



***Aphelochaeta* (Polychaeta: Cirratulidae) from the Pacific coast of Costa Rica, with a description of five new species**

HARLAN K. DEAN^{1,3} & JAMES A. BLAKE^{2,3}

¹*Department of Invertebrate Zoology, Museum of Comparative Zoology, Harvard University, 26 Oxford Street, Cambridge, Massachusetts 02138 USA. E-mail: harlan.dean@umb.edu*

²*Aquatic Research and Consulting, 24 Hitty Tom Road, Duxbury, MA 02332 USA. E-mail: jablake9@gmail.com*

³*University of Massachusetts, Boston, 100 Morrissey Blvd. Boston, MA 02125 USA*

Abstract

Five new species of bitentaculate Cirratulidae belonging to the genus *Aphelochaeta* are herein described from the Pacific coast of Costa Rica, all from shallow subtidal depths. *Aphelochaeta antelonga* **sp. nov.** is characterized by a long biannulate peristomium and fibrillated capillary setae and is from 11–18 m in the Gulf of Nicoya. *Aphelochaeta guimondi* **sp. nov.**, with a wide dorsal trough in the thorax and hirsute capillaries (visible using SEM), is described from 11–26 m in the Gulf of Nicoya. *Aphelochaeta praeacuta* **sp. nov.**, with its first peristomial annulation extending as a dorsal crest over the second annulation and first setiger, was collected from 11–28 m in Bahia Culebra. *Aphelochaeta striata* **sp. nov.**, collected from 11–28 m in the Gulf of Nicoya, is recognized by its narrow body and the transverse blue stripes across the venter of setigers 5–8 produced with methyl green stain. *Aphelochaeta zebra* **sp. nov.**, collected from a coral reef in Golfo Dulce, is characterized by its expanded posterior end and the darkly staining intersegmental regions using methyl green stain. Additionally, *A. glandaria* Blake, 1996, a species reportedly with a widespread geographic distribution (Blake, 1996), was also encountered subtidally from the Gulf of Nicoya and Golfo Dulce.

Key words: Annelida, Polychaeta, *Aphelochaeta*, taxonomy, new species, Eastern Pacific

Introduction

Polychaetes of the family Cirratulidae are poorly characterized and the recognition of distinct species has been difficult due to the relative lack of differentiating characters as well as the “lumping” of similar appearing species into a single species with variable characters. Blake (1991, 1996) began a reassessment of the bitentaculate genera of cirratulids, describing many new species as well as placing others in synonymy, and recognizing new generic designations. The eastern Pacific bitentaculate cirratulids have been further characterized with additional new species by Blake (2006, 2015), Doner & Blake (2009), and Dean & Blake (2007, 2009). The cirratulids are proving to be one of the more speciose families of polychaetes especially in offshore shelf and slope habitats (Blake 2006).

Perhaps the most enigmatic genus of bitentaculate cirratulids is *Aphelochaeta*. This genus was established by Blake (1991) to include bitentaculate cirratulids possessing all smooth capillary setae thus differentiating them from members of the genera *Monticellina* and *Tharyx*, all of which had previously been included in the single genus *Tharyx*. Blake (1996) redescribed the type species, *A. monilaris* (Hartman, 1960), and six new species from California, three of which had been previously misidentified as *A. monilaris*. Doner & Blake (2009) have since described two additional new species of *Aphelochaeta* from deep water off California. More recently, Elías & Rivero (2009) described a new species of *Aphelochaeta* from Argentina and Magalhães & Bailey Brock (2013) described three new species from Hawaii. A major problem in the identification of species in this genus is the apparent lack of setal characters and this has led to the recognition of a small number of weakly described, widely distributed species. The use of methyl green staining patterns as an additional identifying character has been helpful in the differentiation of species but has not been reported for many of the previously described species.

Dean & Blake (2007, 2009) re-examined species of the bitentaculate genera *Chaetozone*, *Caulleriella* and

Monticellina from the Pacific coast of Costa Rica and described three, five and six new species, respectively, from these genera. The present paper examines the species of the genus *Aphelochaeta* from this same region of Costa Rica and describes five new species: *A. antelonga* sp. nov., *A. guimondi* sp. nov., *A. praeacuta* sp. nov., *A. striata* sp. nov., *A. zebra* sp. nov., and the previously described species *A. glandaria* Blake, 1996.

Material and methods

Subtidal collections were taken during (1) a benthic survey of the Gulf of Nicoya, conducted from 1979 to 1982, using a modified Smith-McIntyre bottom grab (refer to Maurer & Vargas 1984 for more complete station data), (2) a survey of Bahia Culebra in May, 2011 using an Ekman grab and (3) a survey from the Nicoyan Peninsula (NP stations) and Golfo Dulce (GD stations) in December, 1985 on surveys on the RV *Victor Hensen* using a 50 cm x 50 cm box corer. The locations of earlier subtidal station sites in the Gulf of Nicoya may be found in Maurer & Vargas (1984) and for the Golfo Dulce in León-Morales & Vargas (1998). *Aphelochaeta zebra* sp. nov. was collected using SCUBA from the coral reef at Punta Islotes in Golfo Dulce by Ana Fonseca (now deceased). Intertidal specimens were collected by the senior author or José A. Vargas (Universidad de Costa Rica). Most specimens were preserved in 10% formalin and later transferred to 80% ethanol. The methyl green staining pattern (MGSP) was determined by submerging specimens in a saturated solution of methyl green (MG) in 80% ETOH for a minimum of 60 seconds followed by rinsing of excess stain in 80% ETOH. Specimens for Scanning electron microscopy (SEM) were critical point dried using CO₂ prior to being mounted on stubs and coated with gold (200Å thickness). SEM specimens were viewed with a Zeiss EVO 50 Scanning Electron Microscope at the Center for Nanoscale Systems (CNS), Faculty of Arts and Sciences, Harvard University.

Type specimens of the five newly described species are deposited in the Museum of Comparative Zoology (MCZ) in Cambridge, MA, USA; paratypes and additional material are deposited in the University of Costa Rica Museum of Zoology (UCRMZ), San Pedro, Costa Rica. Non-type materials are deposited in the general collections of the MCZ.

Abbreviations used on figures: an, annulations; 1st br, first branchiae; 2nd br, second branchiae; mdr, median dorsal ridge; nuO, nuchal organ; pr, prostomium tn, dorsal tentacle.

Species descriptions

Genus *Aphelochaeta* Blake, 1991

Type species: *Tharyx monilaris* Hartman, 1960. Designated by Blake 1991.

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

Remarks. The generic diagnosis was modified slightly to include the rounded prostomium of *A. zebra* sp. nov. Based upon setal morphology revealed using SEM it was necessary to stress that the lack of distinct serrations in this genus refers to their appearance using light microscopy. These serrations seen in SEM for some species of *Aphelochaeta* are visible fibril endings irregularly protruding along the shaft of the seta, typically with pointed tips and often frayed. These are structurally different from the protruding denticles or teeth found on setae in members of the genus *Monticellina*.

Aphelochaeta antelonga sp. nov.

Figures 1A, 2A–B, 3A

Aphelochaeta longisetosa: Dean 1996a (in part). Not Hartmann-Schröder, 1965. Not Carrasco, 1977.

Aphelochaeta glandaria: Dean 2004 (in part). Not Blake, 1996.

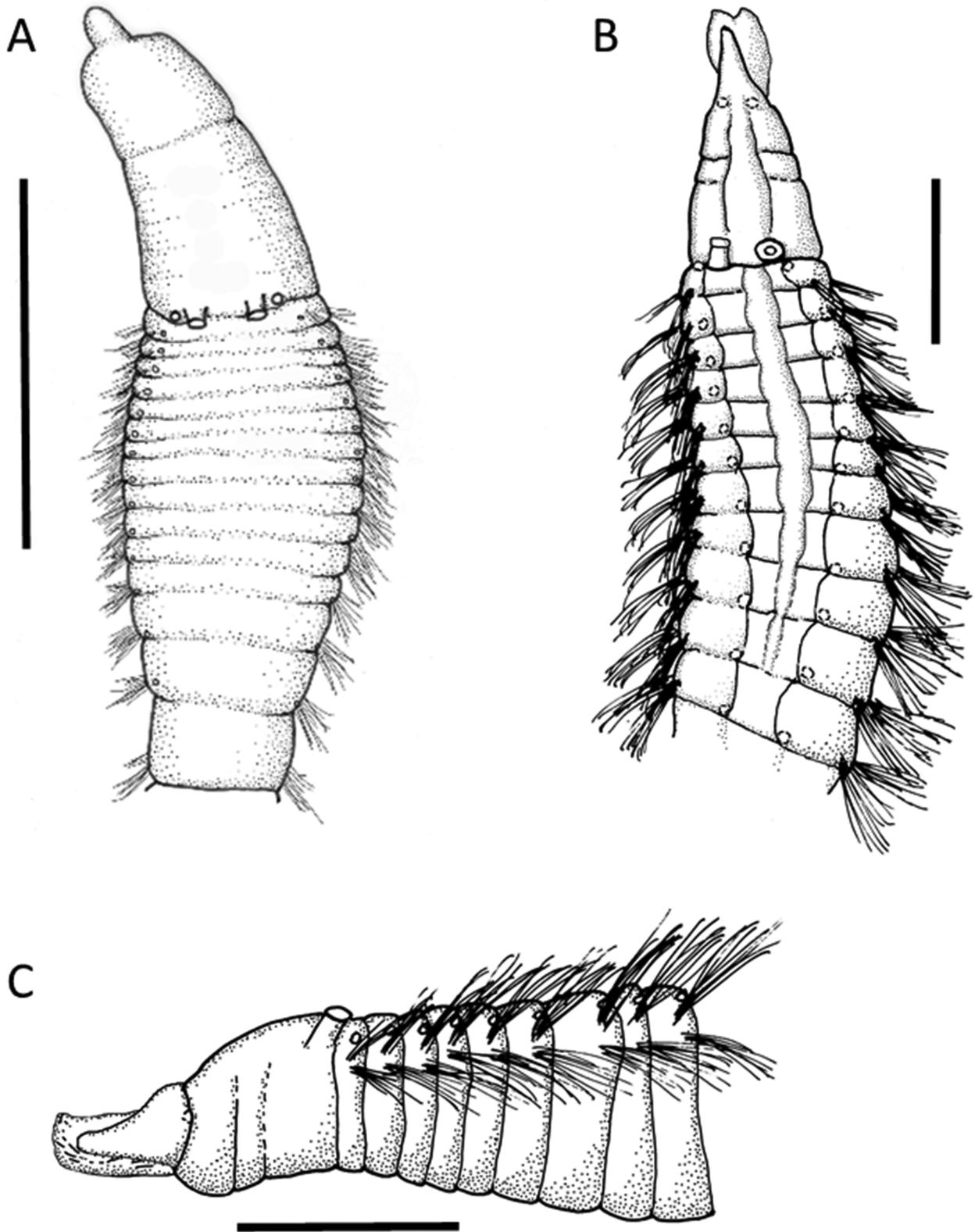


FIGURE 1. *Aphelochaeta antelonga* sp. nov. A, holotype (MCZ 132794); *Aphelochaeta guimondi* sp. nov. B-C, holotype (MCZ 132798). A, anterior end, dorsal view; B, anterior end, dorsal view; C, anterior end, lateral view. Scale bars: A–C = 500 μ m.

Material examined. Gulf of Nicoya: Station (Sta.) 30, 9°54'40"N, 84°45'50"W, 18 m, muddy sand, Aug 1981, **Holotype** (MCZ 132794); Sta. 29, 9°54'55"N, 84°45'15"W, 18 m, muddy sand, Oct 1980, **1 Paratype** (MCZ 132796), (2), Jan 1981, (1), Apr 1981 (2), Jul 1981, **1 Paratype** (MCZ 132795 (SEM)), (1), Apr 1982 (1). Bahia

Culebra: Nicoyan Peninsula (NP) Sta. 15, 1036'35.4"N, 85°40'43.1"W, 18 m, sandy mud, Dec 1985, **1 Paratype** (MZUCR 362-01); Sta. NP 16, 10°37'9.1"N, 8540'28.3"W, 22 m, sandy mud, Dec. 1985 (1); Sta. Bahia Culebra (BC) 6, 10°35'41.6"N, 85°39'3"W, 16 m, May 2011 (1); Sta. BC 16, 10°37'9.1"N, 85°40'28.3"W, 22 m, May 2011 (1).

Description. A narrow-bodied species, thoracic region wider than remainder of body with 13 segments each 7.5 times wider than long (Fig. 1A, 2A), thorax dorso-ventrally rounded in cross section; abdominal setigers 1.5–2.0 times longer than wide, dorso-ventrally rounded. Holotype incomplete, 9.0 mm long, thoracic region 0.5 mm wide, remainder of body 0.25 mm wide for 38 setigers. All specimens incomplete, pygidium absent. Color in alcohol cream white.

Prostomium short, narrow, rounded on anterior margin, as long as wide; nuchal organs rounded, small, located beneath peristomium at postero-lateral prostomial border; peristomium 2.5 times as long as wide with a weak, rounded dorsal crest and two annulations, second longer than first; both annulations with numerous transverse creases apparent with SEM; dorsal tentacles emerging from posterior margin of peristomium (Fig. 1A, 2A). First pair of branchiae arising posterior-lateral to dorsal tentacles on peristomium, subsequent branchiae postero-dorsal to notosetae from setiger 1. Parapodia in thoracic region low swellings, with setae emerging directly from body wall throughout. Setae thin capillaries with blade-like base and occasional fine fibrils; SEM revealing numerous long thin, pointed, fibrillar endings along one side of seta, some protruding (Fig. 2B); setiger 1 with three notosetae and four neurosetae, remainder of thoracic setigers with 8–10 notosetae and 6–8 neurosetae; abdominal setigers with 25–28 notosetae and 16–20 neurosetae, each setal fascicle elongate capillaries with an anterior row of 5–8 shorter capillaries.

Methyl green staining pattern. Body uniform light green, venter of thoracic setigers 8–12 darker green, prostomium and peristomium unstained (Fig. 3A).

Remarks. The most striking characteristic of this species is the long, biannulate peristomium and the relatively narrow prostomium that is rounded on the anterior margin (Fig. 1A, 2B). The posterior end is unknown but the elongate peristomium is most similar to that of *Aphelochaeta elongata* Blake, 1996 from Tomales Bay in northern California. Both these species also have a slightly expanded thorax relative to the rest of the body. The first pair of branchiae is found on the peristomium in *A. antelonga* **sp. nov.** but on setiger 1 in *A. elongata*; a median dorsal thoracic ridge is present in *A. elongata* while no such ridge occurs in *A. antelonga* **sp. nov.** Additionally, the thoracic segments are more crowded and the setae are fibrillated in *A. antelonga* **sp. nov.** whereas *A. elongata* has less crowded thoracic segments and the setae are smooth when using a light microscope; details using SEM are not known. The methyl green staining patterns of the two species also differ. *Aphelochaeta elongata* has transverse stripes on the thoracic venter while *A. antelonga* **sp. nov.** has a light blue staining thorax but no transverse stripes. *Aphelochaeta malefica* Elías & Rivero, 2009 also has an elongate prostomium-peristomium with three prostomial annulations and fibrillated setae but the thoracic segments are not crowded, the prostomium is much more conical and pointed and the setal fibrils are shorter than in *A. antelonga* **sp. nov.**

Etymology. The specific name is from the Latin *ante*, in front of, and *longus*, meaning elongate.

Distribution. Known from 11–18 m in sandy to muddy sand sediments in the Gulf of Nicoya.

***Aphelochaeta glandaria* Blake, 1996**

Figures 2C, 3B

Aphelochaeta longisetosa: Dean 1996a (in part). Not Hartmann-Schröder, 1965.

Aphelochaeta glandaria: Dean 2004 (in part). Not Blake, 1996.

Material examined. Gulf of Nicoya. Sta. 24, 9°49'25"N, 84°41'20"W, 11 m, sand, Oct 1980 (2); Sta. 29, 9°54'55"N, 8445'15"W, 18 m, muddy sand, Jul 1980 (15, MCZ 132979 (SEM)), Jun 1981 (1), Apr 1982 (2); Sta. 30, 9°54'40"N, 84°45'50"W, 18 m, muddy sand, Apr 1981 (2). Golfo Dulce, Sta. GD-03, 8°35'N, 83°16'W, 200 m, soft black mud, Dec 1993. Col. R. León-Morales & J.A. Vargas (1).

Description. Robust species with uniformly wide body with a slightly expanded thorax. Complete specimen 10.2 mm long, 1.6 mm wide for 167 segments, Dorsum of thorax rounded, swollen, venter flat with numerous minute glands producing creamy white region extending onto anterior abdomen, with mid-ventral groove only on last thoracic setigers; abdominal setigers approximately six times as wide as long, oval in cross section, about 1.5

times as wide as high, with mid-ventral groove; expanded posterior region 2.0 mm wide with 35 crowded setigers up to 14 times wider than long, with mid-dorsal and mid-ventral groove; pygidium a short rounded lobe ventral to anal opening. Color in alcohol light yellow-brown with thoracic and anterior abdominal region creamy white ventrally.

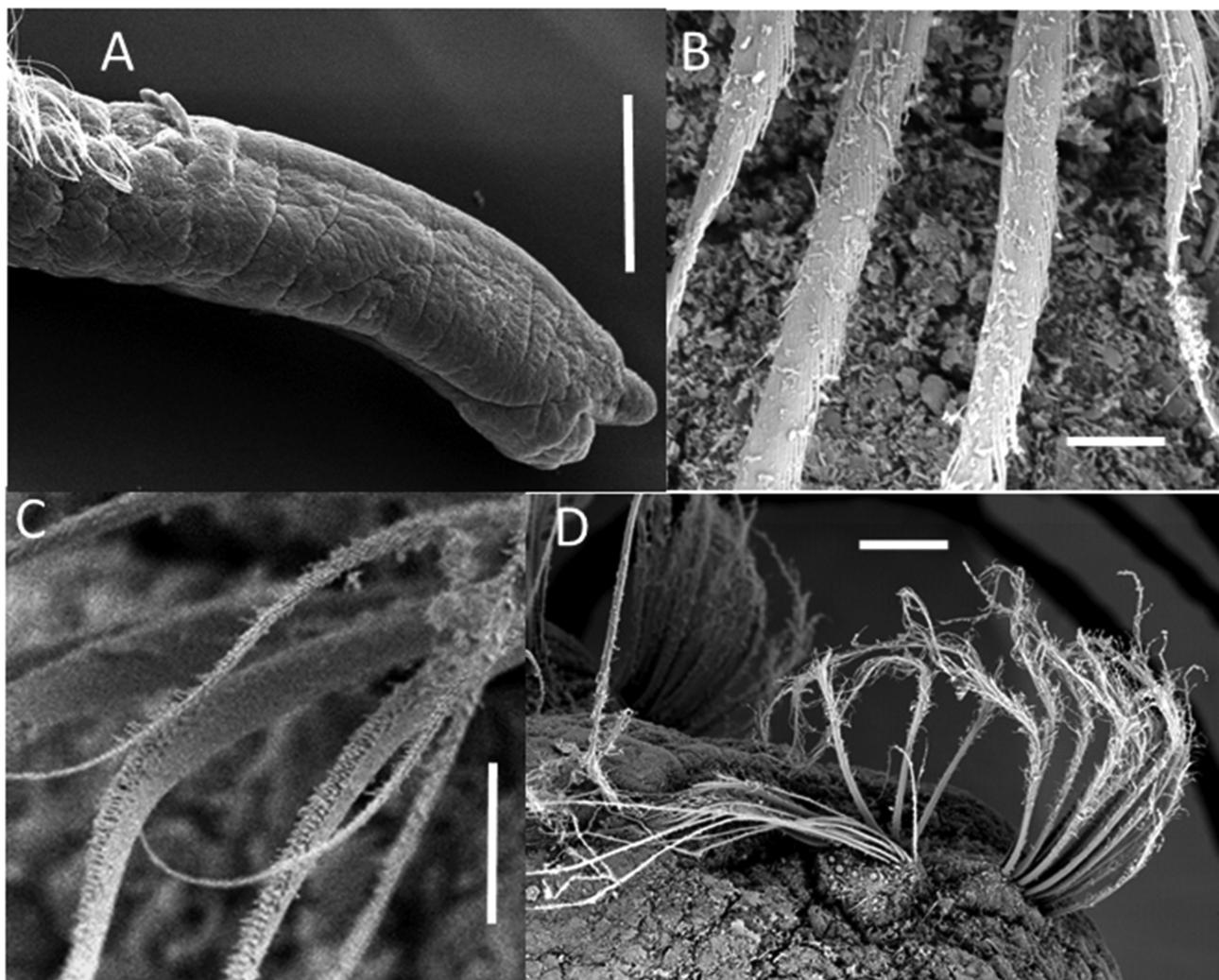


FIGURE 2. *Aphelochaeta antelonga* sp. nov. A–B, paratype (MCZ 132795); *Aphelochaeta glandaria* C, voucher specimen (MCZ 132797); *Aphelochaeta guimondi* sp. nov. D, paratype (MCZ 132799). A, anterior end, lateral view; B, neurosetae, setiger 4. C, neurosetae, setiger 2. D, noto- and neurosetae, mid body. Scale bars: A = 200 μ m, B = 5 μ m, C = 10 μ m, D = 20 μ m.

Prostomium pointed, conical, about as wide as long; peristomium slightly longer than wide, with three well-differentiated annulations, often deeply cleft dorso-laterally at junctions between annulations (Fig. 3B), weak dorsal crest present extending along dorsum of first three or four thoracic setigers as narrow ridge; paired dorsolateral nuchal organs on posterior edge of prostomium; dorsal tentacles arise from peristomium, which extends over dorsum of setiger 1, just anterior to setiger 2. First branchiae dorsal to notosetae of setiger 1 lateral to dorsal tentacles; subsequent branchiae also dorsal to notosetae. Thoracic parapodia well developed dorso-lateral lobes with notopodia forming shoulders; setae emerge ventro-laterally from slightly swollen regions of body wall in abdominal segments. Noto- and neuropodia close to one another throughout.

Setae all capillaries with notosetae 2–3 times longer than neurosetae; with 10–12 notosetae and 6–8 neurosetae in thoracic region, 8–10 setae per fascicle in each ramus in abdominal region, reduced in number in far posterior setigers, notosetal and neurosetal fascicles somewhat separate throughout. Long capillary setae rounded in cross section with short fibrils along one side, shorter setae more flattened with minute fibrils along one edge (Fig. 2C).

Methyl green staining pattern. Dorsum of peristomium with scattered blue speckles, greatest density of

speckles on peristomium at base of tentacles, extending as a diagonal streak ventrally from lateral edge of dorsal tentacles (Fig. 3B). Anterior thoracic region with weak blue stain on venter; remainder of body light blue-green; pygidium and prostomium unstained.

Remarks. The cream colored thoracic venter makes this species easily identifiable in benthic samples. The many crowded setigers, the wide thoracic region, and expanded posterior end with both a dorsal and ventral groove are all easily recognizable characters. The microscopic fibril endings on the otherwise smooth capillary setae (Fig. 2C), which were noticed by Blake (1996), are also visible using light microscopy in the Costa Rican specimens. Blake (1996) indicated that this species may either have a wide geographic range or be a complex of sibling species as morphologically similar specimens have been reported from northern Europe, the eastern United States and Australia. Comparison of the Costa Rican specimens with paratypes of *A. glandaria* from California show similar staining patterns but differences in staining intensity, perhaps due to differences in fixation.

Distribution. Collected in 11–18 m from muddy sand to sandy sediments in the Gulf of Nicoya. This species was previously collected at 76–410 m in the Santa Maria Basin and Western Santa Barbara Channel off California, USA. The presence of this species in the Gulf of Nicoya extends the range of this species from central and southern California to Pacific Costa Rica.

Aphelochaeta guimondi sp. nov.

Figures 1B–C, 2D, 3C

Aphelochaeta longisetosa: Dean 1996a (in part). Not Hartmann-Schröder, 1965.

Aphelochaeta glandaria: Dean 2004 (in part). Not Blake, 1996.

Material examined. Gulf of Nicoya; Sta. 24, 9°49'25"N, 84°41'20"W, 11 m, sand, Oct 1981, **Holotype** (MCZ 132798); Sta. 24, 9°49'25"N, 84°41'20"W, 11 m, sand, Oct 1980 (71), Jan 1981 (2). Oct 1981, **1 Paratype** (MZUCR 363-01); Sta. 28, 9°52'16"N, 84°45'30"W, 26 m, mud, Oct 1980 (3); Sta. 29, 9°54'55"N, 84°45'15"W, 18 m, muddy sand, Jul 1980 (3), Oct 1980 (2), Jan 1981 (1), Jun 1981, **4 Paratypes** (MZUCR 364-01), **1 Paratype** (MCZ 132799 (SEM)) (1), Aug 1981 (2), Apr 1982 (4); Sta. 30, 9°54'40"N, 84°45'50"W, 18 m, muddy sand, Jan 1981, **2 Paratypes** (MCZ 132800) (1), Aug 1981 (1).

Description. An elongate, narrow species, holotype in two pieces (anterior 2.4 mm, posterior 17.6 mm), 20.0 mm long, 0.3 mm wide in thoracic region, slightly narrower in abdomen, expanded posterior end 0.4 mm wide; with 118 setigers, thoracic region 18 setigers, eight times as wide as long, slightly rounded dorsally with median ridge (Fig. 1B, 3C), flattened ventrally, larger specimens with more greatly expanded thoracic region; remainder of body rounded dorsally, flattened ventrally with mid ventral groove, setigers two times as wide as long; expanded posterior end with 27 crowded setigers, with wide, shallow, ventral furrow, setigers up to ten times as wide as long; pygidium simple ventral lobe. Color in alcohol white.

Prostomium narrow, conical with rounded tip, slightly longer than wide, with prominent dorsal crest, continuing over dorsum to about setiger 10; unpigmented nuchal organs present on posterior-lateral margin of prostomium. Peristomium as long as wide, with three annulations, second annulation about one-half length of first, third almost three times length of second; dorsal tentacles located at posterior border of peristomium and setiger 1, lateral to dorsal crest (Fig. 1B–C). First branchiae posterior-lateral to dorsal tentacles at anterior border of setiger 1; subsequent thoracic branchiae at dorsal posterior border of notopodial lobe becoming more dorsal, shifting medially and further separated from notosetae on medial surface of shoulder; branchiae in abdominal region at posterior border of notopodia, dorso-lateral to and some distance from notosetae.

Thoracic parapodia robust ridges, with notosetae emerging dorso-laterally with swollen notopodial lobes extending medially, forming a well-defined channel along dorsum (Fig. 1B); abdominal setigers with parapodia poorly developed with setae emerging from lateral body wall. Notosetae and neurosetae emerging close to one another throughout (Fig. 2D). Setae capillaries with occasional fibrils visible using oil immersion (1000 x), SEM revealing numerous, long delicate fibrils emerging along one side of seta providing a plume-like appearance to setae (Fig. 2D). Thoracic region with 8–14 long, fibrillated notosetae, mid-body with up to 15 notosetae occurring in double rows, including up to five thin, smooth natatory setae in anterior row and 7–10 slightly shorter but wider fibrillated notosetae in posterior row (Fig. 2D), reduced to 4–6 in posterior segments; neurosetae 7–8 fibrillated setae in thorax, 7–12 in mid-body, reduced to 3–5 setae in posterior segments.

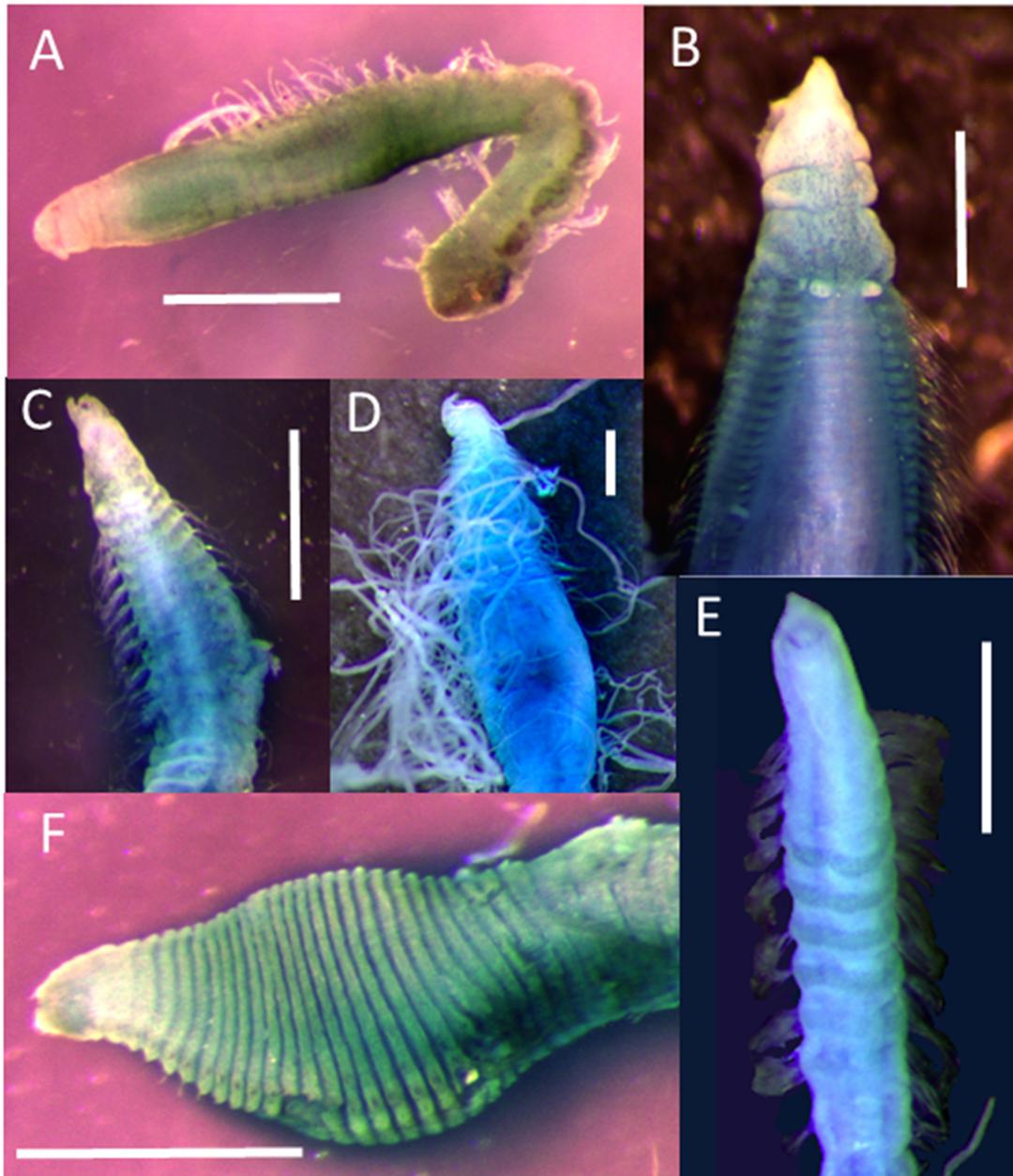


FIGURE 3. *Aphelochaeta antelonga* sp. nov. A, Paratype MZUCR 132794; *Aphelochaeta glandaria* B, voucher specimen (MCZ 132797); *Aphelochaeta guimondi* sp. nov. C, Holotype MCZ 132798; *Aphelochaeta praeacuta* sp. nov. D, Holotype MCZ 132801; *Aphelochaeta striata* sp. nov. E, Holotype MCZ 132803; *Aphelochaeta zebra* sp. nov. F, Holotype MCZ 132807. A, MGSP of anterior end, ventral view; B, MGSP of anterior end, dorsal view; C, MGSP of anterior end, ventral view; D, MGSP of anterior end, ventral view; E, MGSP of anterior end, ventral view; F, MGSP of anterior end, ventral view. Scale bars; A–F = 500 μ m.

Methyl Green Staining Pattern. Venter of posterior half of thorax staining dark blue, prostomium and peristomium unstained, remainder of body weak blue-green (Fig. 3C).

Remarks. Important in the identification of *Aphelochaeta guimondi* sp. nov. is the wide mid-dorsal channel along the thorax and the extension of the prostomial dorsal crest as a mid-dorsal thoracic crest (Fig 1B). The long fibrils of the setae (often not visible with light microscopy) is a noticeable character for this species. The long narrow, pointed prostomium of *A. guimondi* sp. nov. is similar to that of *A. monilaris* (Hartman, 1960), as is the expanded thorax and posterior end. The peristomium is longer than wide in *A. guimondi* sp. nov. and subequally as wide as long in *A. monilaris*. The first branchial pair occurs on setiger 1 in *A. guimondi* sp. nov. and on the peristomium in *A. monilaris*, additionally the thoracic branchiae of *A. guimondi* are dorsally separated from the

notosetae becoming located on the edge of the mid-dorsal channel, whereas in *A. monilaris* they are close to the notosetae. The middle body setigers of *A. monilaris* are typically moniliform but are not in *A. guimondi* **sp. nov.** While both species stain intensely on the ventral surface of thoracic segments, the stain forms bands on the anterior segmental margins of *A. monilaris*, whereas in *A. guimondi* **sp. nov.** the staining is more uniform over the ventral surface; the tip of the prostomium is unstained in *A. guimondi* **sp. nov.** but is stained in *A. monilaris*.

Etymology. This species is named after Professor Robert Guimond, University of Massachusetts, Boston in recognition of his dedication to his students and in the friendship and kindnesses to the first author (HKD) which have sustained his academic career and research efforts for many years.

Distribution. Collected in the Gulf of Nicoya from 11–26 m in mud, muddy sand, and sandy sediments.

Aphelochaeta praeacuta **sp. nov.**

Figure 3D, 4A, 5A–C

Material examined. Bahia Culebra, Sta. 6, 10°35' 35.8" N, 85°39' 32.1" W, 13 m. May 2011, **Holotype** (MCZ 132801); Sta. 13, 10°36' 19.4" N, 85°40' 59.9" W, 28 m. May 2011, **1 Paratype** (MCZ 132802).

Description. A narrow bodied species. Holotype incomplete, 11.0 mm long, 0.8 mm at widest point in anterior abdominal region for 46 setigers; paratype incomplete, 10.3 mm long, 0.8 mm wide for 45 setigers. Thoracic region 12 setigers long, dorso-ventrally flattened, with segments 4.5 times wider than long; first 13–14 abdominal setigers widened, dorso-ventrally flattened, up to six times wider than long; subsequent abdominal segments dorso-ventrally rounded, 1.3 times as wide as long. Mid-ventral groove present throughout. Far posterior region widened in holotype (Fig 5B), dorso-ventrally flattened, grooves lacking. Pygidium absent. Color in alcohol white.

Prostomium conical, with a narrow pointed tip (Fig. 4A), directed dorsally, best seen in lateral view (Fig. 5A); pigmented nuchal organs present at posterior border (Fig. 4A). Peristomium with two annulations; first as long as wide, extending as a dorsal hood over second annulation, one-fourth length of first, incomplete dorsally; paired dorsal tentacles emerging at border between two peristomial annulations (Fig. 4A, 5A). First pair of branchiae arising on enlarged first setiger posterior to dorsal tentacles, second pair of branchiae dorsal to notosetae at posterior of setiger 1, remaining branchiae arising dorsal to notosetae throughout (Fig. 4A), first setiger three times as wide as long, with noto- and neurosetae emerging from posterior lateral border; subsequent thoracic setigers five times as wide as long. Parapodia low, fleshy lobes, with setae emerging in a row directly from body wall. Thoracic setae all broad based with long, fine fibrils along one edge (Fig 5C), 7–8 in notopodia, 5–8 in neuropodia; abdominal region with up to 12–13 notosetae and 10–12 neurosetae, both broad, fibrillated setae and shorter, thin capillaries apparently lacking emergent fibrils. Swollen far posterior pre-pygidial region two times as long as wide (Fig. 5B).

Methyl green staining pattern. Dorsum of thoracic region staining dark blue, remainder of body lighter blue; prostomium unstained (Fig. 3D).

Remarks. The relatively large first peristomial annulation extending as a dorsal crest above the second annulation, the darkly pigmented nuchal organs, and the enlarged first setiger bearing the first two pairs of branchiae help to recognize this species. Additionally the lack of well-developed shoulders over the thoracic parapodia is shared with only *A. phillipsi* Blake, 1996 and *A. antelonga* **sp. nov.**, both of which have smooth setae. *A. bullata* Doner & Blake, 2009 also has a similar posteriorly extended dorsal crest and the first setiger is somewhat enlarged but the prostomium and peristomium of that species are inflated and bulbous with a rounded prostomial tip, while *A. praeacuta* **sp. nov.** has a narrow anterior end and a sharply pointed prostomium. Additionally, the long fine fibrils on the capillaries of *A. praeacuta* **sp. nov.** are different from the smooth capillaries of *A. bullata*. *Aphelochaeta antelonga* **sp. nov.** also has capillary setae with fibrils but the fibrils are not as fine while the elongate anterior region is much different from that of *A. praeacuta* **sp. nov.** The biannulate peristomium of this species is also seen in *A. multifilis* (Moore, 1909), and perhaps *A. petersenae* Blake, 1996 and *A. williamsae* Blake, 1996 (although these latter two species are described as having 2–3 peristomial annulations) but fibrillated setae are not reported for these species. *A. striata* **sp. nov.**, described below, also has two peristomial annulations but the prostomium/peristomium is much longer in that species and the thoracic segments are not as crowded.

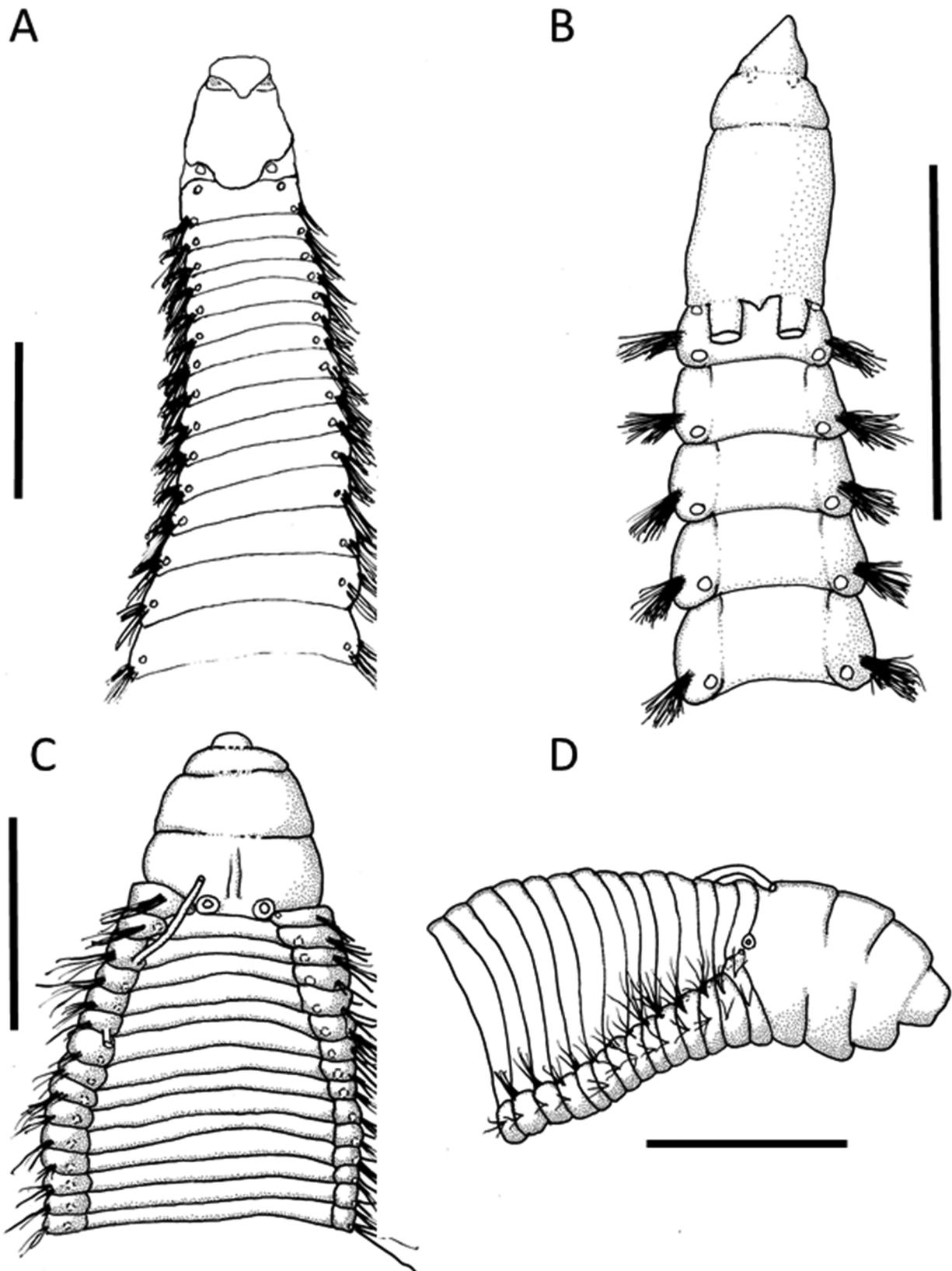


FIGURE 4. *Aphelochaeta praeacuta* sp. nov. A, Holotype MCZ 132801; *Aphelochaeta striata* sp. nov. B, Holotype MCZ 132803; *Aphelochaeta zebra* sp. nov. C-D, Holotype MCZ 132807. A, anterior end, dorsal view; B, anterior end, dorsal view; C, anterior end, dorsal view; D, anterior end, lateral view. Scale bars: A–D = 500 μ m.

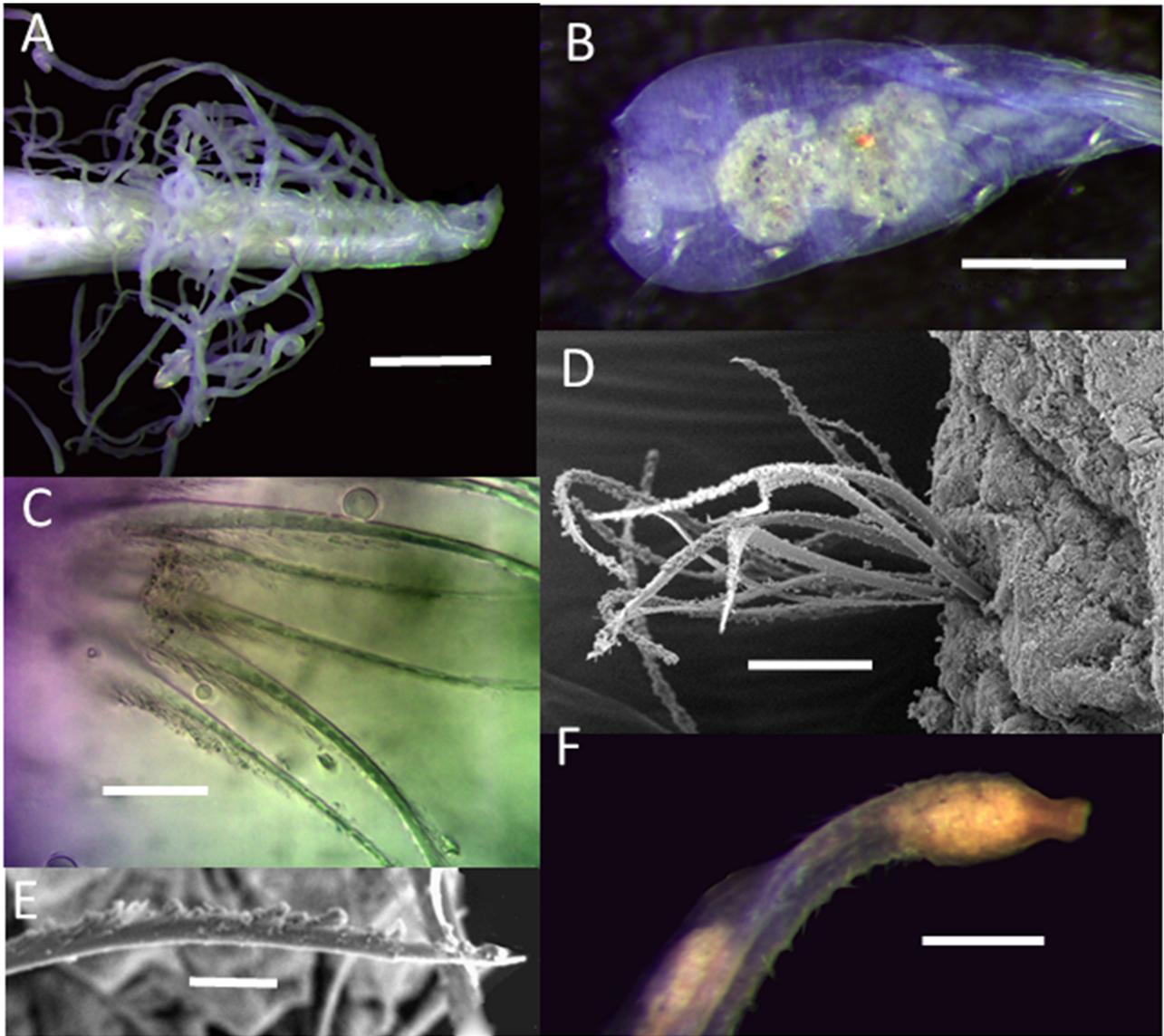


FIGURE 5. *Aphelochaeta praeacuta* sp. nov. A-C, Holotype MCZ 132801; *Aphelochaeta striata* sp. nov. D-F, Paratype MCZ 132806. A, anterior end, lateral view; B, posterior end, ventral view; C, thoracic neurosetae; D, notosetae, setiger 10; E, notoseta, setiger 10; F, posterior end. Scale bars: A–B = 500 μ m, C–D = 20 μ m, E = 5 μ m, F = 200 μ m.

Etymology. From the Latin, *praeacutus* which means sharp, pointed front or anterior, for the sharply pointed, almost digitate, nature of the prostomium.

Distribution. Collected subtidally from sandy sediments at 13 and 28 meters depth from Bahia Culebra, Pacific coast of Costa Rica.

***Aphelochaeta striata* sp. nov.**

Figure 3E, 4B, 5D–F

Material examined. Gulf of Nicoya. Sta. 24, 9°49'25"N, 84°41'20"W, 11 m, sand, Oct 1980, **Holotype** (MCZ 132803), Sta. 24, 9°49'25"N, 84°41'20"W, 11 m, sand, Oct 1980 (10), Jan 1981 (1), Aug 1981 (1), Oct 1981, **1 Paratype** (MCZ 132804), Aug 1981, **1 Paratype** (MCZ 132805); Sta. 29, 9°54'55"N, 84°45'15"W, 18 m, muddy sand, Jul 1980 (2), Oct 1980 (3), Jan 1981, **1 Paratype** (MCZ 132806 (SEM)) (80), Apr 1981 (6), Jun 1981 (1), Apr 1982 (9); Sta. 30, 9°54'40"N, 84°45'50"W, 18 m, muddy sand, Apr 1981 (1).

Description. Holotype incomplete, 5.7 mm. long, 0.3 mm wide at mid thorax for 23 setigers, paratype MCZ

132804 (dried) complete, 11.4 mm long for 114 setigers, and 0.4 mm wide; paratype MCZ 132805 2.84 mm long 0.2 mm wide in mid thorax with 24 setigers. Thoracic region narrow, twelve setigers long, dorsum somewhat flattened, ventrum rounded, remainder of body dorso-ventrally rounded in cross section; thoracic setigers three times as wide as long; remaining setigers two-thirds as wide as long. With a narrow mid-ventral groove throughout. Posterior end slightly expanded laterally, dorsally and ventrally rounded (Fig. 5F), pygidium rounded, anus terminal. Color in alcohol white, unpigmented.

Prostomium conical, with paired nuchal organs at posterior border; peristomium with two annulations; second annulation 3.5 times as long as first (Fig. 4B), with slight posterior mid-dorsal triangular projection between tentacles emerging at posterior end of second peristomial annulation. First pair of branchiae emerging from anterior margin of setiger 1, lateral to base of dorsal tentacles; second branchial pair emerging from posterior margin of setiger 1, thus two branchiae on first setiger; subsequent branchiae emerging slightly posterior and medial to notosetae throughout. Noto- and neuropodia greatly reduced with setae emerging directly from body wall throughout (Fig. 5D); notopodial region slightly inflated producing weak, low-lying shoulders in thoracic region. Thoracic neurosetae 10–12 per fascicle, abdominal neurosetae 5–8 per fascicle, 18–22 notosetae per fascicle in thoracic region, about 8–10 setae in abdominal fascicles; notosetae longer than neurosetae. Setae with numerous short fibrils and scattered knob-like projections along one side (Fig 5D, E), producing a rough, irregular appearance as observed with SEM.

Methyl green staining pattern. Body stains light blue; transverse blue stripes across ventrum of setigers 4–8 (Fig. 3E).

Remarks. *Aphelochaeta striata* **sp. nov.** is distinguished by the narrow body, the relatively uncrowded setigers in the thoracic region, and the first two pair of branchiae occurring on setiger 1 (Fig 4B). Additionally, the bright blue transverse stripes of the thoracic region using methyl green staining easily identify this species (Fig. 3E).

This species is similar to *Aphelochaeta elongata* in having a narrow body, an elongate peristomium, uncrowded thoracic segments and transverse stripes across the ventral surface of posterior thoracic setigers. The prostomium and peristomium of *A. elongata* are indistinguishable and there are no visible peristomial annulations while in *A. striata* the prostomium and peristomium are distinct and the peristomium consists of a short anterior and long posterior annulation. The dorsal tentacles of *A. elongata* arise from the anterior margin of the first setiger and the first branchiae are posterior to the tentacles while in *A. striata* **sp. nov.** the first pair of branchiae are lateral to the dorsal tentacles. Additionally, there are median dorsal mounds on thoracic setigers and the posterior region is not expanded in *A. elongata* but *A. striata* **sp. nov.** lacks dorsal mounds and has a somewhat expanded posterior end.

Aphelochaeta striata **sp. nov.** also shares an elongate peristomium with *A. antelonga* **sp. nov.** but that species has a larger first peristomial annulation and the prostomium is more conical than in *A. striata* **sp. nov.** The anterior setigers are more crowded and the thoracic region is wider in *A. antelonga* **sp. nov.** compared to *A. striata* **sp. nov.** Additionally, the long fibrils of the setae of *A. antelonga* **sp. nov.** are quite different than the short, beaded projections on the setae of *A. striata* **sp. nov.**

Etymology. From the Latin striatum meaning striped, for the blue transverse stripes on the venter of setigers 4–8.

Distribution. Collected subtidally from sand and muddy sand, 11–28 meters depth, the Gulf of Nicoya, Pacific coast of Costa Rica.

Aphelochaeta zebra **sp. nov.**

Figures 3F, 4C–D, 6B

Material examined. Golfo Dulce; Coral reef, Punta Islotes, 8°43'41"N; 83°23'8"W. Col: Ana Fonseca by SCUBA, **Holotype** (MCZ 132807).

Description. Holotype complete, in two pieces (anterior 17.2 mm, posterior 2.2 mm), 19.4 mm long for 154 setigers, thoracic width 0.7 mm, abdomen 0.4 mm wide, swollen posterior end 0.6 mm wide. Thoracic region with 22 crowded segments 25–30 times wider than long, dorsum inflated, dome-like (Fig. 4C, D), venter flattened with mid-ventral line, groove absent; abdominal segments of uniform width, approximately two times as wide as long, rounded dorsally, flattened ventrally, first 21 abdominal setigers with narrow mid-ventral groove, subsequent

setigers with mid-ventral line, groove absent; posterior end inflated dorso-ventrally, with 29 setigers; pygidium with small dorsal and ventral lobes (Fig. 3F). Color in alcohol brownish yellow.

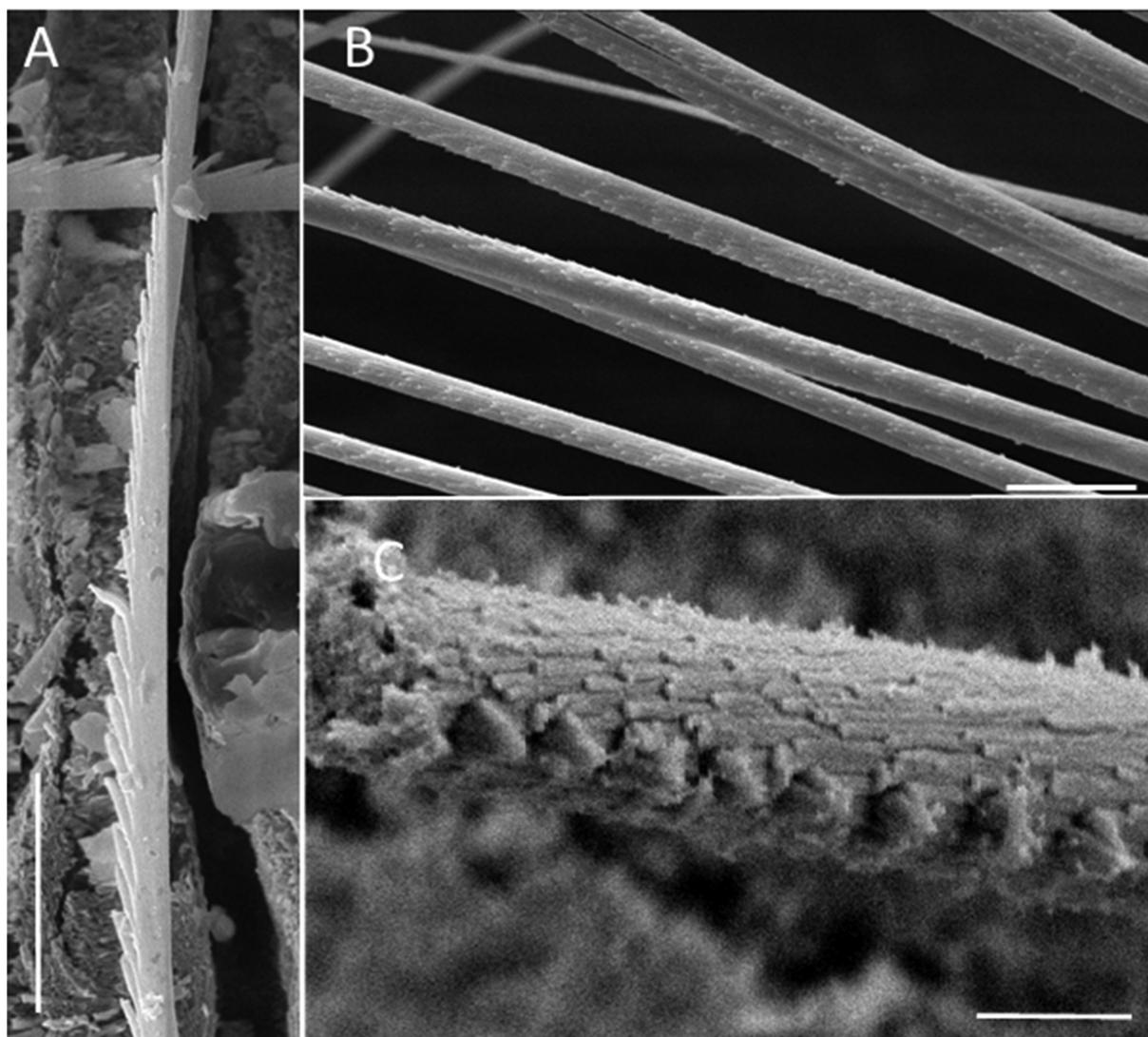


FIGURE 6. *Aphelochaeta* sp. A. Undescribed species, Gulf of Nicoya; *Aphelochaeta zebra* sp. nov. B, Holotype MCZ 132807; *Monticellina carrikeri* Dean & Blake, 2009, C. Gulf of Nicoya specimen. A, neurosetae from mid-body region; B, abdominal notosetae, mid body; C, thoracic neuroseta. Scale bars: A–B = 10 μ m, C = 2 μ m.

Prostomium short, rounded, nuchal organs not apparent, prostomium retracted into peristomium; peristomium short, wider than long, with three annulations, anterior annulation approximately one-half length of two posterior annulations, with short, narrow, median dorsal ridge on posterior annulations (Fig. 4D); dorsal tentacles emerging from posterior margin of peristomium. First pair of branchiae immediately lateral to dorsal tentacles on anterior edge of setiger 1; subsequent thoracic branchiae at posterior border of notopodial lobe at medial surface of shoulders, gradually moving closer to, and becoming adjacent to notosetae by setiger 10; abdominal branchiae emerging from conical notopodial lobe dorsal to notosetae. Thoracic parapodia swollen lobes forming weak shoulders along lateral surface of body, notosetae emerging from apex of elevated shoulder, neurosetae from slightly elevated cone ventral to notopodia; abdominal notosetae emerging apically from short, cone-like projections, neurosetae emerging from body wall at base of notopodial cone.

Setae long, smooth capillaries, with minute, ragged-edged scale-like structures visible with SEM (Fig. 6B); thoracic parapodia with up to seven setae in each fascicle; abdominal segments with up to 24 notosetae and seven neurosetae, reducing to eight notosetae and four neurosetae in far posterior; swollen posterior end with up to five notosetae and three neurosetae, reducing in number posteriorly.

Methyl green staining pattern. Body staining dull greenish-grey, ventral groove of posterior thoracic region

dark green, pygidium unstained; swollen posterior region with intersegmental lines staining dark green providing a striped zebra-like pattern (Fig. 3F).

Remarks. *Aphelochaeta zebra* **sp. nov.** is similar to *A. multifilis* in having a broadly rounded prostomium, a relatively broad peristomium and a robust body throughout. However, the posterior end of *A. multifilis* is inflated with paired ventral grooves while that of *A. zebra* **sp. nov.** is more greatly inflated, possesses only a single mid-ventral groove, and has a distinctive, striped methyl green staining pattern within the intersegment grooves. This striped staining pattern on the swollen posterior region of *A. zebra* **sp. nov.** is somewhat similar to that of *A. tigrina* Blake, 1996 but in *A. tigrina* the staining occurs on the entire ventral surface of individual setigers except for the intersegmental region while in *A. zebra* **sp. nov.** staining does not occur in the median area of each setiger but stains intensely in the intersegmental grooves. *Aphelochaeta zebra* **sp. nov.** shares a shortened anterior region, a triannulate peristomium, crowded thoracic segments and smooth setae with *A. guttata* Doner & Blake, 2009 but the first branchiae occur on the peristomium in that species while they occur on setiger one in *A. zebra* **sp. nov.**

Etymology. The species name is from the Portuguese *zebra* meaning wild ass and refers to the striking methyl green staining pattern of the swollen posterior end.

Distribution. Known only from a coral reef at Punta Islotes, Golfo Dulce, Costa Rica.

Discussion

The genus *Aphelochaeta* is difficult to characterize due to the lack of a morphological synapomorphy. The single character that characterizes this group of bitentaculate cirratulids is the presence of only “smooth” capillary setae. Species of *Aphelochaeta* had previously been included within the genus *Tharyx* which was believed to possess only smooth capillary setae, distinguishing this genus from the other two bitentaculate genera, *Chaetozone* and *Caulleriella*, both possessing spines or hooks in addition to capillary setae. After examination of types of *Tharyx acutus* Webster & Benedict, 1887, the type species of the genus *Tharyx*, Blake (1991) revised the *Tharyx* to include only those species possessing irregularly notched spines along with smooth capillaries. He then designated two other genera, *Monticellina* Laubier, 1961 with denticulate capillaries and *Aphelochaeta* with smooth, or non-dentate, setae to accommodate species with only capillary-tipped setae that had formerly been included in *Tharyx*. Blake (1991) referred ten species to the genus *Aphelochaeta*. Additional species have been added by Blake (1996), Doner & Blake (2009), Elías & Rivero (2009), and Magalhães & Brock (2013). This report adds another five species of *Aphelochaeta* from Pacific Costa Rica.

Blake (1996) pointed out that setal characters in species of *Aphelochaeta* are difficult to quantify and would be a poor character to use in the differentiation of species but further work with this taxa has found that some species possessed setae which appear smooth under light microscopy but, in fact, exhibit fibrils of various forms and density emerging from the shaft that are best observed using SEM (Doner & Blake 2009) but can be seen in some species using Phase Contrast microscopy (Blake 1996). Magalhães & Bailey Brock (2013) reported capillaries with short fibrillar extensions in *Aphelochaeta arizonae* Magalhães & Bailey Brock, 2013 and *A. saipanensis* Magalhães & Bailey Brock, 2013 from Hawaii and Elías & Rivero (2009) found setae with fine serrations, seen only by using SEM, in *A. malefica* from Argentina. Similar setae from an undescribed species of *Aphelochaeta* (due to lack of sufficient material) from Costa Rica is shown in Fig. 6A. While some capillary setae are smooth even when viewed with SEM (Fig 6B) (with perhaps some fine surface sculpture), some have a microscopic serration of what appear to be bundles of fibrils (Fig. 6A), and others have varying lengths of fibrils extending from the setal surface (Fig. 2 B–D, 5D–E). All these species are included within *Aphelochaeta* as noted by Doner & Blake (2009) who emended the generic diagnosis to reflect that fibrillated endings or serrations may be visible when using SEM despite the general appearance of the capillaries as smooth using light microscopy. The various fibrillated setal types of this genus should not be confused with the dentitions or teeth on the setae in the genus *Monticellina*. For example, *Monticellina carrikeri* Dean & Blake, 2009 exhibits distinct dentition on the setal shaft which may itself be finely fibrillated (Fig. 6C). It is apparent that the fine structure of the capillaries of the *Aphelochaeta* when viewed using SEM or special types of light microscopy (e.g., Phase Contrast or Nomarski Differential Interference optics) may be a useful character in differentiation of species.

TABLE 1. Morphological characters of 19 species of *Aphelochaeta* from the Eastern North Pacific, Hawaiian Islands and Central Pacific

Species/Character	Prostomial shape	Prostomial-peristomial length vs width	Number of peristomial annulations	Dorsal peristomial crest	Position of dorsal tentacles	Position of first pair of branchiae	Two pair branchiae, setiger one	Crowded Thoracic segments	Ventral body groove	Thoracic shoulders	Setae	Expanded thorax
<i>A. amielonga</i> sp. nov.	Rounded	2.0	2	Absent	Per.	Per.	No	Yes	No	No	fib.	Yes
<i>A. arizonae</i> Magalhães & Bailey Brock, 2013	Pointed	1.0	3	Absent	Set. 1	Per.	Yes	Yes	No	Yes	mser.	Yes
<i>A. bullata</i> Doner & Blake, 2009	Rounded	1.2	4	Present	Per.	Per.	No	Yes	No	Yes	sm.	Yes
<i>A. elongata</i> Blake, 1996.	Pointed	2.0	3	Absent	Set. 1	Set. 1	No	No	No	Yes	sm.	No
<i>A. glandaria</i> Blake 1996	Pointed	1.2	3	Present	Set. 1	Set. 1	No	Yes	Yes	Yes	fib.	Yes
<i>A. guimondi</i> sp. nov.	Pointed	1.7	3	Absent	Per.	Set. 1	No	No	Yes	Yes	fib.	Yes
<i>A. guttata</i> Doner & Blake, 2009	Rounded	1.2	3	Present	Per.	Per.	No	No	No	Yes	sm.	Yes
<i>A. honouliuli</i> Magalhães & Bailey Brock, 2013	Rounded	1.1	3	Present	Per.	Set. 1	Yes	Yes	No	Yes	fib.	Yes
<i>A. malefica</i> Elías & Rivero, 2009	Pointed	1.9	3	Present	Set. 1	Set. 1	No	No	No	Yes	mser.	No
<i>A. monilaris</i> (Hartman, 1960)	Pointed	0.9	3	Absent	Per.	Per.	No	No	No	Yes	sm.	Yes
<i>A. multifilis</i> (Moore, 1909)	Rounded	1.1	2	Absent	Per.	Per.	No	Yes	No	Yes	sm.	Yes
<i>A. petersenae</i> Blake, 1996	Pointed	1.2	2–3	Absent	Per.	Per.	No	Yes	No	Yes	sm.	No
<i>A. phillipsi</i> Blake, 1996	Pointed	1.7	1	Absent	Set. 1	Per.	Yes	No	No	No	sm.	No
<i>A. praeacuta</i> sp. nov.	Pointed	1.3	2	Present	Per.	Set. 1	Yes	Yes	No	No	fib.	No
<i>A. saipanensis</i> Magalhães & Bailey Brock, 2013	Rounded	1.0	3–4	Absent	Set. 1	Set. 1	Yes	Yes	No	Yes	mser.	No
<i>A. striata</i> sp. nov.	Pointed	3.0	2	Absent	Per.	Set. 1	Yes	No	Yes	Yes	fib.	No
<i>A. tigrina</i> Blake, 1996	Pointed	1.0	3	Present	Per.	Per.	No	Yes	No	Yes	fib.	Yes
<i>A. williamsae</i> Blake, 1996	Pointed	1.1	2–3	Absent	Per.?	Per.	No	Yes	No	Yes	sm.	Yes
<i>A. zebra</i> sp. nov.	Rounded	1.0	3	Absent	Set. 1	Set. 1	No	Yes	Yes	Yes	sm.	Yes

fib. = fibrillated; mser. = microserrations; Per = peristomium; Set. = setiger; sm. = smooth

Blake (1996) identified a group of non-setal characters which may be of value in species differentiation and a list of such characters is included in Table 1. The prostomium may be rounded or conical and the length of the prostomium/peristomium compared to maximum peristomial width ranges from 0.9 in *A. monilaris* to 3.0 in *A. striata* **sp. nov.** The number of peristomial annulations ranges from one in *A. elongata* and *A. phillipsi* to four in *A. bullata* (and perhaps *A. saipanensis*) and there may or may not be a domed dorsal crest on the posterior peristomium. The placement of the dorsal tentacles and the first pair of branchiae may be of importance arising either from the peristomium anterior to setiger one or from setiger one, although it may be difficult to discern. The thorax is often widened relative to the remainder of the body and the notopodia may extend slightly above the dorsum forming shoulders in several species. A mid-ventral groove may be present or absent along the body and the posterior end may be expanded in some species.

A previously overlooked morphological character in *Aphelochaeta* is the emergence of the first two pairs of branchiae from setiger 1. This character is also seen in *A. arizonae*, *A. honouliuli* Magalhães & Bailey Brock, 2013, *A. phillipsi*, *A. praeacuta* **sp. nov.**, *A. saipanensis*, and *A. striata* **sp. nov.** Blake (2015) reported a similar situation in *Chaetozone allanotai* Blake, 2006, *C. anasima* Doner & Blake, 2006, *C. michellae* Magalhães & Bailey-Brock, 2013, and *C. camasetosa* Blake, 2015 and suggested that perhaps an asetigerous segment had been fused with setiger 1 while its branchiae were retained. While the emergence of the first pair of branchiae from either the posterior of the peristomium or anterior of setiger 1 may be difficult to discern, this character may prove to be of importance in the discrimination of species in the *Aphelochaeta*, *Chaetozone*, and perhaps other genera of Cirratulidae.

Magalhães & Bailey Brock (2013) noted that methyl green staining patterns may be of limited use in differentiating species of *Aphelochaeta* as most species show staining of the posterior thoracic ventral surface; in addition, descriptions of such staining often are not precise enough and for many species, no staining results are reported. The use of methyl green staining may not be helpful for some species but the distinct bands described for *A. striata* **sp. nov.** (Fig. 3E) and *A. tigrina* Blake, 1996 are a clear character, as are the stained specks on the dorsum of the peristomium of *A. glandaria* (Fig. 3B) and the lack of a staining reaction in the ventral thorax of *A. bullata*, *A. guttata*, *A. malefica*, *A. multifilis*, and *A. zebra* **sp. nov.** Additionally, the transverse stripes in the swollen posterior body region of *A. tigrina* and *A. zebra* **sp. nov.** (Fig. 3F) are important species specific characters.

The bitentaculate cirratulids of the Pacific coast of Costa Rica are a species rich group. Dean & Blake (2007) reported five species of *Chaetozone* (three of them new species), and five newly described species of *Caulleriella* while Dean & Blake (2009) reported eight species of *Monticellina* from this region, six of them new species. In the present study six new species of *Aphelochaeta* are described and *A. glandaria* is newly reported from the region. This brings to 24 the number of species of bitentaculate cirratulids currently recognized from the Pacific side of Costa Rica. Additionally, several additional species of bitentaculate cirratulids were collected from this area but were represented by poor or incomplete specimens not useful for description. It is probable, therefore, that other species of these cirratulids may be found in other geographic regions but are poorly known or misidentified and further work will greatly increase our knowledge of this diverse group of organisms.

Acknowledgements

The collection of specimens from Costa Rica could not have been made without the help of Prof. José A. Vargas, Prof. Jenaro Acuña and Ana Fonseca all of Centro de Investigaciones en Ciencias del Mar y Limnología (CIMAR). Some of these collecting trips were supported by the Costa Rica-United States of America (CR-USA) Foundation for Cooperation through grants to Prof. José A. Vargas. Scanning Electron Microscopy (SEM) was conducted with the guidance of Richard Schalek, Ellen Hodges and Carolyn Marks (all of CNS, Harvard University). This study was supported by the National Science Foundation under Grant No. DEB-0118693 (PEET) to James A. Blake, University of Massachusetts, Boston. This is a contribution of the Centro de Investigación en Ciencias del Mar y Limnología (CIMAR), Universidad de Costa Rica. The manuscript benefitted from comments by Dr. Brigitte Ebbe.

Literature cited

- Blake, J.A. (1991) Revision of some genera and species of Cirratulidae (Polychaeta) from the western North Atlantic. *Ophelia Supplement*, 5, 17–30.
- Blake, J.A. (1996) Family Cirratulidae Ryckholdt, 1851 including a revision of the genera and species from the Eastern North Pacific. In: Blake, J.A., Hilbig B. & Scott, P.H. (Eds.), *Taxonomic atlas of the benthic fauna of the Santa Maria Basin and western Santa Barbara Channel, Volume 6. The Annelida, Part 3*. Santa Barbara Museum of Natural History, Santa Barbara, California, pp. 263–384.
- Blake, J.A. (2006) New species and records of deep-water Cirratulidae (Polychaeta) from off Northern California. *Scientia Marina*, 70S3, 45–57.
- Blake, J.A. (2015) New species of *Chaetozone* and *Tharyx* (Polychaeta: Cirratulidae) from the Alaskan and Canadian Arctic and the Northeastern Pacific, including a description of the lectotype of *Chaetozone setosa* Malmgren from the Spitzbergen in the Norwegian Arctic. *Zootaxa*, 3919 (1), 501–552.
<http://dx.doi.org/10.11646/zootaxa.3919.3.5>
- Carrasco, F.D. (1977) Polychaeta (Annelida) de Bahía de Concepción, Chile. Familias Orbiniidae, Cirratulidae, Cossuridae, Capitellidae y Ampharetidae, con la descripción de tres especies y una subespecie nuevas. *Boletín de la Sociedad de Biología de Concepción*, 51, 67–92.
- Dean, H.K. (1996a) Subtidal benthic polychaetes (Annelida) of the Gulf of Nicoya, Costa Rica. *Revista Biología Tropical*, 44 (Suppl. 3), 69–80.
- Dean, H.K. (1996b) Polychaete worms (Annelida) collected in Golfo Dulce during the Victor Hensen Costa Rica expedition (1993/1994). *Revista Biología Tropical*, 44 (Suppl. 3), 81–86.
- Dean, H.K. (2004) Marine biodiversity of Costa Rica: Class Polychaeta (Annelida). *Revista Biología Tropical*, 52 (Suppl. 2), 131–181.
- Dean, H.K. & Blake, J.A. (2007) *Chaetozone* and *Caulleriella* (Polychaeta: Cirratulidae) from the Pacific Coast of Costa Rica, with description of eight new species. *Zootaxa*, 1451, 41–68.
- Dean, H.K. & Blake, J.A. (2009) *Monticellina* (Polychaeta: Cirratulidae) from the Pacific coast of Costa Rica, with description of six new species. *Zoosymposia*, 2, 105–126.
- Doner, S.A. & Blake, J.A. (2006) New species of Cirratulidae (Polychaeta) from the northeastern United States. *Scientia Marina*, 70S3 (Suppl. 3), 65–73.
- Doner, S.A. & Blake, J.A. (2009) Two new species of *Aphelochaeta* (Polychaeta: Cirratulidae) from deep-water off Northern California. *Zoosymposia*, 2, 127–137.
- Elías, R. & Rivero, M.S. (2009) Two new species of Cirratulidae (Annelida: Polychaeta) from Mar del Plata, Argentina (SW Atlantic). *Zoosymposia*, 2, 139–148.
- Hartman, O. (1960) Systematic account of some marine invertebrate animals from the deep basins of Southern California. *Allan Hancock Pacific Expeditions*, 22, 69–215.
- Hartmann-Schröder, G. (1965) Die Polychaeten des Sublitorals. In: Hartmann-Schröder, G. & Hartmann, G. Zur Kenntnis des Sublitorals der chilenischen Küste unter besonderer Berücksichtigung der Polychaeten und Ostracoden. *Mitteilungen des Hamburgischer Zoologischen Museums und Instituts*, 62, 59–305, 300 figs.
- Hutchings, P. & Murray, A. (1984) Taxonomy of polychaetes from the Hawkesbury River and the southern estuaries of New South Wales, Australia. *Records of the Australian Museum*, 36 (Suppl. 3), 1–118.
<http://dx.doi.org/10.3853/j.0812-7387.3.1984.101>
- Maurer, D. & Vargas, J.A. (1984) Diversity of soft-bottom benthos in a tropical estuary: Gulf of Nicoya, Costa Rica. *Marine Biology*, 81, 97–106.
<http://dx.doi.org/10.1007/BF00397631>
- León-Morales, R. & Vargas, J.A. (1998) Macrofauna of a tropical fjord-like embayment: Golfo Dulce, Costa Rica. *Revista Biología Tropical*, 46 (Suppl. 6), 81–90.
- Magalhães, W.F. & Bailey-Brock, J.H. (2013) Bitentaculate Cirratulidae (Annelida: Polychaeta) from the northwestern Pacific Islands with description of nine new species. *Zootaxa*, 3630 (1), 80–116.
<http://dx.doi.org/10.11646/zootaxa.3630.1.3>
- Moore, J.P. (1909) Polychaetous annelids from Monterey Bay and San Diego, California. *Proceedings of the Philadelphia Academy of Natural Sciences*, 61, 235–295.