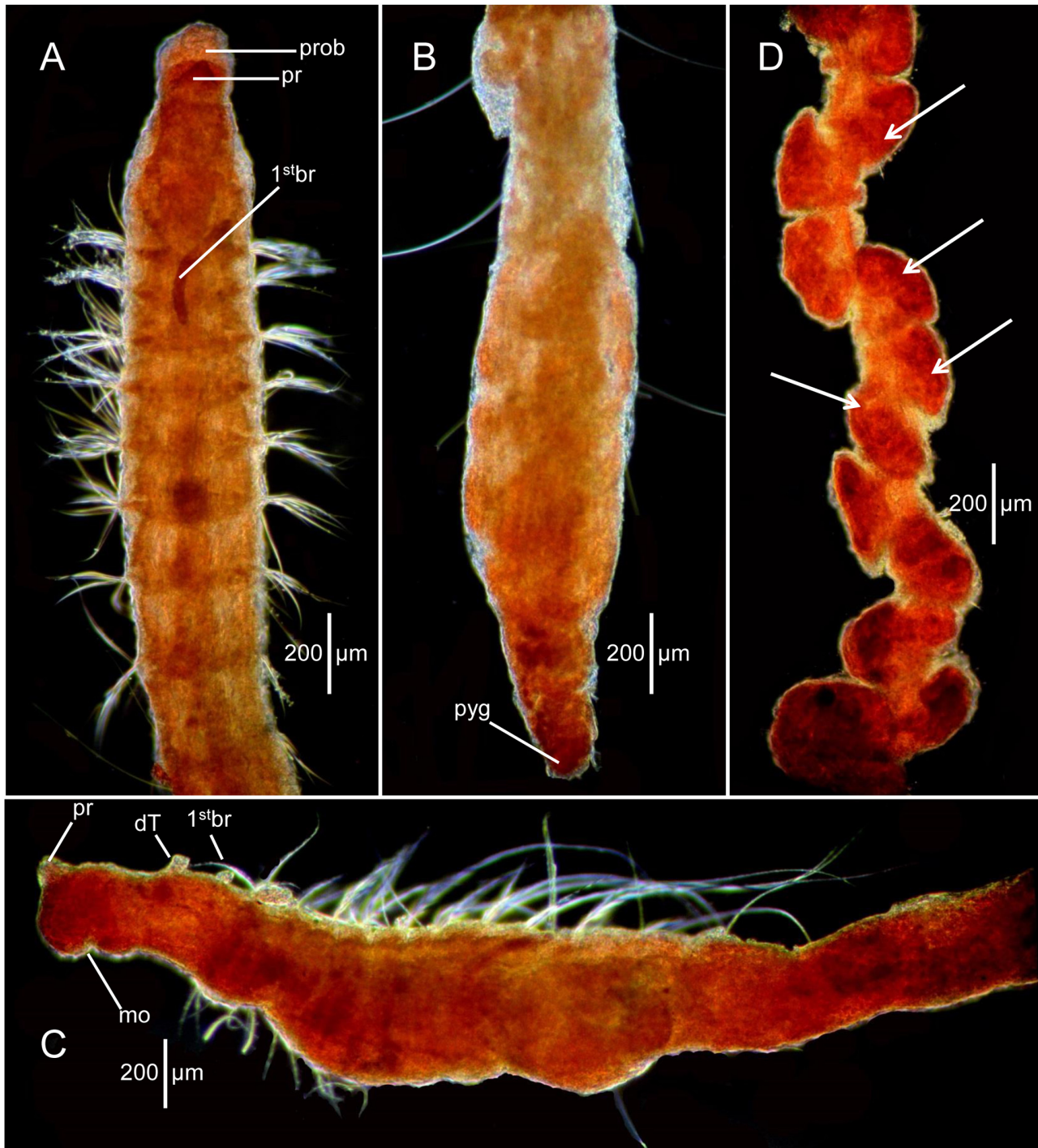


FIGURE 4. *Aphelochaeta clippertonensis* n. sp. Holotype (USNM 1557530): A, anterior end, dorsal view; B, posterior end, dorsal view. Paratype (USNM 1557533): C, anterior end middle body segments, left lateral view. Paratype (LACM-AHF Poly 12259): D, middle body segments with embryos (arrows). All stained with Shirlastain A.

Aphelochaeta spargosis new species

Figures 5–6

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Tharyx sp. B: Wilson & Hessler 1987: Appendix E (in part).

Tharyx sp. C: Wilson & Hessler 1987: Appendix E (in part).

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion-Clipperton Fracture Zone, ECHO I, DOMES Site C, R/V *Melville* cruise, coll. R. Hessler, 0.25 m² Sandia box core, H351, 1–5 cm fraction, 14 Jun 1983, 14°37.6334'N, 125°26.3840'W, 4516 m, **holotype** (LACM-AHF Poly 11260) and fragments (LACM-AHF Poly 11261); Sta. H362C, 0–1 cm fraction, 18 Jun 1983, 14.7013°N, 125.4309°W, 4480 m, 1 **paratype** (LACM-AHF Poly 11262).

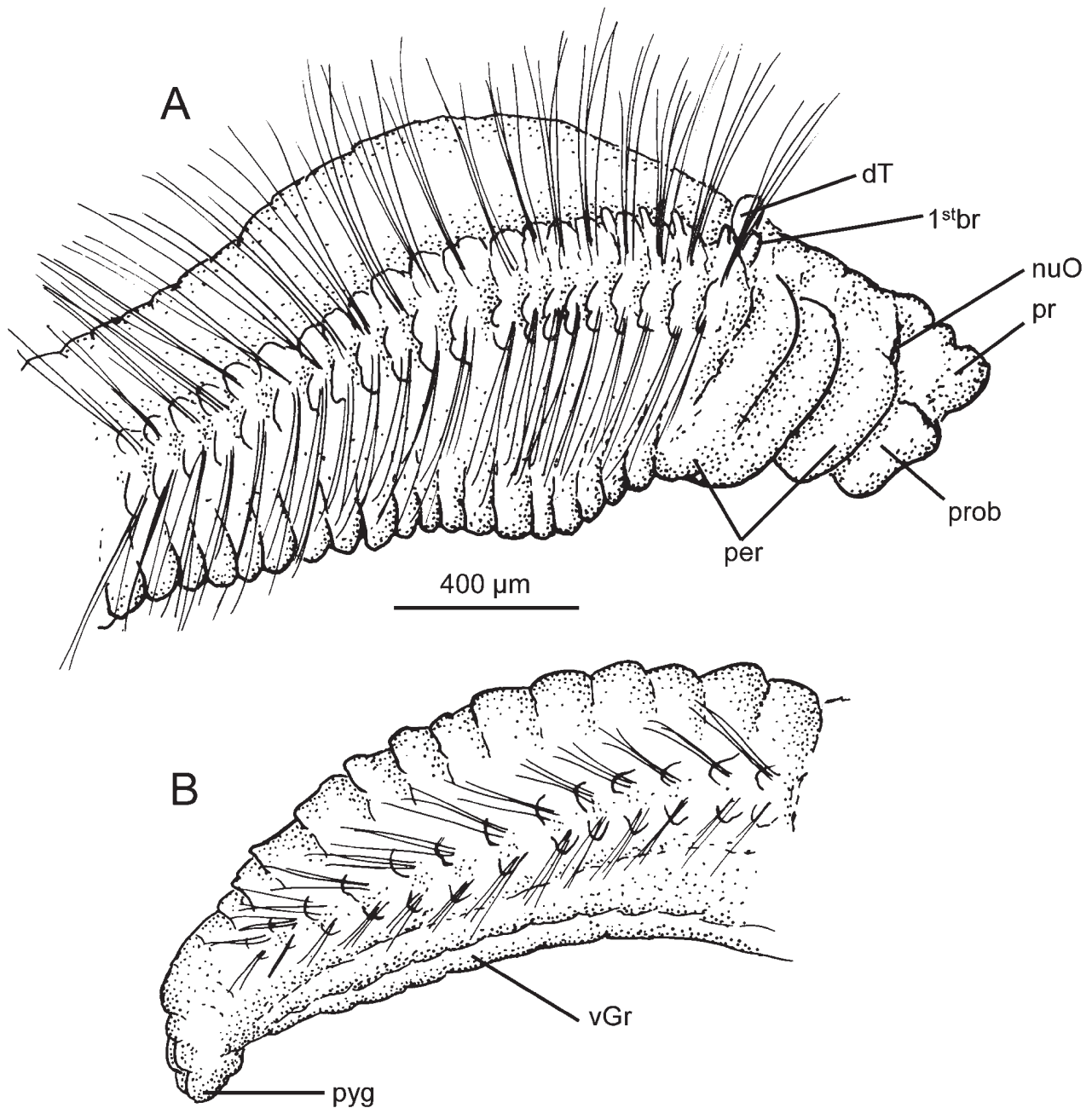


FIGURE 5. *Aphelochaeta spargosis* n. sp. Holotype (LACM-AHF Poly 12260): A, anterior end, right lateral view; B, posterior end, right lateral view.

Description. A small species, but more robust, not threadlike as most other cirratulids from the CCFZ. Holotype complete, pygidium with minor damage, 6.2 mm long, 0.94 mm wide across swollen anterior segments, 0.65 mm wide across middle and posterior segments, with 58 setigerous segments. Holotype with body thick, robust, anterior segments swollen producing large dorsal hump and prominent ventral swelling (Fig. 5A); paratype with anterior segments not as swollen, dorsum appearing flaccid. Individual segments narrow, crowded along entire body; larger rounded segments entirely absent. Dorsum generally rounded throughout, venter flattened, with shallow groove (Fig. 5B). Body gradually narrowing in posterior segments; no enlargement or separate narrowing of far posterior segments; pygidial segment with terminal anus surrounded by several lobes (Fig. 5B). Color in alcohol light tan.

Pre-setiger region thick, about as long as first nine crowded setigers (Fig. 5A). Prostomium short, bluntly rounded on anterior margin; eyespots absent; nuchal organs narrow slits on posterior lateral margin. Peristomium with three annular rings, best developed laterally; dorsum with narrow crest, not crossed by annular rings (Fig. 5A). Dorsal tentacles on posterior margin of peristomium; first pair of branchiae lateral to tentacles (Fig. 5A). Second pair of branchiae on setiger 1 dorsal to notosetae; subsequent branchiae in similar locations. Most branchiae broken or stubs, short intact branchiae present in middle segments.

Parapodia well developed throughout with swollen podial lobes forming distinct lateral shoulders (Fig. 5A). Noto- and neurosetae all capillaries arising close together but on distinctly separate noto- and neuropodia. All capillaries of first 12–15 segments long, projecting dorso-laterally, providing a bristled appearance to anterior swollen segments. Anterior notosetae numbering 15 or more per fascicle; anterior neurosetae numbering about 10–12 per fascicle; capillaries of middle and posterior segments shorter, reduced to 7–8 in notopodia and 4–6 in neuropodia. Individual capillaries thin, with no fibrils evident in light microscopy. Long, natatory setae not evident.

Methyl Green stain. Prominent MG staining pattern evident (Fig. 6). Holotype with distinct lateral bands crossing prostomium and peristomium, with heavy banding defining three peristomial rings. Prostomium crossed by single band. Parapodia with stain concentrated on posterior borders of noto- and neuropodia along entire body, continuing as a broad band across venter and also across dorsum on first 4–5 setigers, rest of dorsum generally unstained. Paratype also with bands encircling anterior segments, but less prominent.

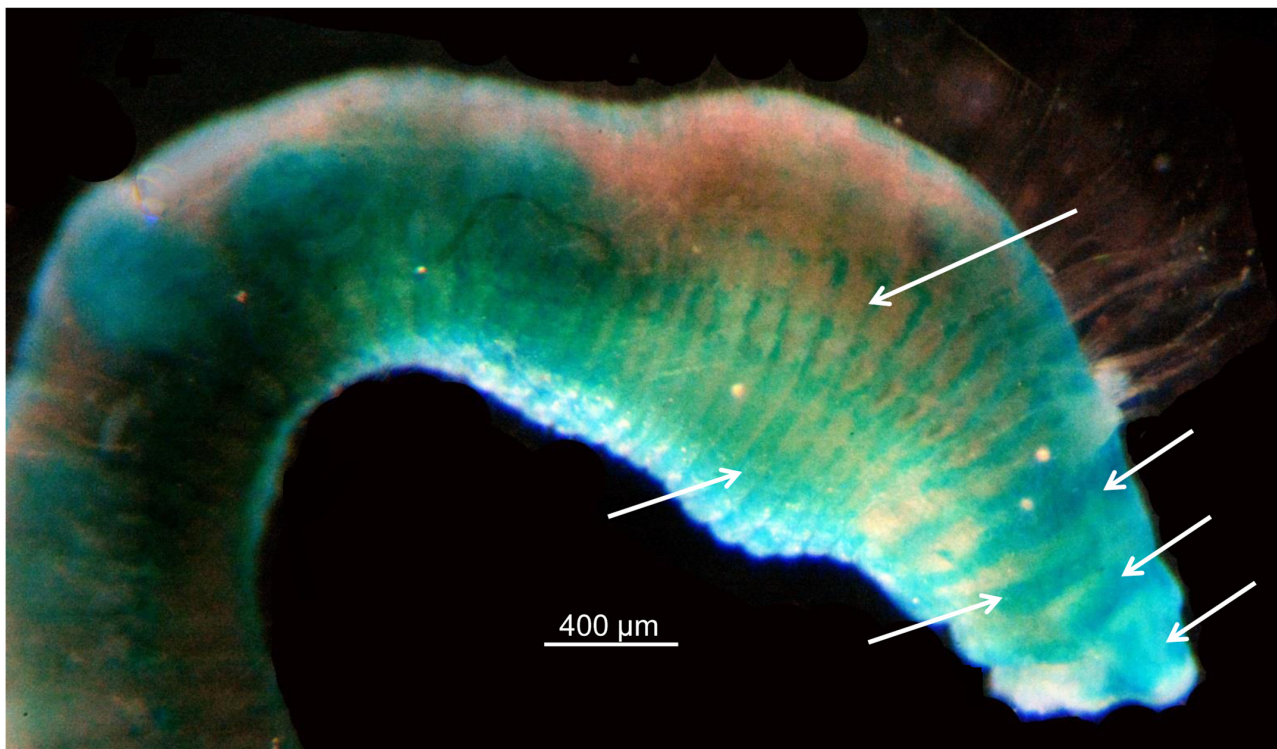


FIGURE 6. *Aphelochaeta spargosis* n. sp. Holotype (LACM-AHF Poly 12260): Anterior end, right lateral view methyl green staining pattern (arrows).

Etymology. The epithet is from the Latin, *spargosis*, for distension or swelling, referring to the very enlarged and swollen anterior segments of this species.

Remarks. *Aphelochaeta spargosis* n. sp. is a unique species in the nature of the swollen anterior segments. All

segments are crowded and narrow throughout with prominent parapodial shoulders along the entire body. There is no evidence of any enlargement or narrowing of the posterior segments. In addition, the species has a prominent and distinctive MG staining pattern. *Aphelochaeta hormosa* Blake, 2018 from Antarctica has a similar appearance to the anterior end and a distinctive MG staining pattern but a long section of the body has moniliform segments and the capillaries on anterior segments are short, not conspicuously long.

Distribution. Abyssal Pacific Ocean, 4480–4516 m.

Aphelochaeta tanyperistomia new species

Figures 7–8

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Tharyx sp. A: Wilson & Hessler 1987: Appendix E (in part).

Tharyx sp. C: Wilson & Hessler 1987: Appendix E (in part).

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion–Clipperton Fracture Zone, NOAA BIE Project site, coll. D.D. Trueblood, Sandia box corer, Sta. DDT-01-94, veg. 6, 5–10 cm fraction, 25 Jul 1994, 12°55.788'N, 128°35.843'W, 4851 m, 1 **paratype** (USNM 1557535); Sta. DDT-4-94, veg. 22, 5–10 cm fraction, 27 Jul 1994, 12°55.967'N, 128°35.758'W, 4851 m, **holotype** (USNM 1557536); Sta. DDT-7-93, veg. 4, 2–5 cm fraction, 02 Sep 1993, 12°56.303'N, 128°35.311'W, 4844 m, 1 juvenile (USNM 1557537); veg. 7, 5–10 cm 1 juvenile (USNM 1557538); Sta. DDT-9-94, 29 Jul 1994, 12°54.980'N, 128°35.440'W, 4877 m, 1 juvenile (USNM 1557539).—**ECHO I, DOMES Site C**, R/V *Melville* cruise, coll. R. Hessler, 0.25 m² Sandia box core, Sta. 350, 1–5 cm fraction, 14 Jun 1983, 14°38.1226'N, 125°26.8208'W 4506 m, 1 specimen (LACM-AHF Poly 11263); Sta. H351, 5–10 cm fraction, 14 Jun 1983, 14°37.6334'N, 125°26.3840'W, 4516 m, 1 specimen (LACM-AHF Poly 11264); Sta. 356, 1–5 cm fraction, 21 Jun 1983, 14°42.4541'N, 125°24.2664'W, 4518 m, 1 specimen (LACM-AHF Poly 11256); Sta. H358, 1–5 cm fraction, 23 June 1983, 14°42.1930'N, 125°24.2556'W, 4516 m, 1 specimen (LACM-AHF Poly 11266); Sta. H362, 1–5 cm fraction, 18 Jun 1983, 14.7013°N, 125.4309°W, 4480 m, 1 specimen (LACM-AHF Poly 11267).

Description. A small species, holotype complete, in three parts, about 8 mm long, 0.3 mm wide across narrow peristomium, 0.70 mm wide across expanded anterior segments, and 0.33 mm wide across posterior segments with about 40 setigerous segments total. Paratype smaller, incomplete, 2.45 mm long, with 27 setigerous segments. Body of holotype with unusually elongate, narrow pre-setiger region (Fig. 7A) and first 3–4 setigers followed by 10–12 expanded anterior segments, then narrowing again in posterior segments. Body generally cylindrical throughout with anterior expanded segments and dorsum elevated over parapodia; no ventral or dorsal grooves evident. Color in alcohol opaque white with no pigmentation.

Pre-setiger region elongate, narrow, as long as first eight setigers in holotype (Fig. 7A) and first 12 setigers in paratype (Fig. 7B). Prostomium relatively short, rounded on anterior margin, paratype and juvenile with distinct palpode on tip (Figs. 7B, 8A–C); eyespots absent; nuchal organs not observed on holotype; present as narrow grooves on paratype at posterior border with peristomium (Fig. 7B). Peristomium two to three times longer than wide; surface appearing wrinkled, with no annular rings evident (Fig. 7A–B); dorsal surface forming low crest. Dorsal tentacles arising mid-dorsally near posterior margin of peristomium (Fig. 7A–B). First pair of branchiae arising on setiger 1 dorsal to notosetae; branchiae arising from similar location on subsequent setigers (Fig. 7A); branchiae or stubs observed over first half of body.

Parapodia moderately developed as expanded lobes or shoulders best observed in anterior expanded segments; posterior segments with small podial lobes from which setae arise. Setae all capillaries with 5–7 relatively long capillaries in anterior notopodia with 1–2 additional very long, natatory-like capillaries (Fig. 8A–B, D); capillaries reduced in number to 4–5 per setiger posteriorly and not as long; neurosetae also long, with up to 8–10 capillaries in anterior setigers, reduced to 4–6 posteriorly.

Body of holotype terminating in pygidium with flattened ventral lobe.

Juvenile Morphology. Two complete juveniles, with 11 and 17 setigers, respectively, were encountered in a single box core from Sta. DDT-7-93.

An 11-setiger juvenile (USNM 1557538, veg 4), 2.7 mm long, 0.1 mm wide across peristomium, 0.2 mm wide across expanded anterior section, and 0.09 across posterior segments. Pre-setiger region narrow and elongate as in

adults, with distinct palpode on anterior end of prostomium (Fig. 8A–C). Peristomium relatively smooth, but with irregular lobes or wrinkles evident; dorsal tentacles and branchiae not developed. Expanded anterior segments with only four setigers (Fig. 8A–B), rapidly narrowing to long middle and posterior section, terminating in narrow pygidial segment with rounded lobe (Fig. 8A).

Second juvenile (USNM 1557539, veg. 7), with 17 setigerous segments, 2.2 mm long, 0.18 mm wide across peristomium, 0.40 mm across expanded anterior section, and 0.18 mm across far posterior segments. Specimen with ten setigers in expanded anterior area (Fig. 8D), and seven setigers in posterior section. Palpode on anterior margin of prostomium appears partially retracted. Rudiment of one dorsal tentacle observed on posterior margin of peristomium and clear spots evident on several anterior segments suggesting sites of branchial development. With pair of fragile anal cirri evident arising laterally from pygidial lobe (Fig. 8E).

Methyl Green stain. No pattern.

Etymology. The epithet is from the Greek, *tany*, for long or stretched and *peristome*, for the region around the mouth, and refers to the unusual elongate peristomial morphology of this species.

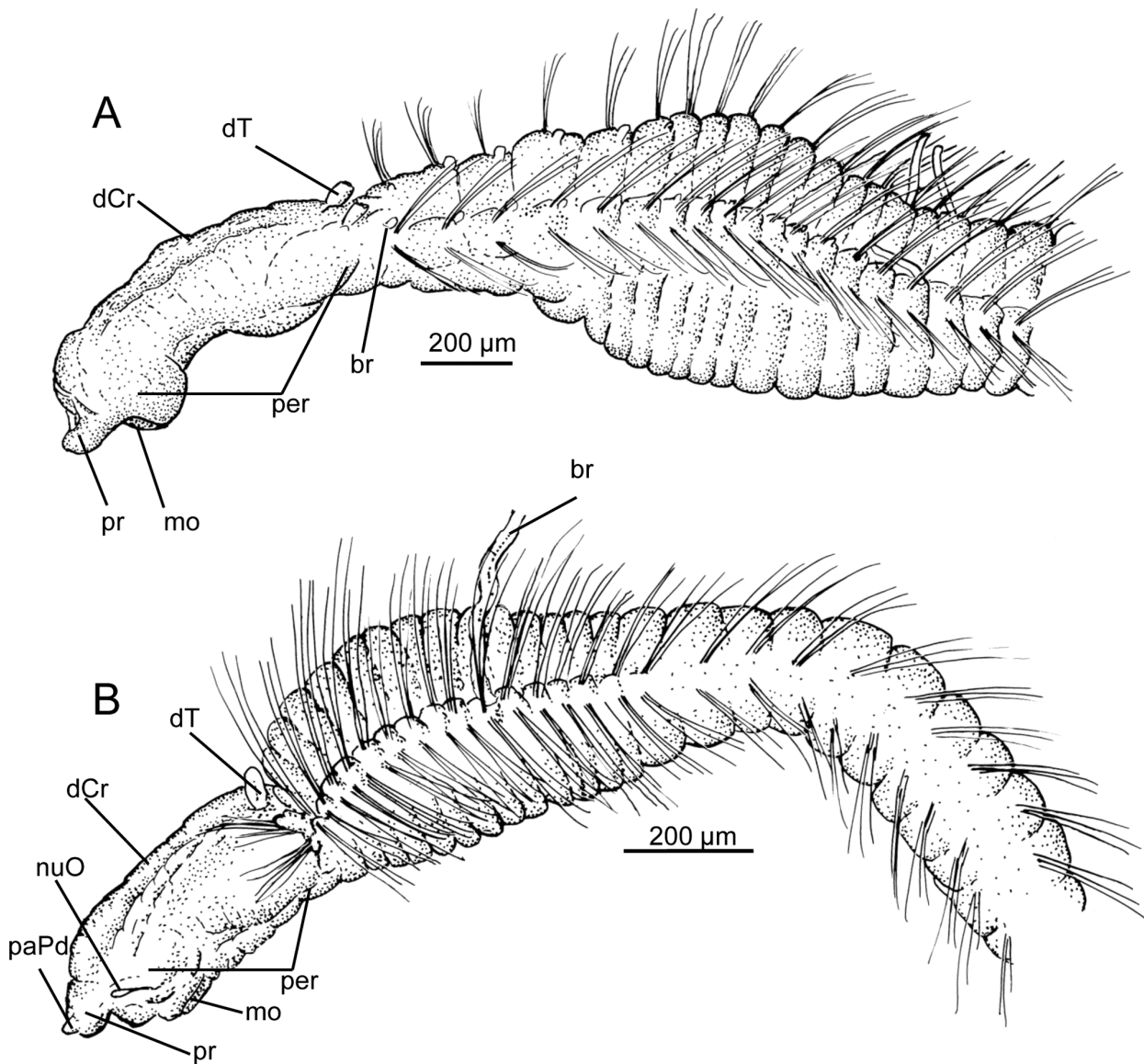


FIGURE 7. *Aphelochaeta tanyperistomia* n. sp. Holotype (USNM 1557536): A, anterior end, left lateral view. Paratype (USNM 1557535): B, anterior end, left lateral view.

Remarks. *Aphelochaeta tanyperistomia* n. sp. is unusual among bitentaculate cirratulids in the nature of the elongate pre-setiger region. The wrinkled epidermis of the peristomium on both the holotype and paratype suggest that the entire pre-setiger region is subject to considerable expansion and contraction: the pre-setiger region and

first four setigers of the paratype are contracted whereas the same pre-setiger and anterior setigers of the holotype appear stretched. The long stretched-out region of the holotype followed by an expanded segmental region suggests

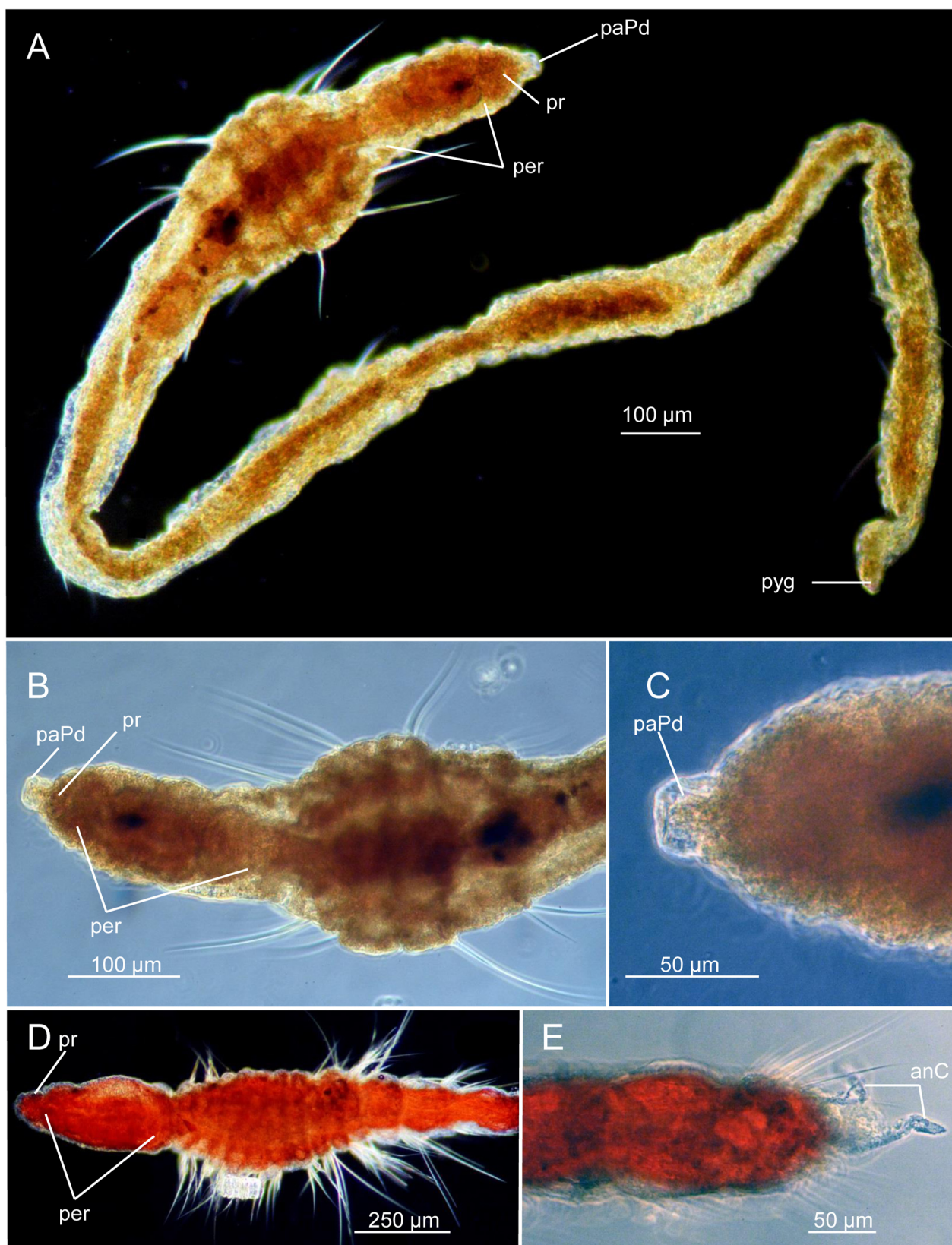


FIGURE 8. *Aphelochaeta tanyperistomia* n. sp. 11-setiger juvenile (USNM 1557538): A. entire worm, dorsal view; B. anterior end, dorsal view; C. detail of prostomium palpode. 17-setiger juvenile (USNM 1557539): D. anterior end middle segments, dorsal view; E. posterior end and pygidium, dorsal view. All stained with Shirlastain A.

that the species is an active burrower using hydrostatic pressure to produce cracks in the sediment into which the worm moves. The mechanics of this kind of cirratulid burrowing were described by Che & Dorgan (2010) and Dorgan *et al.* (2011) for *Cirriiformia moorei* Blake, 1996, a common intertidal species in California. The topic was also reviewed by Blake & Magalhães (2019). The holotype, paratype, and one juvenile of *A. tanyperistomia* **n. sp.** were taken from the lower 5–10 cm fraction of 10 cm subcores of the box core; the smaller 11-setiger juvenile was taken from the middle 2–5 cm fraction. These results suggest that these worms are deep burrowers.

Other species of *Aphelochaeta* with long pre-setiger regions are: *A. antelonga* Dean & Blake, 2016 from off Costa Rica to Chile, *A. striata* Dean & Blake, 2016 also from Costa Rica, and *A. elongata* Blake, 1996 from northern California (Blake 1996, 2018; Dean & Blake 2016). All three of these species have a pre-setiger region that is 2–3 times as long as wide, but unlike *A. tanyperistomia* **n. sp.** their pre-setiger region is relatively smooth or with shallow peristomial transverse grooves instead of a strongly wrinkled surface with no evidence of transverse grooves.

The presence of a distinct palpode on the tip of the prostomium of the paratype and two juveniles of *A. tanyperistomia* **n. sp.** is reminiscent of similar structures in some species of Paraonidae and Opheliidae and appears to be unique within the Cirratulidae. The palpode is likely retracted in the holotype. In paraonids, Strelzov (1973, 1979) suggested that the prostomial palpode was tactile in function and he noted that it was capable of retracting by means of a muscle innervated directly from the brain.

The juveniles exhibit features that not only provide important developmental information on this species, but for bitentaculate cirratulids in general. The developmental morphology revealed in the 11- and 17-setiger juveniles clearly suggests a pattern where the elongate, narrow pre-setiger region develops early and the initial segmentation produces elongate narrow segments that are subsequently enlarged and modified in the anterior half of the body, resulting in the characteristic expanded anterior or thoracic region followed by the narrow posterior or abdominal region. The anterior expanded region consists of only four segments in the 11-setiger juvenile, ten segments in the 17-setiger juvenile and up to 15 setigers in the larger holotype and paratype. The dorsal tentacles and branchiae appear later in development, which has been documented for other cirratulids (Blake 1975).

Distribution. Abyssal Pacific Ocean, 4506–4877 m.

Aphelochaeta wilsoni new species

Figures 9–10

urn:lsid:zoobank.org:act:BA8C564D-1003-4DD6-A26B-CC8CBB8F2CC3

Tharyx sp. A: Wilson & Hessler 1987: Appendix E (in part).

Tharyx sp. B: Wilson & Hessler 1987: Appendix E (in part).

Chaetozone sp. A: Wilson & Hessler 1987: A: Appendix E (in part).

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion-Clipperton Fracture Zone. **ECHO I, DOMES Site C**, R/V *Melville* cruise, coll. R. Hessler, 0.25 m² Sandia box core, Sta. H354, 0–1 cm fraction, 18 June 1983, 14°41.8091'N, 125°24.2202'W, 4514 m, **holotype** (LACM-AHF Poly 11268); Sta. H348, 0–1 cm fraction, 13 June 1983, 14°38.0720'N, 125°38.0720'W, 4504 m, 1 specimen (LACM-AHF Poly 11269); Sta. H349, 0–1 cm fraction, 14 June 1983, 14°38.3925'N, 125°27.1791'W, 4517 m, 1 **paratype** (LACM-AHF Poly 11270); Sta. H353, 0–1 cm fraction, 18 Jun 1983, 14°42.0879'N, 125°24.2679'W, 4516 m, 1 **paratype** (LACM-AHF Poly 11271); Sta. H354, 0–1 cm fraction, 18 Jun 1983, 14°41.8091'N, 125°24.2202'W, 4514 m, 1 specimen (LACM-AHF Poly 11272); Sta. H-360, nodule wash, 17 Jun 1983, 14°40.7987'N, 125°22.0379'W, 4500 m, 1 specimen (LACM-AHF Poly 11273); Sta. H361, 0–1 cm fraction, 18 Jun 1983, 14.7013°N, 125.4309°W, 4567 m, 1 specimen (LACM-AHF Poly 11274).—**NOAA BIE Project site**, coll. D.D. Trueblood, 0.25 m² Sandia box corer, Sta. DDT-7-93, veg. 12, 5–10 cm, 02 Sep 1993, 122° 56.303'N, 128°35.311'W, 4844 m, 1 specimen (USNM 1557540); Sta. DDT-9-93, 03 Sep 1993, 12°56.280'N, 128°35.440'W, 4860 m, 1 specimen (USNM 1557541); Sta. DDT-10-93, veg. 7, 2–5 cm, 03 Sep 1993, 12°56.127'N, 128°35.854'W, 4840 m, 1 specimen (USNM 1557542); Sta. DDT-3-94, veg. 8, 0–2 cm, 26 Jul 1994, 12°56.104'N, 128°35.523'W, 4854 m, 1 specimen (USNM 1557543).

Description. An elongate threadlike species, holotype (LACM-AHF Poly 11268) complete, 6.2 mm long, 0.18 mm wide across anterior segments, reduced to 80–100 µm wide across middle and posterior segments; with 31 setigers; paratype (LACM-AHF Poly 11270), complete, 3.9 mm long, ca. 100 µm across anterior segments. Both

specimens with beaded or moniliform segments, with anterior and far posterior segments rounded, about as long as wide (Figs. 9A, 10A, C–D); middle segments elongate and narrow, three to four times as long as wide with parapodia and setae located in posterior one-fourth of these segments (Figs. 9B–C, 10B). Anterior segments weakly expanded in holotype (Fig. 10A), with rest of body consistently narrow along length; smaller paratype with pre-setiger region slightly wider than following setigers (Fig. 9A). Dorsal and ventral grooves absent. Color in alcohol, opaque white.

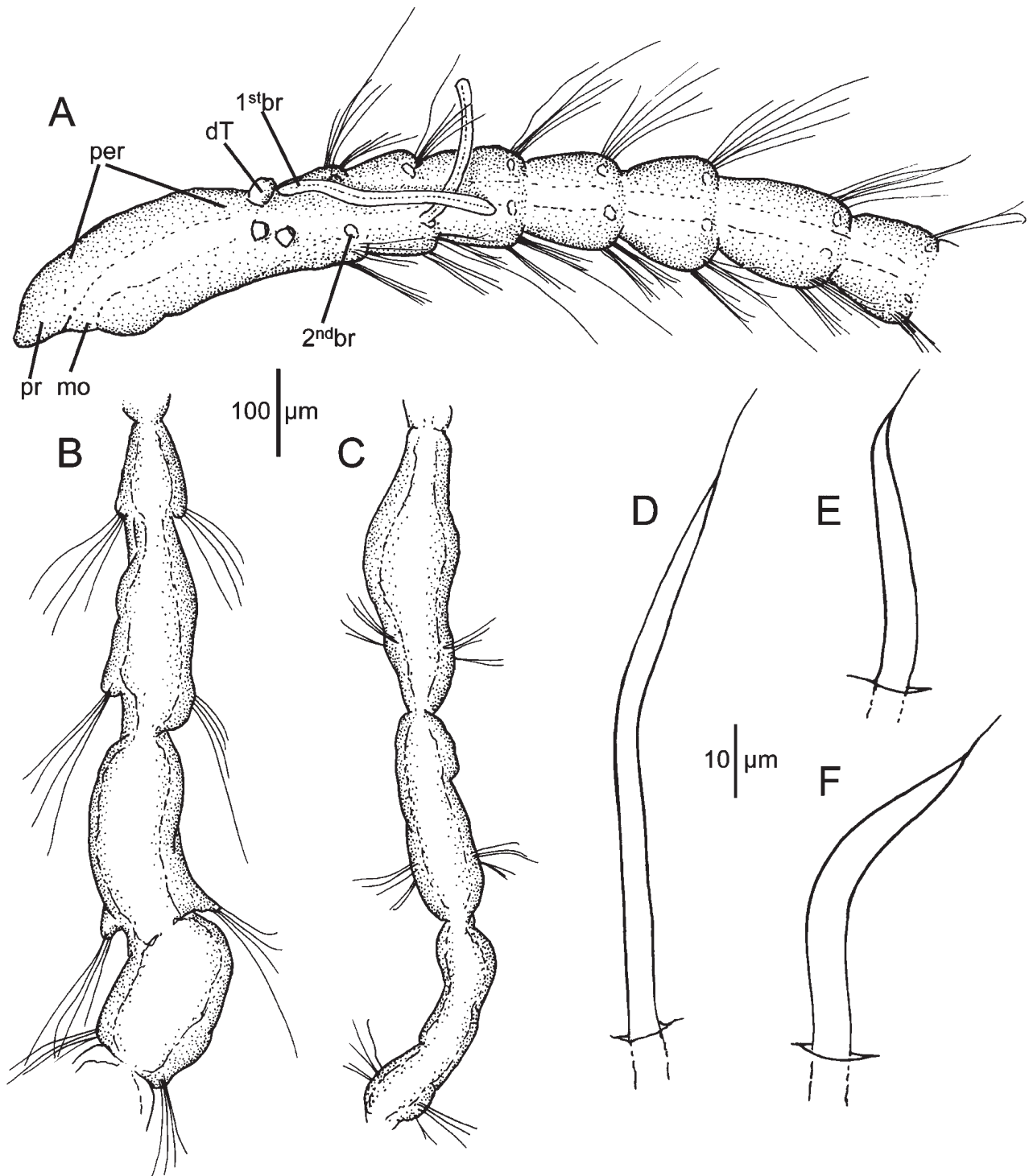


FIGURE 9. *Aphelochaeta wilsoni* n. sp. Paratype (LACM-AHF Poly 11270): A, anterior end, left lateral view; B, middle body segments 10–13, C, middle body segments 17–19; D, capillary neurosetae of middle body segment; E–F, far posterior neurosetae.

Pre-setiger region elongate, relatively smooth with no evidence of annular rings, about three times as long as wide (Figs. 9A, 10A). Prostomium short, conical, rounded on anterior margin; eyespots absent; nuchal organs not

observed. Peristomium lacking annular rings, merging seamlessly with setiger 1 (Fig. 9A); dorsal tentacles arising from posterior margin of peristomium, first pair of branchiae immediately posterior to dorsal tentacles (Fig. 9A). Second pair of branchiae arising dorsal to notosetae on setiger 1; subsequent branchiae in same position on following segments (Fig. 9A); branchiae present on middle and some posterior segments.

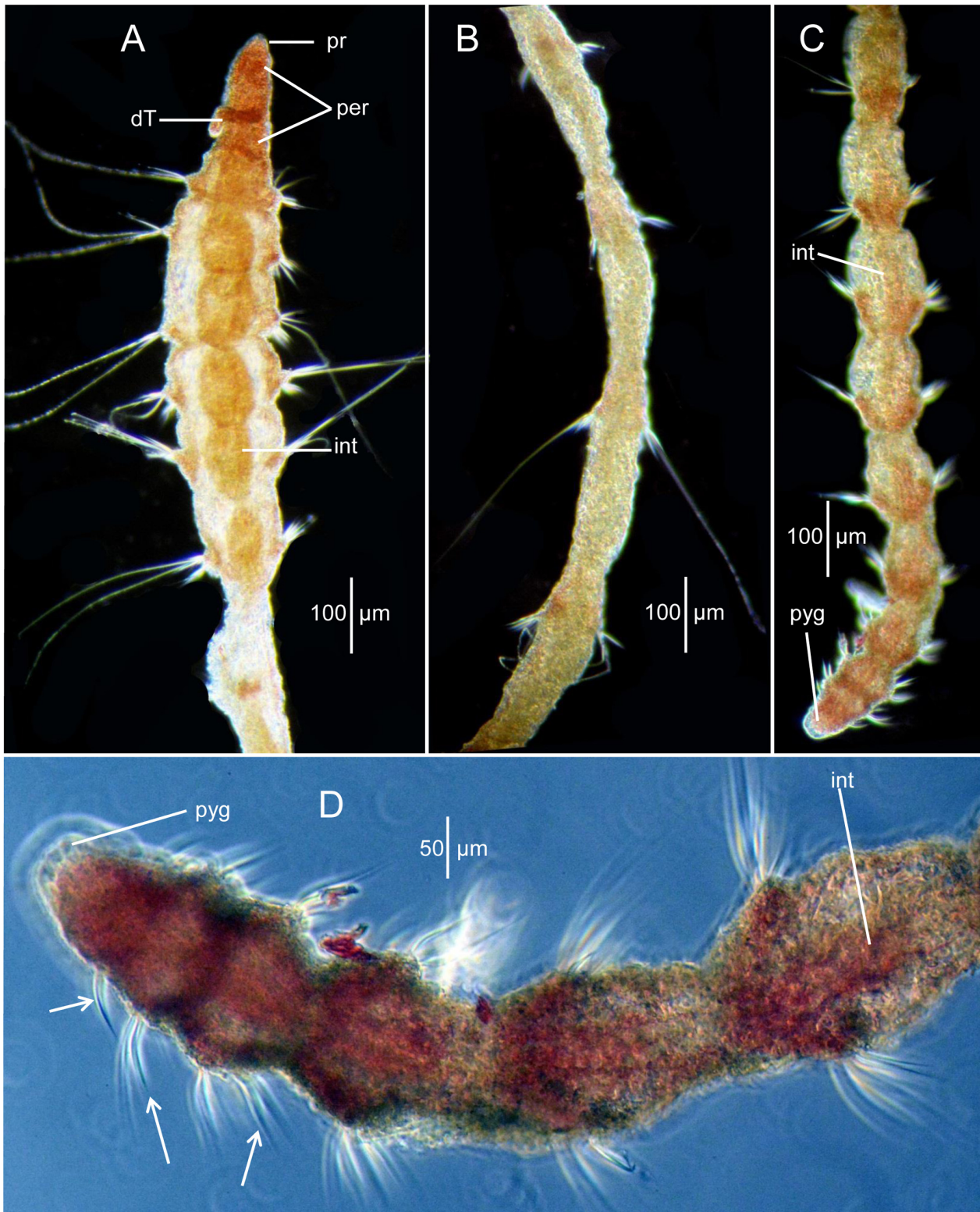


FIGURE 10. *Aphelochaeta wilsoni* n. sp. Holotype (LACM-AHF Poly 11268): A, anterior end, dorsal view; B, middle body segments, dorsal view; C, posterior segments and pygidium, dorsal view; D, far posterior segments, dorsal view (arrows denote thick capillaries).

Noto- and neuropodia close together along entire body, individual parapodia simple mounds on posterior margin of anterior and posterior segments from which setae arise; parapodia of middle body more elongate (Fig. 9B), sometimes pointed, extending laterally from posterior end of each segment from which setae arise. All setae capillaries, with those of anterior and middle segments long, but relatively simple, with narrow shaft gradually tapering to fine tip (Fig. 9D); with about 6–7 capillaries per fascicle, many notopodia having 1–2 long natatory-like capillaries (Fig. 10A–B). Far posterior setigers with 2–3 short, bent neurosetae, those of posterior-most segments shorter, with thick, curved shafts, appearing spinous (Figs. 9E–F, 10D) but tapering to short, finely pointed tip; notosetae of same segments including 2–3 longer, thin capillaries.

Pygidium a simple disk-like lobe ventral to anal opening (Fig. 10C–D).

Methyl Green stain. Stain somewhat concentrated over first 4–5 anterior segments, but no stain retained over rest of body; no pattern.

Etymology. This species is named for Dr. George D.F. (Buz) Wilson, prominent deep-sea biologist and isopod specialist who has written extensively on the benthic biology of the Clarion-Clipperton Fracture zone.

Remarks. *Aphelochaeta wilsoni* n. sp., like most of the abyssal cirratulids encountered in this study, has an elongate, threadlike body. Although a few of the anterior segments are crowded in some specimens, the individual segments are generally moniliform in shape along the entire body, with those of middle segments becoming long and pellet-shaped before rounding up again in the far posterior segments. This is in contrast to the type-species, *A. monilaris* (Hartman, 1960), from off California and *A. hormosa* Blake, 2018 from Antarctica that have distinct moniliform segments limited to middle body segments, and the anterior and posterior segments forming expanded regions of narrow, crowded segments.

Unlike other species of *Aphelochaeta*, *A. wilsoni* n. sp. has a few short, heavy-shafted capillary neurosetae in the posterior-most, pre-pygidial segments. These heavier shafted capillaries suggest a modification of posterior segments similar to species of *Chaetozone* and *Tharyx* where acicular spines of various kinds and size are present. However, these thicker curved capillaries in *A. wilsoni* n. sp. exhibit no other modification that would suggest they belong to the other genera.

Distribution. Abyssal Pacific Ocean, Clarion-Clipperton Fracture Zone, 4500–4860 m.

Genus *Caulleriella* Chamberlin, 1919

Type species: *Cirratulus viridis* Langerhans, 1881, original designation by Chamberlin 1919.

Diagnosis. Prostomium elongate; peristomium short to elongate, dorsal tentacles usually beginning anterior to setiger 1. Middle body segments not beaded; parapodia with noto- and neuropodia widely separated from one another. Modified setae including bidentate, crotchet-like hooks, not arranged into modified cinctures.

Remarks. Species of *Caulleriella* are among the easier bitentaculate cirratulids to identify. Unlike other bitentaculates, the noto- and neuropodia are widely separated from one another on each setiger and bidentate hooks are present in at least the neuropodia somewhere along the body. Species of *Caulleriella* species, however, have rarely been reported from deep-sea habitats. *Caulleriella bathytata* n. sp. reported here represents the deepest known occurrence for the genus.

Caulleriella bathytata new species

Figures 11–12

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Caulleriella sp. A: Wilson & Hessler 1987: 66, Appendix E.

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion-Clipperton Fracture Zone. NOAA BIE Project site, coll. D.D. Trueblood, Sandia box corer, Sta. DDT-9-94, 0–2 cm fraction, 29 Jul 1994, 12°54.980'N, 128°35.440'W, 4877 m, **holotype** (USNM 1557546); Sta. DDT-1-93, 08 Sep 1993, 12°56.042'N, 128°35.940'W, 4824 m, 1 specimen (USNM 1557549); Sta. DDT-2-93, veg. 16, 0–2 cm fraction, 10 Aug 1992, 12°56.166'N, 128°35.520'W, 4869 m, 1 **paratype** (USNM 1557545); Sta. DDT-9-93, veg. 25, 0–2 cm fraction, coll. 03 Sep 1993,

12°56.280'N, 128°35.440'W, 4860 m, 1 **paratype** (USNM 1557547); Sta. DDT-1-94, veg 1, 0–2 cm fraction, 25 Jul 1994, 12°55.788'N, 128°35.843'W, 4851 m, 1 specimen (USNM 1557548).—**ECHO I, DOMES Site C**, R/V *Melville* cruise, coll. R. Hessler, Sta. Sta. H348C, 1–5 cm fraction, 13 Jun 1983, 14°38.0720'N, 125°38.0720'W, 4504 m, 1 specimen (LACM-AHF Poly 11275); Sta. H361N, 1–5 cm fraction, 18 Jun 1983, 14°42.0775'N, 125°25.8565'W, 4567 m, 1 specimen (LACM-AHF Poly 11276).

Description. A long, narrow, threadlike species. Holotype complete, with long, slender body, 8.2 mm long, 0.20 mm across anterior and some middle segments, 0.10 mm across far posterior segments, with 51 setigers; not expanded anywhere along length. One complete paratype (USNM 1557547) 12 mm long, 0.21 mm wide across anterior setigers, with 49 setigers. Anterior segments 1–7 narrow, about twice as wide as long; subsequent segments becoming elongate, up to two or three times as long as wide in about 30 middle segments (Fig. 12D), with some much longer, 5–6 times as long as wide, becoming elongate, but not moniliform; posterior segments rounded, shorter (Figs. 11C, 12E). Body generally cylindrical in cross section, with no dorsal or ventral grooves. One paratype (USNM 1557545) with 3–4 middle segments distended due to large ova measuring 60–70 µm in diameter (Fig. 12A, C). Color in alcohol: opaque white, no pigmentation.

Pre-setiger region elongate, narrow, about twice as long as wide (Figs. 11A–B). Prostomium triangular, weakly separated into anterior and posterior sections, narrowing to pointed tip (Figs. 11A–B, 12A–B); eyespots absent; nuchal organs elevated mounds on posterior lateral margins (Fig. 11B). Peristomium generally smooth with no distinct lateral grooves, annulations or dorsal crest, merging almost seamlessly with anterior margin of setiger 1 (Fig. 11A–B). Dorsal tentacles arising from near posterior margin of peristomium (Figs. 11A–B, 12B); first pair of branchiae arising directly posterior to dorsal tentacles (Fig. 11A–B). Second pair of branchiae on setiger 1, arising posterior to first pair dorsal to notosetae; subsequent branchiae in similar location (Fig. 11B). Branchiae present on few middle segments, not observed in posterior segments.

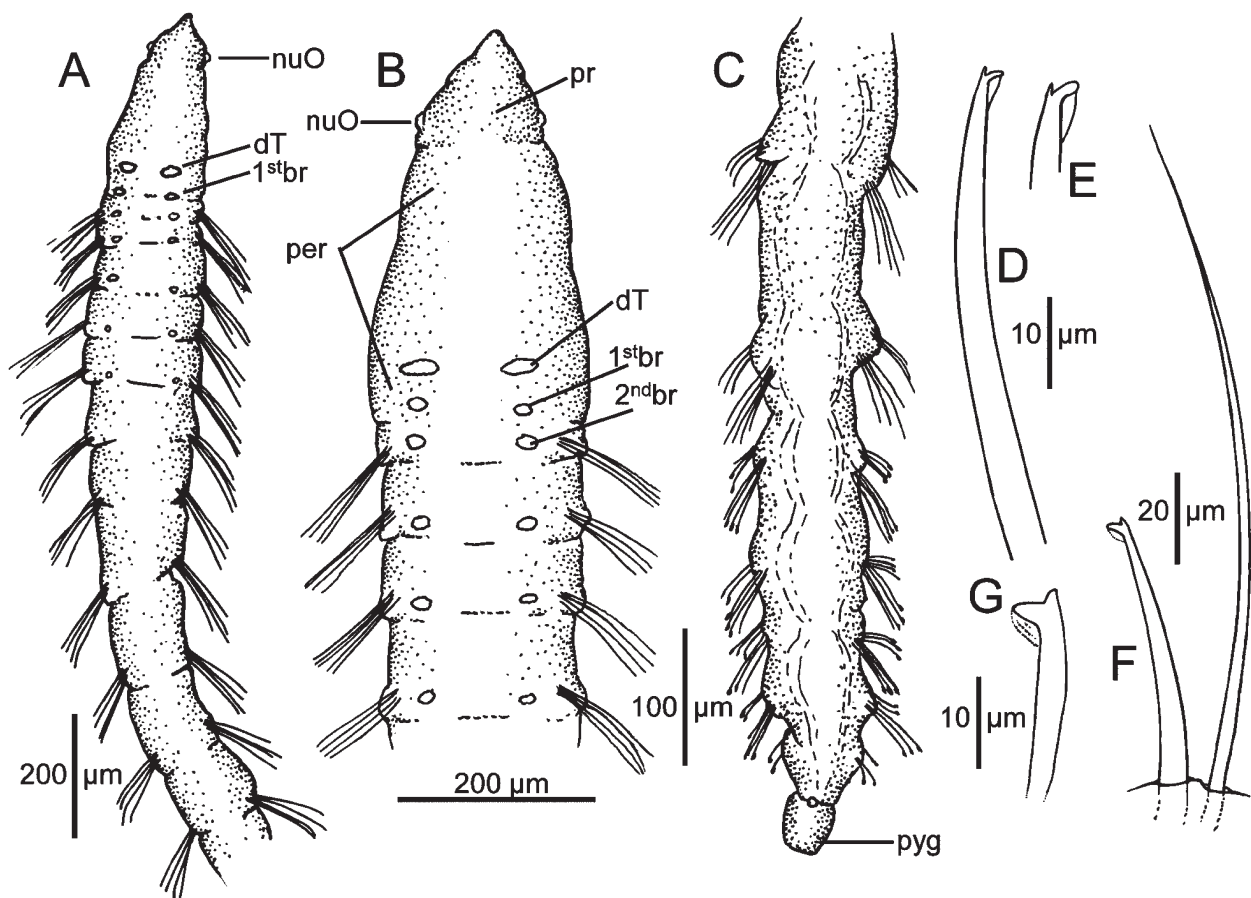


FIGURE 11. *Caulleriella bathytata* n. sp. Holotype (USNM 1557546): A, anterior end, dorsal view with 11 setigers; B, anterior end, dorsal view, detail of pre-setiger region and first four setigers; C, posterior end, dorsal view; D, notopodial bidentate hook; E, detail of hook (not to scale); F, neuropodial bidentate hook and capillary, G, detail of hook.

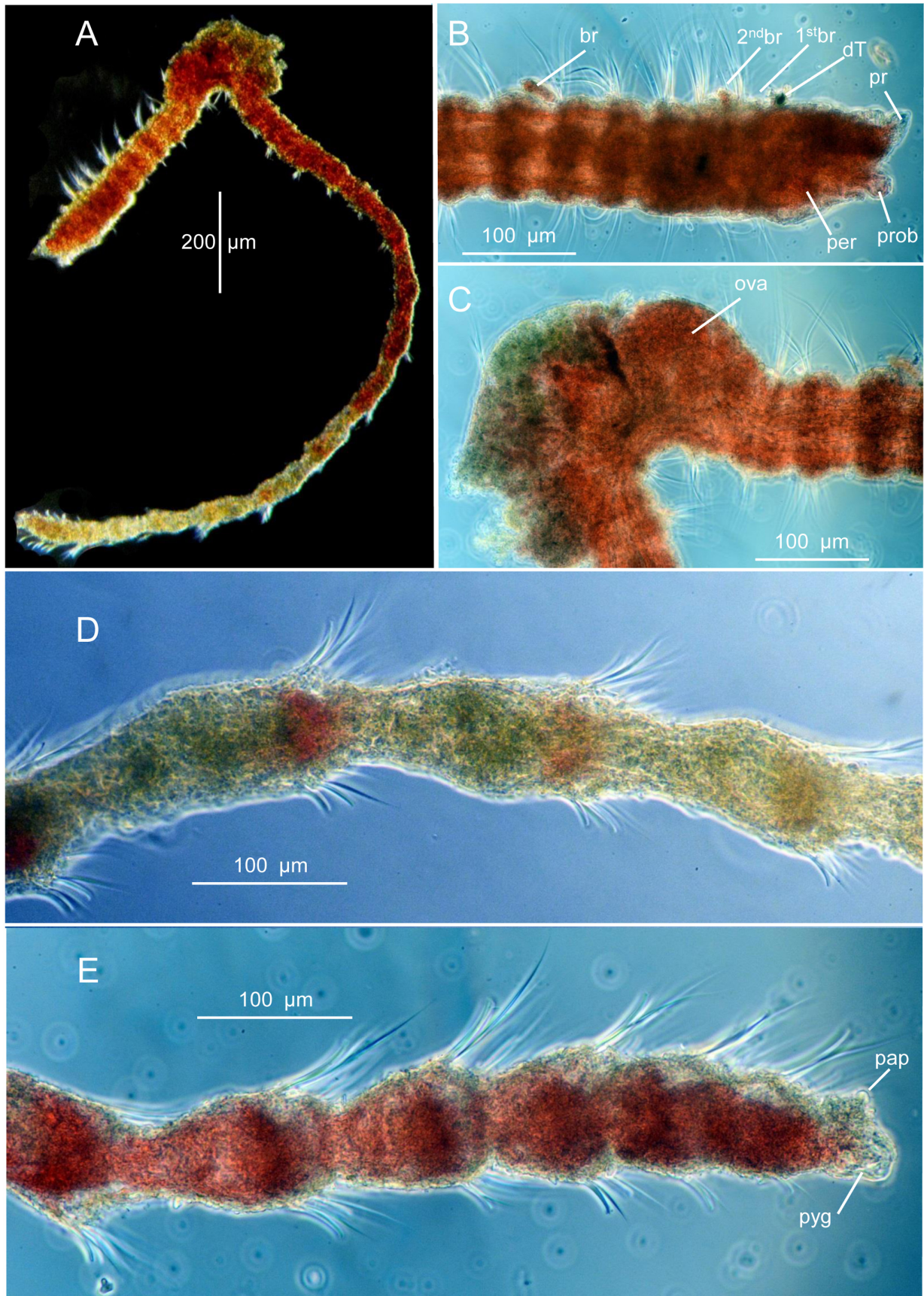


FIGURE 12. *Caulleriella bathytata* n. sp. Paratype (USNM 1557545): A, entire worm, left lateral view; B, anterior end, right lateral view; C, anterior swollen segments with sperm packets; D, middle body segments, dorsal view; E, posterior segments and pygidium, left lateral view. All stained with Shirlastain A.

Noto- and neuropodia reduced to low mounds from which setae arise; podial lobes somewhat larger in farthest posterior segments. Setae all capillaries along most of body; bidentate acicular spines appearing in last 5–6 segments on 51-setiger holotype (setigers 45–46), but somewhat more anteriorly on 49-setiger paratype (USNM 1557547): neuroaciculars (setiger 31), notoaciculars (setiger 39). Capillaries of first ten setigers elongate, with broad blades bearing thin fringe of fibrils along one edge, numbering about 7–8 per fascicle; capillaries of subsequent segments narrower, with thinner blades, reduced to 4–5 per fascicle along most of body until far posterior segments where capillaries increase to 5–6 before being replaced by acicular hooks over last few segments. Paratype (USNM 1557547) with a few long natatory-like setae on 7–12 anterior setigers. Bidentate acicular hooks up to 4–5 per noto- and neuropodium in farthest posterior setigers, with notopodial hooks (Fig. 11D–E) about twice as long as neuropodial hooks (Fig. 11F–G). Individual hooks with curved shaft tapering to a main fang at about a 45° angle to shaft on concave side and surmounted by a minute apical tooth (Fig. 11D–G). A short transparent hood extends from main fang, merging with shaft (Fig. 11D–G); no hood or crest apparent on the convex side.

Pygidium a simple achaetous segment with terminal anus and large, rounded ventral lobe (Fig. 11C); a pair of minute dorsal papillae observed on one specimen dorsal to ventral lobe (Fig. 12E).

Variability. Small specimens with the acicular hooks beginning more anteriorly than on the holotype but limited to posterior one-third of body. Long natatory-like notosetae present or absent.

Methyl Green stain. Stain retained on dorsal and lateral surface of pre-setiger region, but somewhat diffuse. No stain retained elsewhere on body.

Etymology. The epithet *bathytata*, is from the Greek *bathys* for deep sea.

Remarks. To date, only three of the 38 previously known species of *Caulleriella*, are known from depths of 1000 m or greater; these are all from around Antarctica (Blake 2018): *C. antarctica* Hartman, 1978 (1120 m), *C. fimbriata* Blake, 2018 (1884 m), and *C. kacysae* Blake, 2018 (1035 m). Occurring at a depth of more than 4800 m, *Caulleriella bathytata* n. sp. is the deepest recorded species of the genus discovered to date and like its Antarctic deep-water congeners has a small, fragile, threadlike body. Other undescribed deep-water species of *Caulleriella* occur in the North Atlantic (Blake unpublished).

The very long, threadlike body of the largest specimens of *C. bathytata* n. sp. extends for up to 12 mm with a width that is so narrow that the specimens tend to break easily upon handling. It is remarkable that three of the specimens are complete and survived the sample processing intact (a testament to the careful sample handling by Drs. Trueblood and Hessler).

Caulleriella bathytata n. sp. differs from its congeners in having bidentate hooks with a transparent hood extending from the main fang to the concave side of the shaft. Such a hood has not been previously recorded in the Cirratulidae and as such is highly diagnostic for this species. However, a microscope with high magnification (1000 x) is required to clearly observe the hood. Some *Caulleriella* species, however, do have a hood or crest on the convex side of the shaft, which extends forward forming or otherwise being part of the apical tooth (e.g., *C. antarctica*: Blake 2018: Fig. 19F).

Habitat & biology. All BIE specimens were collected from the 0–2 cm depth fraction of the box core, suggesting they reside at or just under the sediment-water interface. Some specimens of *C. bathytata* n. sp. have 3–4 enlarged segments between the anterior and middle body segments that are distended due to large ova (Fig. 12A, C).

Distribution. Abyssal Pacific Ocean, Clarion–Clipperton Fracture Zone, 4504–4877 m.

Genus *Chaetozone* Malmgren, 1867

Type species: *Chaetozone setosa* Malmgren, 1867, by monotypy.

Diagnosis. (after Blake 2018). Prostomium blunt to conical, peristomium short to elongate, usually lacking eye spots, with a pair of small nuchal slits or depressions at posterior edge; with a single pair of grooved dorsal tentacles arising from posterior edge of peristomium, or sometimes more posterior on an asetigerous anterior segment, or rarely an anterior setiger. First pair of branchiae arising from an achaetous segment or first setiger; or sometimes with first two pairs of branchiae on a single anterior segment. Body usually expanded anteriorly, rarely with middle or posterior body segments beaded or moniliform; narrowing posteriorly or posterior end often expanded. Setae include capillaries on most setigers and sigmoid acicular spines in neuropodia and notopodia; spines typically concen-

trated in posterior segments, forming distinct cinctures with spines carried on elevated membranes; cinctures with few to many spines sometimes encircling entire individual posterior segments, accompanied with none to many alternating capillaries; bidentate spines sometimes present in juveniles or occasionally accompanying unidentate spines in ventral most position of far posterior setigers of adults; some species with long, natatory-like capillaries, sometimes limited to gravid individuals. *Pygidium* a simple lobe, disk like, or with long, terminal cirrus.

Remarks. *Chaetozone* is the largest genus of Cirratulidae with 54 species (Blake 2018). Species of *Chaetozone* are characterized by having prominent acicular spines in noto- and neuropodia that in posterior segments arise from elevated podial lobes or membranes that carry the spines and produce a distinctive armature. In some species, the noto- and neuroacicular spines together nearly encircle the posterior segments.

Although widely distributed globally in shelf and slope depths, species of *Chaetozone* are rare in abyssal depths below 3000 m. To date, only six species have been reported from lower continental slope or abyssal depths greater than 3000 m (Blake 2006, 2018). These species are mainly in the eastern Pacific and Southern Oceans where upwelling and primary production is high in surface waters, providing a rich nutrient supply to the seafloor. To date, no species have been reported from oligotrophic habitats such as those found at the CCFZ.

In the present study, three species of *Chaetozone* were identified from the CCFZ samples. All are small and have elongate threadlike bodies that differ from the more robust bodies of typical species of *Chaetozone* including those from deep water. However, the distinctive posterior spines are present and prominent.

Chaetozone akaina new species

Figures 13–14

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Chaetozone sp. B: Wilson & Hessler 1987: 66 Appendix E.

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion-Clipperton Fracture Zone.

NOAA BIE Project site, coll. D.D. Trueblood, Sandia box corer, Sta. DDT-5-94, veg. 20, 2–5 cm fraction, 27 Jul 1994, 12°55.798'W, 128°35.769'N, 4879 m, **holotype** (USNM 1557544).—**ECHO I, DOMES Site C**, R/V *Melville* cruise, coll. R. Hessler, Sandia box corer, Sta. H349C, 1–5 cm fraction, 14 Jun 1983, 14°38.3925'N, 125°27.1791'W, 4517 m, 1 **paratype** (LACM-AHF Poly 11277); Sta. H350C, 0–1 cm fraction, 14 Jun 1983, 14°38.1226'N, 125°26.8208'W, 4506 m, 1 **paratype** (LACM-AHF Poly 11278); Sta. H356T, 1–5 cm fraction, 21 Jun 1983, 14°42.4541'N, 125°24.2664'W, 4518 m, 1 **paratype** (LACM-AHF Poly 11279); Sta. H357, 0–1 cm fraction, 23 Jun 1983, 14°42.1404'N, 125°24.2787'W, 4480 m, 1 juvenile (LACM-AHF Poly 11280); Sta. H362C, 0–1 cm fraction, 18 Jun 1983, 14.7013°N, 125.4309°W, 4480 m, 1 **paratype** (LACM-AHF Poly 11281).

Description. An elongate, slender species with narrow pre-setiger region, gradually widening to about setiger 15 (Figs. 13A, 14A), then narrowing. Holotype complete in two parts, 9.67 mm long, widest 0.2 mm at about setiger 10–12, far posterior segments narrowing to 0.07 mm wide, with 50 setigerous segments. Complete paratype (LACM-AHF Poly 11279) 4.5 mm long with 35 setigers; incomplete paratype (LACM-AHF Poly 12281) 5.8 mm long with 27 setigers. Body generally cylindrical in cross section, posterior third of body with prominent armature consisting of heavy spines and capillaries forming partial cinctures (Fig. 13B). Large heart body visible in anterior segments (Fig. 14A). Color in alcohol light tan.

Pre-setiger region elongate, narrow, about as long as first five setigers (Figs. 13A, 14A–B). Prostomium short, conical with rounded apex; eyespots absent; nuchal organs not observed. Peristomium divided into two weakly developed annular rings, grooves not prominent, best seen laterally; both rings equivalent in length, first ring widest, merging with narrow second ring (Figs. 13A, 14B); dorsal surface smooth, dorsal crest absent; dorsal tentacles arising about mid-way along second ring (Figs. 13A, 14B); first pair of branchiae located immediately posterior to dorsal tentacles near boundary with setiger 1. Setiger 1 weakly set off from peristomium; second pair of branchiae arising in line with first pair, dorsal to notosetae; subsequent branchiae in same location (Figs. 13A, 14B). Branchiae or their stubs evident for only 8–10 setigers, not observed along rest of body.

Parapodia of anterior and middle segments reduced, with setae arising from low mounds or directly from body wall (Fig. 13A); no parapodial shoulders present in anterior segments. Anterior segments with noto- and neuropodia close to one another, then becoming farther apart in middle segments and closing up again posteriorly. Posterior segments with parapodia becoming elevated, forming prominent cinctures of spines (Fig. 13B). Anterior segments with

prominent fascicles of long capillaries, a few natatory-like notosetae in anteriormost segments. Acicular spines first present in neuropodia from setiger 3 on all five type specimens; initially a single spine accompanied by 4–8 capillaries (Fig. 14D), increasing to two and then three spines in middle segments and 3–4 spines in far posterior segments; acicular spines first present in notopodia from setiger 6–7, following similar pattern of numbers as neuroacicular spines. Posterior cinctures each with 3–4 spines in noto- and neuropodia (Figs. 13B, 14E), with up to 6–8 spines on a side; fewer spines on smallest specimens. Spines accompanied by a variable number of long, thin capillaries, usually alternating with spines. Individual spines thick, with weakly curved to pointed apex; core of spine relatively clear (Fig. 14F); spines unusually large and conspicuous for such a thin, elongate worm (Figs. 13B–E, 14C–E).

Posterior end terminating in pygidial segment with a flattened dorsal lobe and broad ventral disk below anal opening (Figs. 13B, 14C).

Methyl Green stain. No obvious pattern, stain absent from pre-setiger region and retained more or less uniformly on anterior and middle segments. Some stain appearing concentrated within intersegmental grooves of some segments and across venter as a band on a few segments, but pattern not prominent.

Etymology. The epithet is from the Greek, *akaina*, f., for thorn or spine, referring to the large acicular spines found on this small species.

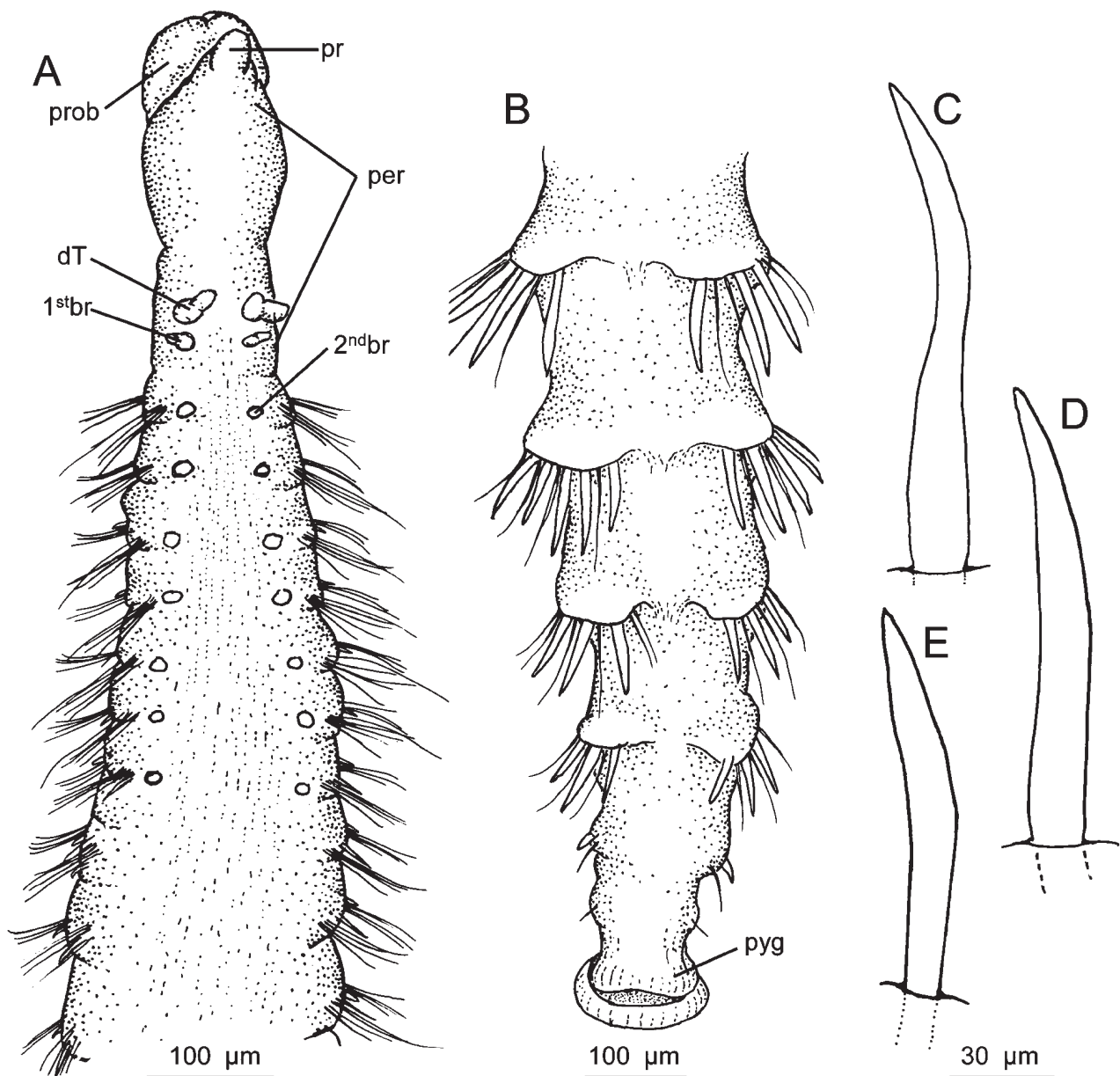


FIGURE 13. *Chaetozone akaina* n. sp. Holotype (USNM 1557544): A, Anterior end, dorsal view; B, posterior end, dorsal view; C, notopodial acicular spine from posterior setiger; D–E, neuropodial acicular spines from posterior setiger.

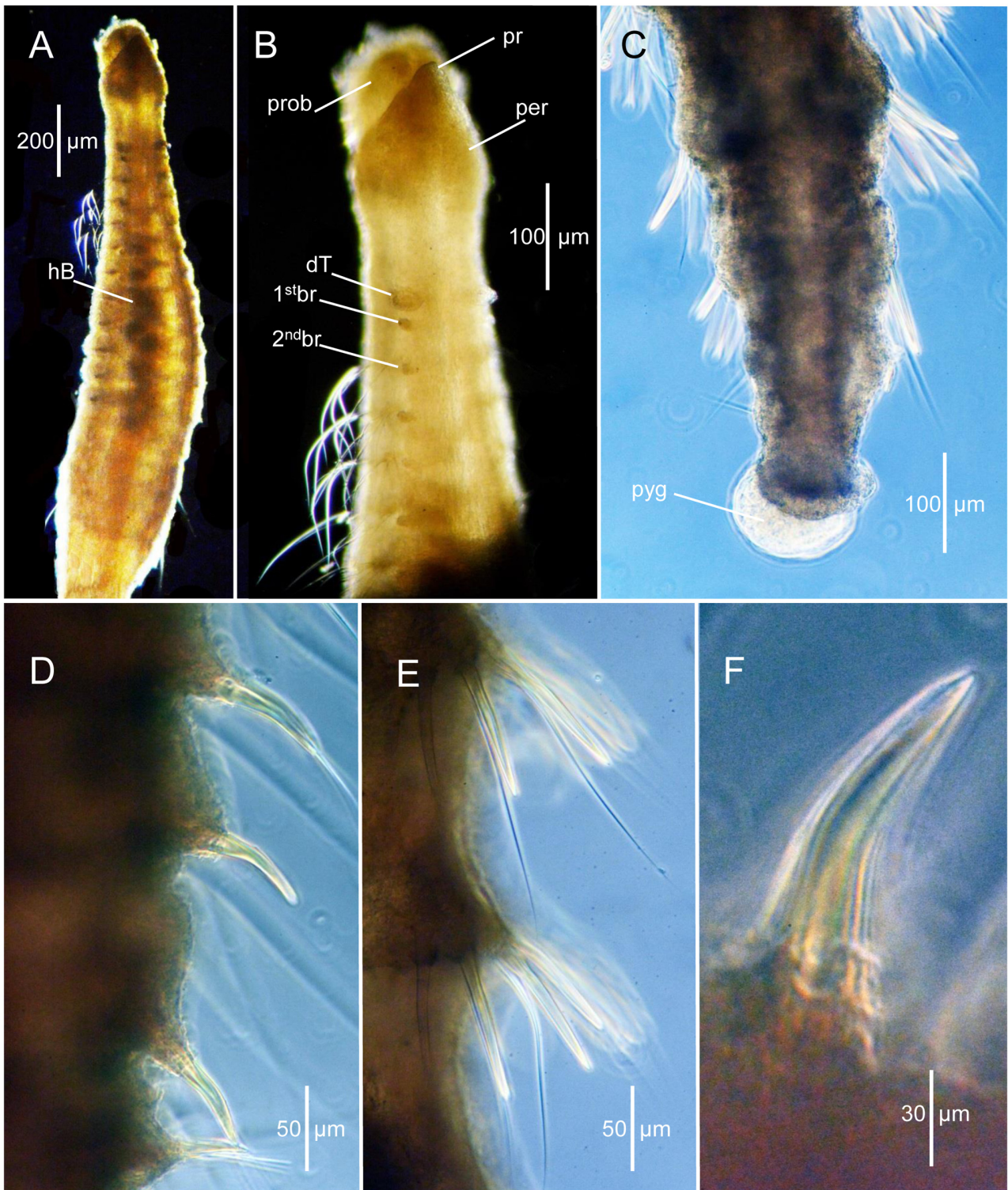


FIGURE 14. *Chaetozone akaina* n. sp. Holotype (USNM 1557544): A, anterior one-third of body, dorsal view; B, anterior end, dorsal view; C, posterior end, dorsal view. Paratype (LACM-AHF Poly 11279): D, neuro-podial acicular spines from anterior segments; E, posterior noto- and neuro-podial acicular spines; F, neuro-podial acicular spine. Stained with Shirlastain A.

Remarks. Like other bitentaculate cirratulids discovered in these abyssal samples, *Chaetozone akaina* n. sp. has an elongate, narrow body; however, this species does have a slight widening of anterior segments. Unique characteristics include the long pre-setiger region, which is as long as the first five setigers and about 2.5 times as long as wide, and an unusual pygidium with a narrow dorsal lobe and a large broad ventral disk. The most obvious character however is the large size of the acicular spines. These begin in setigers 3 and 6–7 in the neuro- and noto-

podia, respectively; other species of *Chaetozone* at the CCFZ have acicular spines beginning in middle or posterior segments. The posterior cinctures of these spines are far more conspicuous than in other species encountered and occur over many more segments.

The parapodia of some anterior and middle parapodia are widely separated, reminiscent of species of *Caulleriella*. However, none of the spines show any evidence of being bidentate and the posterior spines are clearly arranged into reduced cinctures. *Chaetozone armata* Hartman, 1963 from California shelf depths has widely separated parapodia throughout, but in that species the neuropodial hooks number 3–4 per setiger in anterior setigers, then are reduced to a single spine in posterior segments (Blake 1996). This species was recently transferred to *Caulleriella* because some bidentate hooks were observed in small specimens and appear to be abraded in larger specimens (Blake & Magalhães 2019).

Distribution. Abyssal Pacific Ocean, 4480–4880 m.

Chaetozone grasslei new species

Figures 15–16

urn:lsid:zoobank.org:act:3215B796-C25E-4512-8261-2D6BCC792267

Chaetozone sp. A: Wilson & Hessler 1987: 66 Appendix E (in part).

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion-Clipperton Fracture Zone. NOAA BIE Project site, coll. D.D. Trueblood, Sandia box corer, Sta. DDT-5-93, veg. 14, 0–2 cm fraction, 13 Aug 1993, 12°56.566'N, 128°35.408'W, 4870 m, **holotype** (USNM 1557550); Sta. DDT-5-93, veg. 19, 2–5 cm fraction, 1 **paratype** (USNM 1557551); Sta. DDT-3-93, veg. 11, 0–2 cm fraction, 10 Aug 1993, 12°55.972'W, 128°35.395'N, 4867 m (1, USNM 1557552); Sta. DDT-7-93, veg. 16, 2–5 cm fraction, 02 Sep 1993, 12°56.303'W, 128°35.311'N, 4844 m, 1 **paratype** (USNM 1557553); Sta. DDT-11-93, veg. 23, 2–5 cm fraction, 04 Sep 1993, 12°56.055'N, 128°35.695'W, 4859 m (1, USNM 1557554); Sta. DDT-8-94, on a nodule, 29 Jul 1994, 12°55.020'N, 128°35.400'W, 4880 m, 1 **paratype** (USNM 1557555).—**ECHO I, DOMES Site C**, R/V *Melville* cruise, coll. R. Hessler, 0.25 m² Sandia box core, Sta. H350, 0–1 cm fraction, 14 Jun 1983, 14°38.1226'N, 125°26.8208'W, 4506 m, 2 juveniles (LACM-AHF Poly 11282); Sta. 356, 0–1 cm fraction, 21 Jun 1983, 14°42.4541'N, 125°24.2664'W, 4518 m, 1 specimen (LACM-AHF Poly 112843); Sta. H357, 0–1 cm fraction, 23 Jun 1983, 14°42.1404'N, 125°24.2787'W, 4510 m, 1 specimen (LACM-AHF Poly 11284); Sta. H357, top water from box core, 1 juvenile (LACM-AHF Poly 11285).

Description. An elongate, slender species (Fig. 16A). Holotype (USNM 1557550) complete, 3.5 mm long, 0.150 mm wide across anterior setigers, with 36 setigerous segments; paratype (USNM 1557553) in two parts, 4.9 mm long, 0.22 mm wide across anterior segments, with 46 setigerous segments. Anterior 5–6 segments narrow, about three times wider than long (Fig. 15A), middle and posterior segments becoming longer, eventually about 1.5 times as long as wide, sometimes appearing oval or moniliform (Figs. 15B, 16A–B). Holotype and a few larger paratypes with some individual segments along body enlarged, appearing distended due to concentration of ingested sediment particles in intestine (Fig. 16A–B). Dorsum rounded, venter flattened or with shallow groove along much of body. Color in alcohol opaque white, with diffuse reddish pigment on peristomium.

Pre-setiger region relatively narrow, about twice as long as wide (Fig. 15A). Prostomium broadly triangular, narrowing to rounded tip (Fig. 15A); eyespots absent; nuchal organs not observed. Peristomium divided into two rings, first ring broadly rounded ending at narrower second ring bearing dorsal tentacles and first pair of branchiae (Fig. 15A); dorsal crest absent. Dorsal tentacles arising from anterior half of second peristomial ring, immediately followed by first pair of branchiae (Fig. 15A). Second pair of branchiae arising in a line posterior to the first branchiae dorsal to notosetae (Fig. 15A). Subsequent branchiae arising from similar location; branchiae not observed in middle and posterior segments.

Parapodia reduced, lateral shoulders not developed, distinct podial lobes absent, setae appearing to arise directly from body wall, some anterior setigers with low mound posterior to origin of setae. Posterior segments with spines and capillaries forming cinctures, but these arising from low ridges, not elevated into high membranes (Fig. 15B). Anterior setae all capillaries, 3–4 per noto- and neuropodia; additional long natatory capillaries on variable number of anterior and middle segments. Noto- and neuropodial acicular spines from setiger 16 on all larger specimens examined including holotype and a paratype (USNM 1557553). Spines initially numbering 1–2 per podia,

increasing to 5–6 spines in notopodia and 6–8 in neuropodia in posterior 10–12 setigers; with up to 11–14 spines on a side; spines alternating with slender capillaries. Individual spines curved, tapering to pointed tip; notoacicular spines longer and thinner (Figs. 15C, 16D) than neuropodial spines (Figs. 15D, 16E); core of spines clear, weakly striated.

Posterior segments narrow, pygidium with rounded lobe ventral to anal opening (Figs. 15B, 16C).

Methyl Green stain. A weak light-green peristomial band posterior to prostomium, otherwise stain not retained.

Etymology. This species is named for the late Dr. J. Frederick Grassle, prominent deep-sea benthic ecologist of the Woods Hole Oceanographic Institution and the Rutgers University Institute of Marine and Coastal Sciences. Dr. Grassle introduced this author to offshore benthos, including how to collect specimens with care and analyze and interpret the results with the most relevant statistical methods. From his numerous deep-sea surveys, he also provided this author and other investigators with numerous polychaetes from vents and other habitats that have resulted in a rich harvest of species new to science.

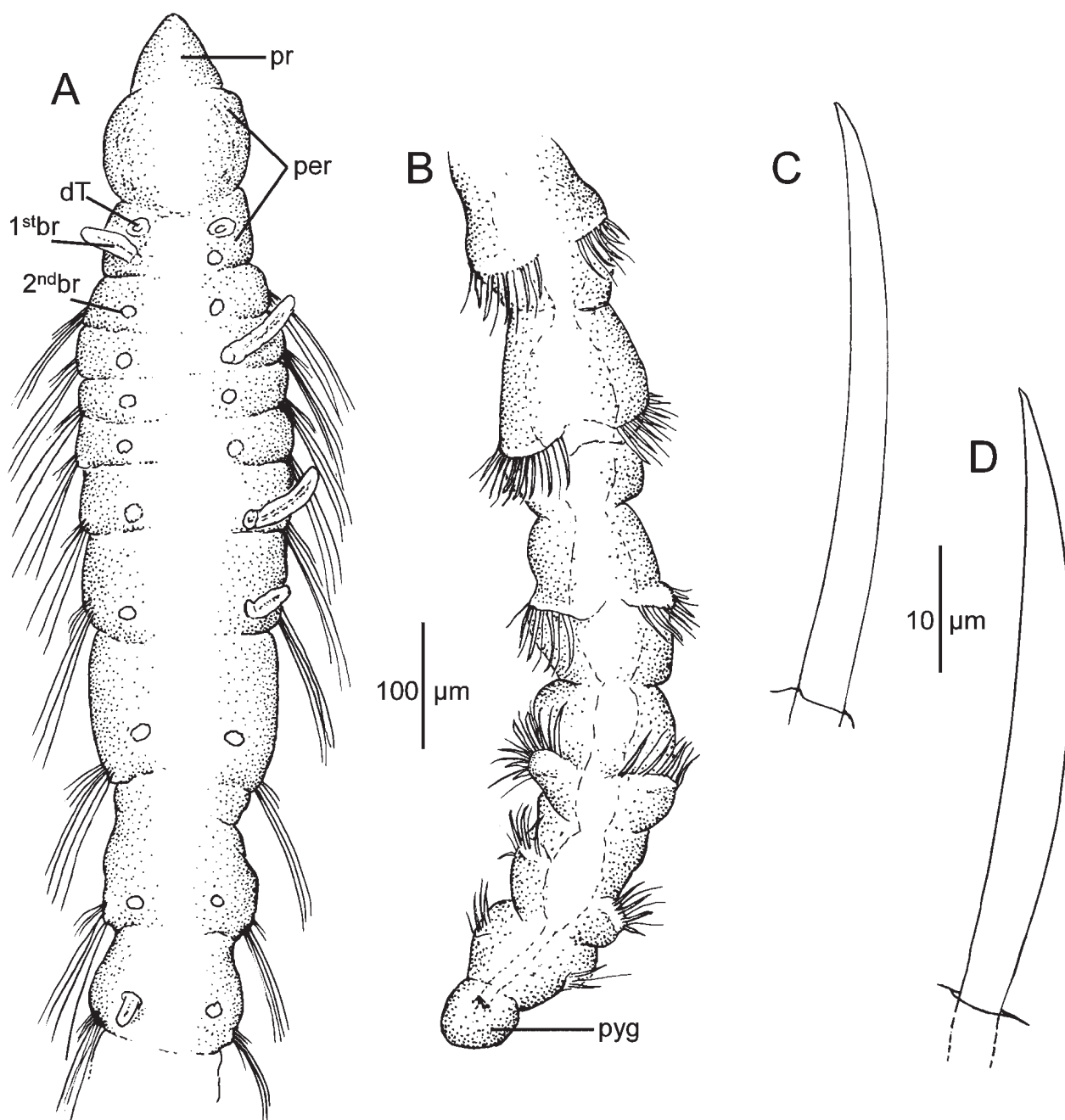


FIGURE 15. *Chaetozone grasslei* n. sp. Holotype (USNM 1557550): A, anterior end, dorsal view; B, posterior end, dorsal view; C, notopodial acicular spine, D, neuropodial acicular spine.

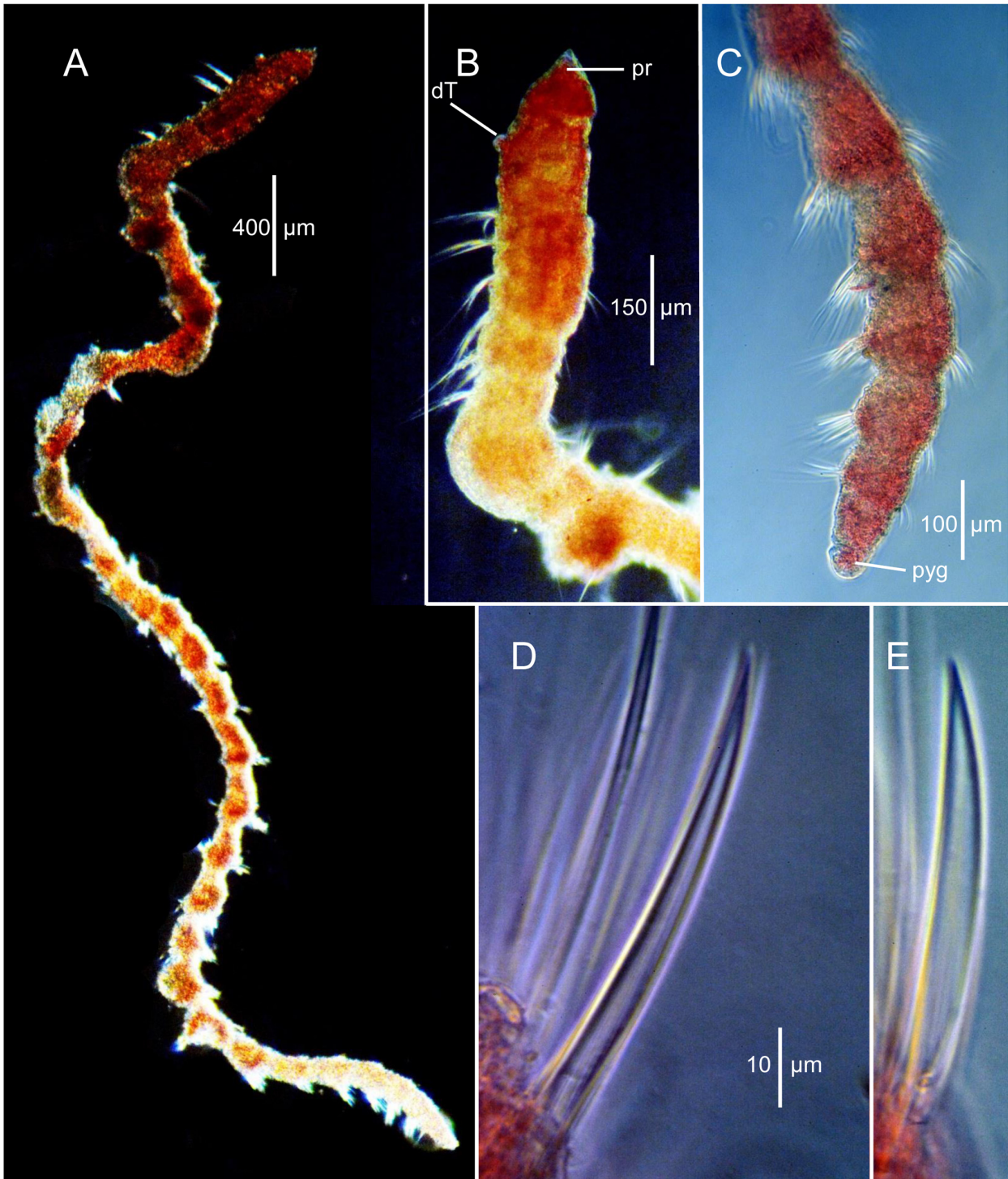


FIGURE 16. *Chaetozone grasslei* n. sp. Holotype (USNM 1557550): A, entire worm, mostly lateral view; B, anterior end, right lateral view; C, posterior end, dorsal view; D, notopodial acicular spine; E, neuropodial acicular spine (same scale as in D). Stained with Shirlastain A.

Remarks. *Chaetozone grasslei* n. sp. is a long slender species with only a slight widening of the anterior segments. Middle and posterior segments are longer and somewhat rounded, sometimes weakly moniliform. The distension of some body segments is due to concentration of sediment in the intestine. These enlarged segments, when present, are conspicuous owing to the otherwise elongate slender appearance of these worms.

There are no described species of *Chaetozone* that have the combination of a long, slender appearance to the body and two peristomial rings. See comments for *C. truebloodi* n. sp. (below).

Habitat & biology. The fine sediment in the gut of these worms suggests a silt-clay habitat. The worms were typically found in the upper 5 cm of the sediment column: two specimens including the holotype were in the 0–2 cm level in the box core and three specimens were at the 2–5 cm level.

Distribution. Abyssal Pacific Ocean, 4844–4880 m.

Chaetozone truebloodi new species

Figures 17–18

urn:lsid:zoobank.org:act:BF3877B9-C3AC-47A2-9FC2-D765D98DEEED

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion-Clipperton Fracture Zone. NOAA BIE Project site, coll. D.D. Trueblood, Sandia box corer, Sta. DDT-8-94, 29 Jul 1994, 12°55.020'N, 128°35.400'W, 4880 m, **holotype** (USNM 1557556).

Description. Holotype complete, 3 mm long, 0.23 mm wide across anterior setigers, 0.145 mm wide across posterior setigers, with 47–48 setigerous segments. Body elongate, narrow throughout; anterior segments not expanded (Figs. 17A, 18A), posterior segments gradually tapering toward posterior end (Fig. 18A). Several mid-body segments enlarged, due to intestinal folds filled with ingested sediment particles causing slight twist to preserved body (Fig. 18A). Dorsal and ventral grooves and ridges not present. Color in alcohol opaque white with no pigmentation.

Pre-setiger region relatively smooth, weakly triangular, about 1.5 times as long as wide (Figs. 17A, 18A–C). Prostomium short, triangular, tapering to broadly rounded apex (Figs. 17A, 18C); eyespots absent, nuchal organs low mounds on posterior lateral margin. Peristomium smooth, with no distinct grooves or annular rings; no dorsal crest present (Figs. 17A, 18C). Paired dorsal tentacles arising from posterior quarter of peristomium, with first pair of branchiae also on peristomium immediately posterior and slightly lateral to dorsal tentacles (Fig. 17A). Second pair of branchiae on setiger 1 arising dorsal to notosetae; subsequent branchiae in similar location (Fig. 17A); branchiae or scars not observed in posterior fourth of body.

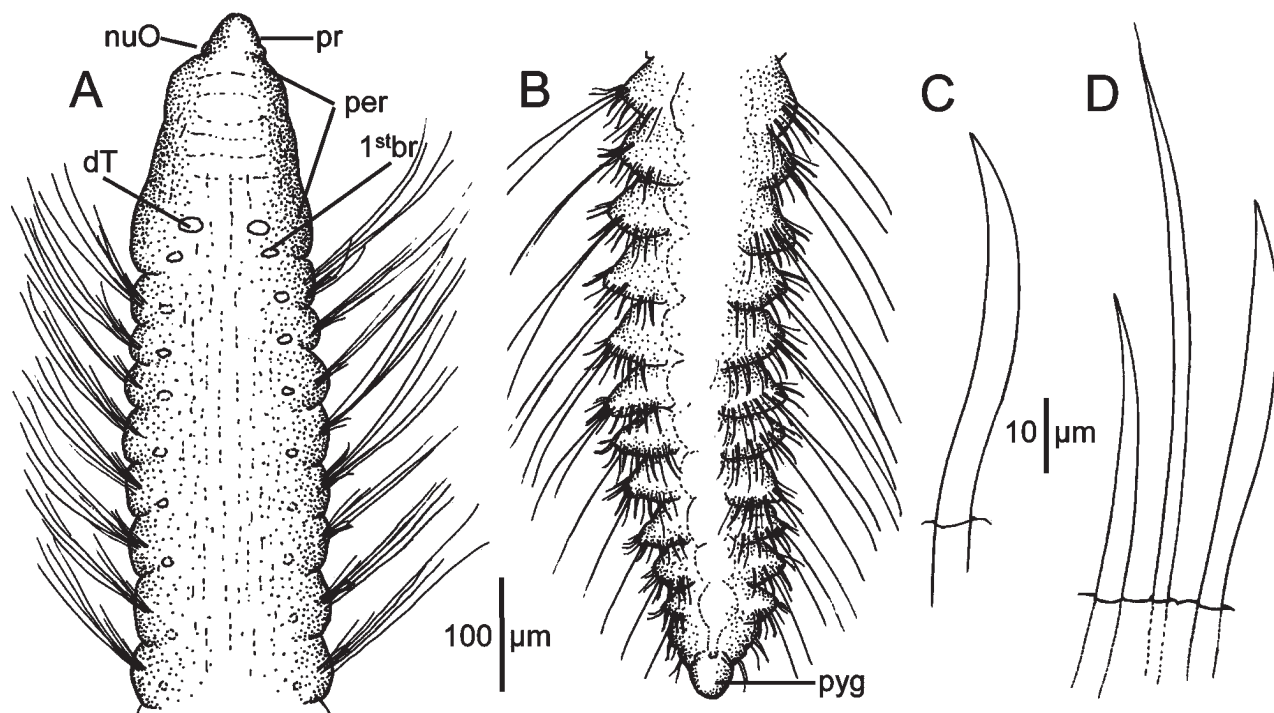


FIGURE 17. *Chaetozone truebloodi* n. sp. Holotype (USNM 1557556): A, anterior end, dorsal view; B, posterior end, dorsal view; C, neuropodial acicular spine; D, posterior neuropodial spines and capillary.

Parapodia reduced with distinct podial lobes not apparent, parapodial shoulders not developed. Dorsal surface between notopodia low, smooth, rounded. Posterior parapodia with cinctures of spines and capillaries partially elevated, but not on high membranes (Figs. 17B, 18D). All segments with long, natatory-like notosetae, 3–4 in anterior segments and 1–2 posteriorly (Figs. 17A–B, 18C–D). Anterior setae all capillaries with about 4–5 each in

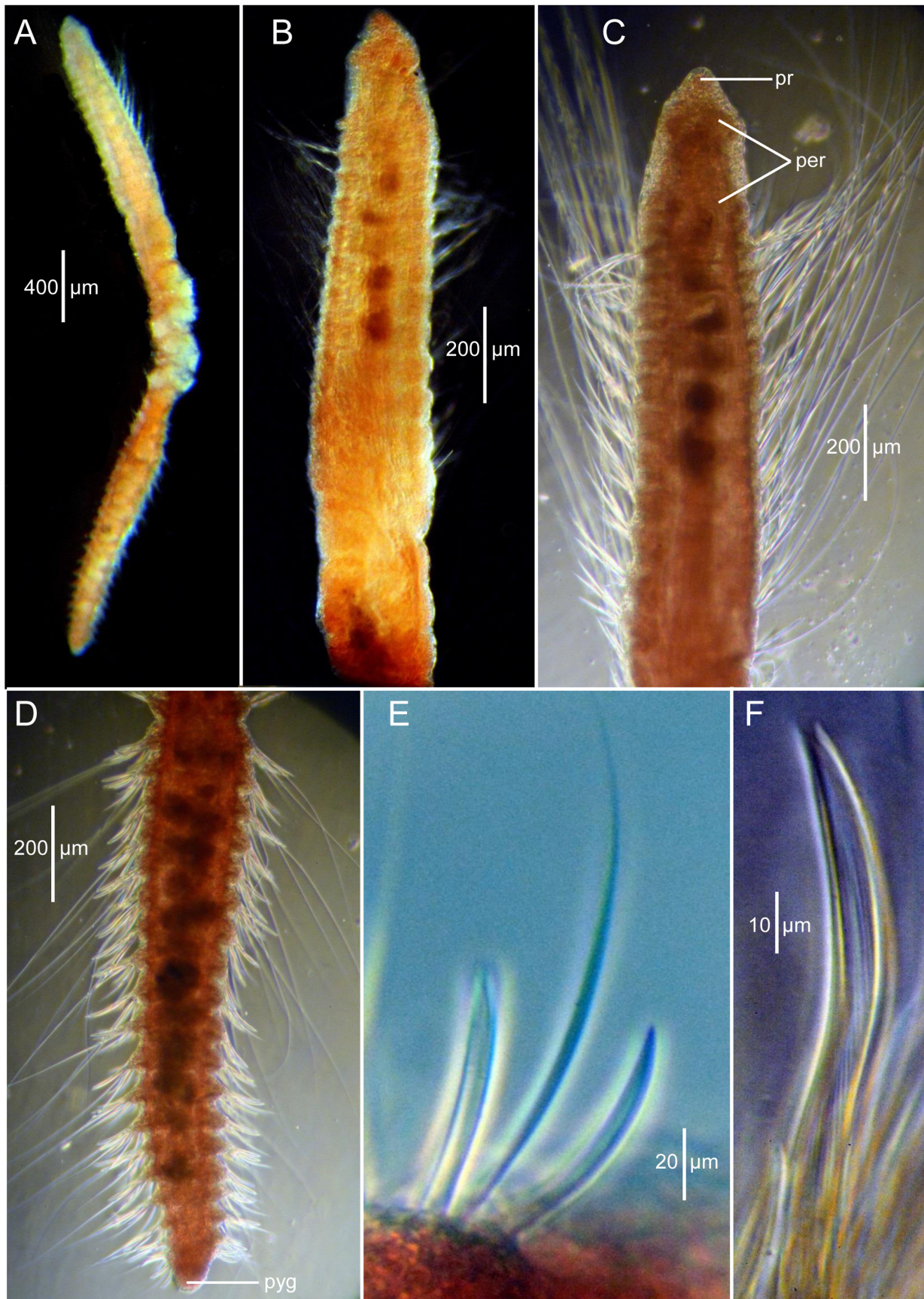


FIGURE 18. *Chaetozone truebloodi* n. sp. Holotype (USNM 1557556): A, entire worm, dorsal view; B, anterior end, dorsal view, emphasizing surficial morphology; C, anterior end, dorsal view, emphasizing capillary setae; D, posterior end, dorsal view; E, posterior neurosetae; F, neuropodial acicular spine. Stained with Shirlastain A.

noto- and neuropodia. Neuroacicular spines from setiger 9, with one spine at first increasing to 3–4 by setiger 13 and 4–5 in posterior cinctures; notoacicular spines from setiger 22, with one spine at first increasing to four per notopodium in posterior cinctures. Cinctures of 8–9 spines on a side with capillaries irregularly arranged, sometimes alternating with spines, or in multiples between spines. Individual spines curved, tapering to pointed tip (Figs. 17C–D, 18E–F); internal core with long striations (Fig. 18F). Notoacicular spines longer (Fig. 17C) than neuropodial spines.

Posterior segments terminating in pygidium with rounded pygidial lobe ventral to anal opening (Figs. 17B, 18D).

Methyl Green stain. Stain concentrated on prostomium, a few dark speckles on dorsum of peristomium; some stain concentrated in intersegmental grooves of anterior setigers; rest of body not retaining stain.

Etymology. This species is named for Dr. Dwight David Trueblood, Project Manager and Chief Scientist for the Benthic Impact Experiment conducted for NOAA at the Clarion-Clipperton Fracture Zone in 1993–1994.

Remarks. The long, slender body of *Chaetozone truebloodi* n. sp. is similar to that of *C. grasslei* n. sp. The two species differ in the nature of the pre-setiger region where *C. truebloodi* n. sp. has a smooth peristomium without annular rings and *C. grasslei* n. sp. has two distinct rings with the first ring being large, rounded, and conspicuous. Both species have long, natatory-like capillaries, but in *C. truebloodi* n. sp. they are numerous and conspicuous along the entire body; whereas in *C. grasslei* n. sp. they are variable and mostly concentrated in a few anterior and middle segments. In addition, *C. grasslei* n. sp. has up to 11–14 spines on a side in posterior cinctures, whereas *C. truebloodi* n. sp. has no more than 8–9.

Distribution. Abyssal Pacific Ocean, 4880 m.

Genus *Kirkegaardia* Blake, 2016

Type-species: *Monticellina heterochaeta* Laubier, 1961. Blake (2016) by original designation.
Monticellina Laubier, 1961. Junior homonym of *Monticellina* Westblad, 1953.

Diagnosis. (after Blake 2016). Bitentaculate cirratulids with distinct body regions and all setae distally pointed. Pre-setigerous area typically elongate, cylindrical, with short, blunt prostomium and long peristomium with none to many weakly developed annulations; dorsal tentacles arising on posterior margin of peristomium, anterior to setiger 1. Thoracic notopodia often shifted dorsally, elevated, producing distinct dorsal groove along thoracic region; other species with thoracic parapodia more lateral, leaving broad elevated dorsum; parapodia of middle and posterior regions lateral. Middle body segments longer than wide, frequently beadlike; posterior segments wider than long, somewhat crowded, with posteriormost segments usually expanded or enlarged. Setae include simple capillaries with fibrils observed under SEM and denticulated capillaries with distinct denticles present along one edge of seta; denticles visible at 400–1000x; blades usually basally expanded.

Remarks. In conjunction with the establishment of *Kirkegaardia* as a replacement name for *Monticellina*, Blake (2016) described 16 new species including *K. fragilis* from the Clarion-Clipperton Fracture Zone. A single specimen labeled *Tharyx* sp. A. from the ECHO I material has been determined to be *K. fragilis*. Another specimen from the BIE samples was also identified.

Kirkegaardia fragilis Blake, 2016

Kirkegaardia fragilis Blake, 2016: 50–52, Fig. 25.
Tharyx sp. A: Wilson & Hessler 1987: Appendix E (in part).

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion-Clipperton Fracture Zone, ECHO I, DOMES Site C, R/V *Melville* cruise, coll. R. Hessler, Sta. H356, 0–1 cm fraction, 4 Jun 1983, 14°38.1226'N, 125°26.8208'W, 4506 m, 1 specimen (LACM-AHF Poly 11286).—NOAA BIE Project site, coll. D.D. Trueblood, Sandia box corer, Sta. DDT-5-93, veg. 15, 2–5 cm fraction, 31 Aug 1993, 12°56.566'N, 128°35.408'W, 4870 m, 1 specimen (USNM 1557557).

Diagnosis. Based on holotype and paratype (USNM 1407165 and 1407166, respectively) from Blake (2016). Body fragile, elongate, narrow, without dorsal or ventral grooves. Holotype 4.2 mm long, 0.17 mm wide across thoracic segments, with 40 setigerous segments. Pre-setiger region of holotype longer than wide. Prostomium conical, tapering to narrow, rounded apex. Peristomium smooth, with thin lateral lines suggesting 2–3 annulations. Dorsal tentacles arising from posterior end of peristomium; first branchiae on setiger 1. Thoracic region of holotype with five setigers, paratypes with 5–7 setigers. Transition to long narrow abdominal region abrupt, with segments as long as wide transitioning to beadlike in middle abdominal segments; far posterior region weakly expanded, flattened ventrally, terminating in narrow, elongate, conical, unsegmented pygidial lobe. Parapodia reduced. Setae all capillaries, with fine denticles evident along one edge from about setiger 20 (middle body) in noto- and neuropodia; noto-setae with denticles directed ventrally and denticles of neurosetae directed dorsally, *vis-à-vis*. Setae numbering 6–8 in both noto- and neuropodia in thoracic segments, 5–7 in middle body segments; and 4–5 in posterior segments.

Remarks. Both of the new specimens generally agree with the original description of specimens from the same samples (Blake 2016). The specimen from Sta. DDT-5-93 (USNM 1557557) is complete, small, only 2.1 mm long with 20 setigerous segments; the denticulated capillaries begin at about setiger 10 or in the mid-body. The posterior segments are moniliform, but only the last two segments are expanded.

The specimen from Sta. H356 (LACM-AHF Poly 11286) is larger, also complete, with 38 setigers in two parts; measuring 5.4 mm long, 0.26 mm wide across the peristomium. The prostomium is broadly triangular, tapering to a rounded apex. The peristomium is weakly divided into two annular rings, with grooves observed only laterally, not crossing the dorsum. Dorsal tentacles arise on the posterior margin of the peristomium with the first branchiae on setiger 1. There are seven anterior or thoracic segments, longer than wide; subsequent abdominal segments are about as wide as long, becoming somewhat rounded posteriorly, but not moniliform. The last eight setigers are crowded, together forming an expanded posterior region that narrows to the pygidium, which consists of a rounded lobe ventral to the anal opening. The noto- and neurosetae are all capillaries; the first denticulated neurosetae occur on setiger 17; these setae are broad basally, tapering to narrow capillary tips. The first denticulated notosetae occur from about setiger 23, these are not as broad basally. The denticles are sharply pointed teeth and are observed along one edge of the expanded basal part of the setae. In a broad flattened view, the denticulated neurosetae have angled transverse grooves extending across the blade to the pointed teeth.

Distribution. Abyssal Pacific Ocean, 4506–4880 m.

Genus *Tharyx* Webster & Benedict, 1887. Emended, Blake 1991

Type species: *Tharyx acutus* Webster & Benedict, 1887, by monotypy.

Diagnosis. (after Blake 2018). Prostomium conical; peristomium elongate, with pair of grooved dorsal tentacles arising on posterior margin; first pair of branchiae typically arising immediately posterior to dorsal tentacles either on posterior margin of peristomium or on setiger 1; abdominal segments sometimes beadlike. Noto- and neurosetae arising close to one another, not widely separated. Setae include simple capillaries in anterior and middle setigers, acicular spines present in posterior setigers either in both noto- and neuropodia or only in neuropodia. Long, nata-tory-like setae present or absent. Spines typically short, curved, sometimes geniculate or sickle-shaped, narrowing to rounded irregularly notched or sub-bidentate tip; tips with pair of stunted or rounded knobs but not with two distinct teeth. Capillaries may accompany posterior spines or are absent, not alternating with spines when present. Pygidium with terminal anus and small ventral lobe or disk. Several species with black pigment markings on posterior lateral margin of peristomium.

Remarks. Following the revision by Blake (1991), species of *Tharyx* were restricted to those having knob-tipped or sub-bidentate acicular spines. Species having simple and serrated capillaries that were formerly included in *Tharyx* were moved to the genera *Aphelochaeta* and *Monticellina* (now *Kirkegaardia*), respectively. The status of the genus *Tharyx* and additional species were recently described by Blake & Göransson (2015) and Blake (2018) bringing the total number of known *Tharyx* species to 15. One new species has been identified from the CCFZ collections and is here described.

Tharyx hessleri new species

Figures 19–20

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Chaetozone sp. A: Wilson & Hessler 1987: 66 Appendix E (in part).

Material examined. North Equatorial Pacific Ocean, abyssal plain, Clarion–Clipperton Fracture Zone, ECHO I, DOMES Site C, R/V *Melville* cruise, coll. R. Hessler, Sta. H350C, 0–1 cm fraction, 4 Jun 1983, 14°38.1226'N, 125°26.8208'W, 4506 m, **holotype** (LACM-AHF Poly 11287); Sta. H360, nodule wash, 17 Jun 1983, 14°40.7987'N, 125°22.0379'W, 4500 m, **paratype** (LACM-AHF Poly 11288).

Description. A small, threadlike species; holotype complete, 3.72 mm long, peristomium 98 µm wide; anterior, middle, and posterior setigers of same width, about 92 µm, last few setigers narrowing slightly; with 39 setigers. Anterior setigers about 1.5 times as wide as long (Fig. 19A); middle and posterior segments becoming somewhat rounded, as long as wide, with far posterior setigers weakly moniliform (Figs. 19B, 20B–C). Paratype (LACM-AHF Poly H360) smaller, broken in two parts, only 2.0 mm long with 20 setigers. Body cylindrical in cross section, with no dorsal or ventral grooves. Color in alcohol opaque white; no pigment.

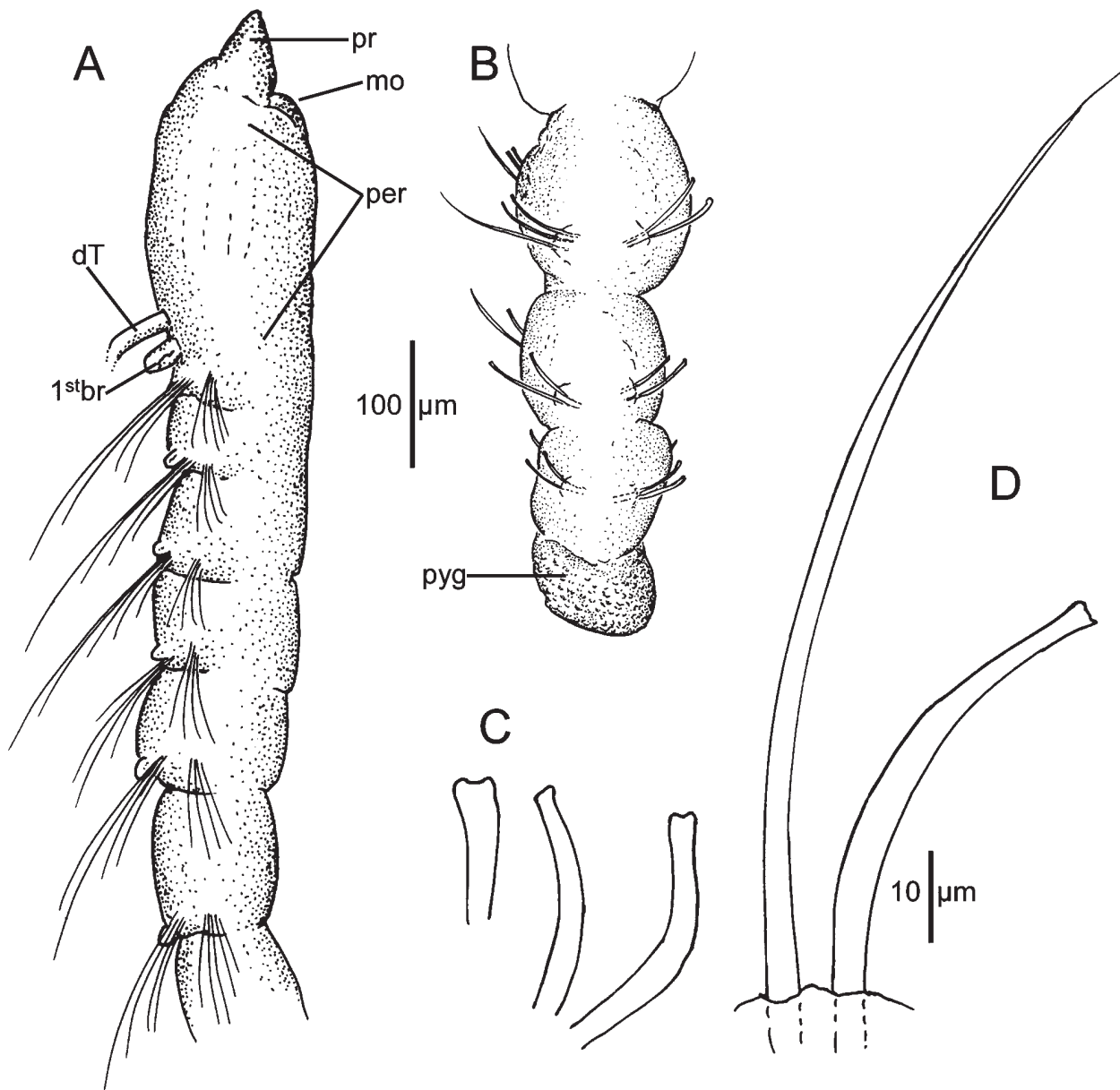


FIGURE 19. *Tharyx hessleri* n. sp. Holotype (LACM-AHF Poly 11287): A, anterior end, right lateral view; B, posterior end, dorsal view; C, neuroacicular spines; D, notoacicular spine and capillary.

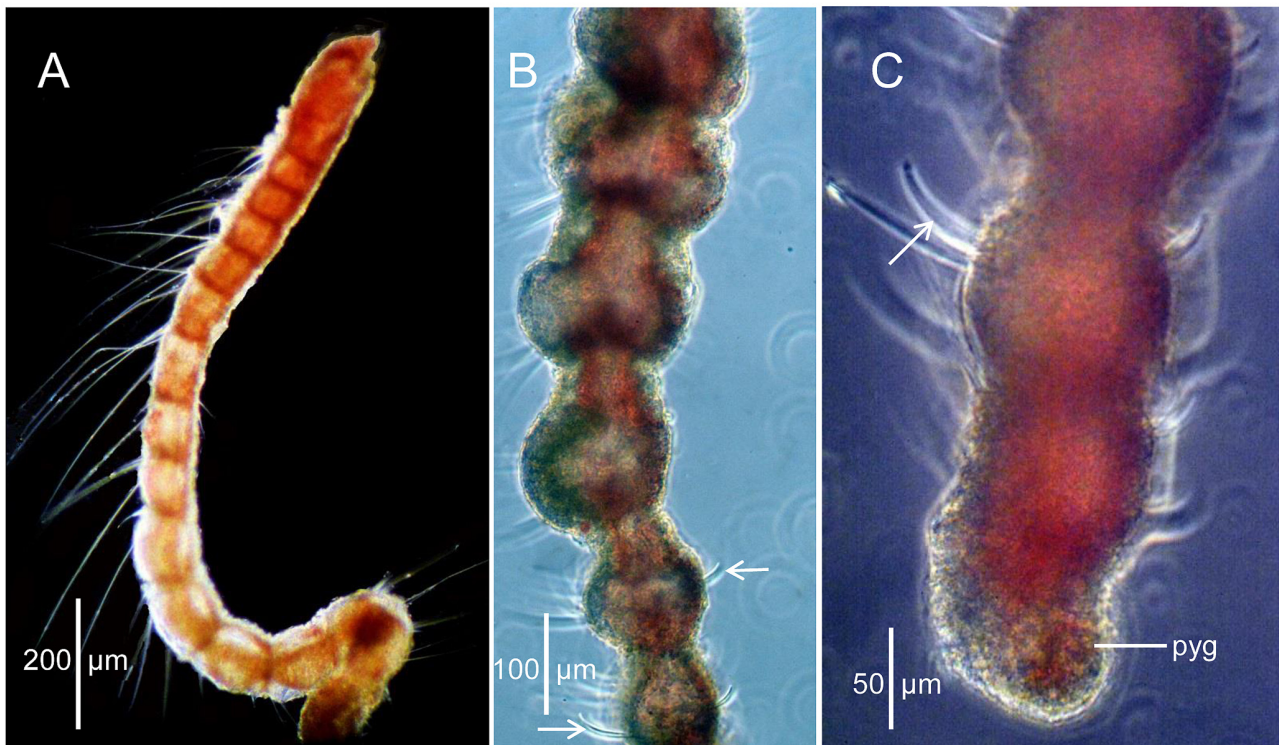


FIGURE 20. *Tharyx hessleri* n. sp. Holotype (LACM-AHF Poly 11287): A, anterior end through setiger 14, right lateral view; B, far posterior segments, dorsal view; C, posterior 3 setigers and pygidium, dorsal view. Stained with Shirlastain A.

Pre-setiger region approximately twice as long as wide, slightly longer than first three setigers (Figs. 19A, 20A). Prostomium triangular, tapering to narrow apex (Figs. 19A, 20A); eyespots absent; nuchal organs not observed. Peristomium entire, smooth, without annular rings (Fig. 19A); dorsal tentacles arising from posterior margin; first pair of branchiae arising immediately posterior and slightly lateral to dorsal tentacles (Fig. 19A). Second pair of branchiae arising from setiger 1, dorsal to notosetae; subsequent branchiae from similar location. Branchiae present as stubs over anterior and some middle segments, not observed on posterior segments.

Parapodia reduced to low mounds from which setae arise. Setae of anterior segments all capillaries with 4–5 notosetae, including some long, natatory-like, continuing through middle body (Figs. 19A, 20A); capillaries of middle and posterior segments shorter, 4–5 per fascicle. Holotype with neuro-acicular spines first present from setiger 18 in neuropodia and far posterior setiger 32 in notopodia. Neuropodial spines typically numbering 1–2 at first, accompanied by 2–3 capillaries; in posterior segments notopodia with 1–2 spines and 1–2 capillaries, neuropodia with 2–3 spines and capillaries present or absent. Notopodial spines of far posterior segments longer than those in neuropodia, but both sets of spines emerging prominently from posteriormost setigers (Figs. 19B, 20B–C). Spines curved, geniculate, terminating in stubby knob-tipped apex (Fig. 19C–D); no denticles observed along shaft.

Pygidium a thick rounded, ventrally directed lobe, surface with a coarse granular texture (Figs. 19B, 20C).

Methyl Green stain. No pattern, de-stains entirely.

Etymology. This species is named for Dr. Robert E. Hessler, prominent deep-sea ecologist whose pioneering work on deep-sea benthos, including collection of the ECHO I samples reported in this study, has inspired generations of scientists.

Remarks. Among the 15 described species of *Tharyx*, only two species have been recorded from depths of 2000 m or greater: *T. kirkegaardii* Blake, 1991 from off the U.S. Atlantic coast in slope and abyssal depths to 3000 m and *T. moniliformis* from the Weddell Sea in 2086 m. *Tharyx hessleri* n. sp. from 4500 m is therefore the deepest recorded for any species of the genus. Both *T. kirkegaardii* and *T. moniliformis* have serrations along the shaft and prominent knobs on the tips of the acicular spines thus providing a sub-bidentate appearance; in contrast, the knobs on the spines of *T. hessleri* n. sp. are rounded off, providing a worn appearance and there are no serrations along the shaft.

Distribution. Abyssal Pacific Ocean, 4500–4506 m.

Discussion

Records of abyssal Cirratulidae. Previous records of Cirratulidae from abyssal depths greater than 3500 m are few and until recently species have been assigned names of previously described species from widely distributed locations. Eight newly described species by Blake (2016, 2018) from the Pacific Ocean and around Antarctica are listed in Table 1 together with a few earlier records from Kirkegaard (1956), Hartman (1965, 1971), and Hartman & Fauchald (1971). This study represents the first effort to document deep-sea Cirratulidae from an abyssal plain habitat. It is noteworthy that the twelve bitentaculate Cirratulidae described here and in Blake (2016) from abyssal depths of 4500–4900 m at the CCFZ are all new to science (Table 2).

TABLE 1. Some previous records of abyssal Cirratulidae (> 3500 m)

Species	Location of deepest records	Depth (m)	Status	Reference
<i>Aphelochaeta brandtae</i>	Drake Passage	3957	Valid species	Blake 2018
<i>Aphelochaeta nigrorostrum</i> ¹	N Atlantic Ocean, off Bermuda	4825	Species inquirendum	Hartman & Fauchald 1971
<i>Chaetocirratulus neogracilis</i>	Peru-Chile Trench	4016	Valid species	Blake 2018
<i>Chaetozone biannulata</i>	South Sandwich Trench	6337	Valid species	Blake 2018
<i>Chaetozone gracilis</i>	Southern California	4016	Valid species	Moore 1923; Hartman 1971; Blake 1996
<i>Chaetozone “setosa”</i> ²	North Atlantic Ocean	4436–4950	Not <i>C. setosa</i> of Malmgren 1867	Hartman 1965; Hartman & Fauchald 1971
<i>Chaetozone spinosa</i>	Peru-Chile Trench	4100	Valid species	Blake 2018
<i>Chaetozone sp.</i> ²	Mozambique Basin	4866–5069	Unknown species	Hartman 1971
<i>Chaetozone spp.</i> ²	NW and Equatorial Atlantic Ocean	~4825	Unknown species	Hartman, 1965, 1971
<i>Kirkegaardia brigittae</i>	Bellinghausen Sea	3801	Valid species	Blake 2016
<i>Kirkegaardia fragilis</i>	CCFZ	4879	Valid species	Blake 2016
<i>Kirkegaardia jumarsi</i>	Peru-Chile Trench	5340	Valid species	Blake 2016
<i>Tharyx moniliformis</i>	Weddell Sea	3935	Valid species	Blake 2018
<i>Tharyx “multifilis”</i>	Banda Trench	6580	Not <i>Aphelochaeta multifilis</i> of Moore 1909	Kirkegaard 1956
<i>Tharyx sp.</i> ²	Mozambique Basin	4983	Unknown species	Hartman 1956

¹Holotype (LACM-AHF Poly 0902) examined; damaged, cannot be characterized beyond genus according to current criteria.

²Not described or characterized in original accounts.

Some species described in the present study represent depth records for the genera *Caulleriella* (*C. bathytata* n. sp.) and *Tharyx* (*T. hessleri* n. sp.). In addition, the six species of *Aphelochaeta* described here collectively represent the deepest confirmed records for the genus. *Aphelochaeta nigrorostrum* (Hartman & Fauchald, 1971) from the North Atlantic occurred in the same depth range, but the holotype (LACM-AHF Poly 0902) is in poor condition and although likely a species of *Aphelochaeta*, it cannot be characterized further. Prior to the present study, the only named species of *Chaetozone* confirmed from abyssal depths were *C. gracilis* Moore, 1909 from off southern California and *C. biannulata* Blake, 2018 from the South Sandwich Trench. Other abyssal records were either referred to *C. setosa*, the type species, or recorded simply as *C. sp.* Blake (2015) redescribed *C. setosa* from the type-locality off Spitzbergen, Norway, and noted that global records of the species refer to numerous undescribed taxa. Three species of *Chaetozone* from the CCFZ are newly described in the present study.

Seafloor characteristics at the DOMES C and BIE survey sites. The two sites are located approximately 350 km apart within the area between the Clarion and Clipperton fracture zones. DOMES site C has an average depth of about 4500 m; the BIE has an average depth of about 4870 m. Both sites were observed to have nodules visible on the surface: nodule coverages of 25–49% were observed in box cores collected at DOMES C site (Wilson & Hessler 1987; Wilson 2017) and overall nodule coverage at the BIE site was about 15% (Trueblood *et al.* 1997). The surficial sediments at DOMES C included a mix of pelagic red clay, siliceous ooze, and firmer Quaternary sediments;

nodules were imbedded in this sediment (Wilson 2017). Details of the sediments at the BIE site are not available but are likely similar to that of the DOMES site. The presence of the nodules provides additional habitat for polychaetes in an otherwise monotonous or undifferentiated environment consisting of fine-grained sediments. At least two of the cirratulids described in this study, *Chaetozone grasslei* n. sp. and *Tharyx hessleri* n. sp., were in part based on specimens that were actually in water that was rinsed from the surface of nodules (Table 2).

Morphology and habitats of abyssal Cirratulidae. One common characteristic of most of the abyssal cirratulids reported in the present study is a long, fragile, thread-like body in which the anterior and posterior ends are either not expanded or only weakly so. In addition, most species have long, natatory-like setae along some or all of the body. In practical terms, such fragile worms are difficult to collect intact and in good condition unless great care is taken during their collection, separation from the sediment, and preservation. It is remarkable, therefore, that each species reported was represented by one or a few specimens that were intact and well preserved. Two species, *Aphelochaeta tanyperistomia* n. sp. and *A. spargosis* n. sp., have more robust bodies with expanded anterior ends, suggesting they are active burrowers that likely use their expanded bodies to open burrows in the mud via crack propagation (Che & Dorgan 2010). These two species were taken from the 1–5 and 5–10 cm depths in the box cores, whereas, the species with consistently slender bodies were mostly collected from the 0–1 and 0–5 cm fractions as well as from the top water in the box or washed from the surface of nodules (Table 2). The slender threadlike species near the sediment-water interface likely burrow by separating particles as they move through the sediment. The presence of long natatory-like setae on some species may be an adaptation for movement at the sediment-water interface. The lack of gametes in these specimens would appear to preclude the long setae being important only during times of reproduction. Holding these setae close to a thin, elongate body would possibly provide rigidity and protection from disturbance.

TABLE 2. Abyssal Cirratulidae from the Clarion-Clipperton Fracture Zone

Species	Depth (m)	Status	Location ¹	Depth in sediment (cm)	Reference
<i>Aphelochaeta abyssalis</i> n. sp.	4514–4861	New species	DOMES C & BIE	0–5	This study
<i>Aphelochaeta clarionensis</i> n. sp.	4516–4518	New species	DOMES C	0–1 & top water	This study
<i>Aphelochaeta clippertonensis</i> n. sp.	4506–4870	New species	DOMES C & BIE	0–10	This study
<i>Aphelochaeta spargosis</i> n. sp.	4516	New species	DOMES C	1–5	This study
<i>Aphelochaeta tanyperistomia</i> n. sp.	4006–4877	New species	DOMES C & BIE	1–5; 5–10	This study
<i>Aphelochaeta wilsoni</i> n. sp.	4500–4860	New species	DOMES C & BIE	0–1	This study
<i>Caulleriella bathytata</i> n. sp.	4504–4877	New species	DOMES C & BIE	0–2; 1–5	This study
<i>Chaetozone akaina</i> n. sp.	4480–4880	New species	DOMES C & BIE	0–1; 1–5	This study
<i>Chaetozone grasslei</i> n. sp.	4844–4880	New species	DOMES C & BIE	0–2; 2–5; top water; on nodule	This study
<i>Chaetozone truebloodi</i> n. sp.	4880	New species	BIE	?	This study
<i>Kirkegaardia fragilis</i> Blake, 2016	4506–4880	Valid species	DOMES C & BIE	0–1; 0–2; 2–5	Blake 2016; this study
<i>Tharyx hessleri</i> n. sp.	4500–4506	New species	DOMES C	0–1; on nodule	This study

¹ DOMES C samples collected as part of the ECHO 1 Survey.

Records of Cirratulidae from the Clarion-Clipperton Fracture Zone. Despite the long-term interest in the CCFZ and numerous surveys over the past 35+ years, there are few published accounts that provide data on the numbers of Cirratulidae relative to polychaetes in total. Wilson (2017: Table S2) provides data on the names and densities per sample of polychaetes from 15 0.25 m² box core samples collected as part of the ECHO 1 survey at DOMES Site C in June 1983. Polychaetes accounted for 50.1% percent of the total benthic infauna (704 of 1390 specimens). Of these, the Cirratulidae with 70 specimens accounted for approximately 10% of the total polychaete density. DeSmet *et al.* (2017: S1) provide data on 12 similar box core samples from Sites B4 and B6 somewhat east of DOMES Site C. In that study, cirratulids accounted for about 12.4% of the total polychaete fauna. Therefore, with cirratulids accounting for 10–12% of the total density of polychaetes in these abyssal habitats, they are an important component in the overall benthic assemblage. However, given the overall low density of benthic macrofauna at the CCFZ, most species, including cirratulids, are rare. Of the 12 species of Cirratulidae reported in this study, eight

occur at both sites with three species occurring only at DOMES C and one species occurring only at the BIE site (Table 2). The two sites are approximately 350 km from one another along a depth gradient of 380 m from DOMES C to BIE.

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