

# A new species of *Branchamphinome* (Annelida: Amphinomidae) from the South-western Atlantic, with an emendation of the genus

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*The genus Branchamphinome Hartman, 1967 is a moderately understood genus of Amphinomidae that differs morphologically from most other genera in the form of its chevron-shaped caruncle and the presence of branchiae from chaetiger 1. Branchamphinome is presently represented by two deep-water species: B. antarctica, described from the Southern Ocean and B. islandica, from Iceland. We describe a new species of Branchamphinome from shallow South-west Atlantic waters, coast of Brazil. The new taxon revealed the surprising presence of notopodial hooks in chaetiger 1, which was subsequently also found to be present in the lectotype of B. antarctica. Both the genus and Hartman's species are emended to include this morphological feature. Historically, the presence of notopodial hooks has long been considered a diagnostic character for the genus Paramphinome, particularly when distinguishing Paramphinome from Linopherus. Branchamphinome tropicalis sp. nov. was found inhabiting sand sediments at depths of 150 m and temperatures of 16–20°C. Branchamphinome tropicalis sp. nov. differs from its congeners by its characteristic and highly developed pigmentation pattern, shape of the caruncle, branchiae and disposition of prostomial eyes. This is the first report of this genus from shallow tropical waters.*

**Keywords:** Biodiversity, Polychaeta, Amphinomida, fireworms, Brazil, Campos Basin

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## INTRODUCTION

The family Amphinomidae presently represents around 180 nominal species in around 28 genera including 20 that are moderately well-defined, of which two represent fossil taxa, and eight whose present status and affinities are not well understood (Kudenov, 1994, 1995; Read, 2014); given questions concerning the synonymy of other taxa, the actual number of valid genera is perhaps 21 (Borda *et al.*, 2012). These worms, often called ‘fireworms’, are best known for colourful, large-bodied tropical species with brilliant white calcareous chaetae. A neurotoxin (complanine) associated with harpoon chaetae induces an irritating sensation in some predators and unlucky divers, and functions as a defence mechanism (Kudenov, 1995; Nakamura *et al.*, 2008). While the majority of amphinomids are reported from shallow and tropical waters, some inhabit polar and deep-sea habitats (Kudenov, 1993, 1995; Barroso & Paiva, 2008, 2011; Borda *et al.*, 2012, 2013), others thrive in chemosynthetic environments (Borda *et al.*, 2012).

*Branchamphinome* Hartman, 1967 is a moderately understood genus that differs morphologically from other genera in

having an unusual chevron-shaped caruncle and branchiae from chaetiger 1.

Two species of *Branchamphinome* are presently known: *Branchamphinome antarctica* Hartman, 1967 was originally described based on deep-water specimens from Antarctica (333–1153 m), and subsequently reported by Amoureux (1982), who identified a single specimen from the North Atlantic. Detinova (1985) later described *B. islandica* from deep North Atlantic waters near Iceland (1413–1605 m), centred on morphological differences in the branchiae and chaetae compared with those of *B. antarctica*.

While studies continue on the phylogeny of the Amphinomida (Borda *et al.*, 2012, 2015), the exact phylogenetic position of *Branchamphinome* within the Amphinomidae has not been completely delineated. That is, in view of its lack of accessory dorsal cirri, *Branchamphinome* is clearly a member of the Amphinominae (Borda *et al.*, 2015). It is also similar anatomically to *Hermodice* and *Pherecardia* in having branchiae on all chaetigers, while the caruncles of *Branchamphinome* and *Pherecardia* are constructed similarly.

The purpose of this study is to describe a new species of *Branchamphinome* from shallow tropical waters (19°S) of the the South-western Atlantic, Brazilian Continental Shelf (150–200 m deep), together with an emendation of the genus and to provide a key to all known species of this genus.

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## MATERIALS AND METHODS

Specimens of *Branchamphinome* were collected from five stations (Figure 1) on South-eastern Brazil's continental shelf – off Espírito Santo State, during a survey conducted by PETROBRAS (Brazilian Energy Company) under the scope of the AMBES project 'Caracterização Ambiental Marinha da Bacia do Espírito Santo e Porção Norte da Bacia de Campos', coordinated by CENPES/PETROBRAS. Sediment sampled with a box corer was sieved using a 0.5 mm mesh; specimens were fixed in 10% formalin, and preserved in 70% alcohol.

Specimens were later examined using stereo- and compound light microscopes and scanning electron microscopy (SEM). For the latter, specimens were first dehydrated in a series of progressively increasing concentrations of ethanol (70–100%), critical point dried, coated with ~35 nm of gold and then examined and photographed at the Laboratório de Microscopia Eletrônica (NEMA/PUC-Rio). Type material was deposited in the Museu Nacional da Universidade Federal do Rio de Janeiro (MNUFRJP) and the Museu de Zoologia da Unicamp (ZUEC).

Abbreviations for museum names:

USNM – Smithsonian Institution National Museum of Natural History

LACM – Natural History Museum of Los Angeles

MNUFRJP – Museu Nacional da Universidade Federal do Rio de Janeiro

ZUEC – Museu de Zoologia da Universidade Estadual de Campinas

## RESULTS

### SYSTEMATICS

AMPHINOMIDAE LAMARK, 1818

AMPHINOMINAE LAMARCK, 1818

*BRANCHAMPHINOME* Hartman, 1967, EMENDED

Kudenov, 1993, EMENDED

### TYPE SPECIES

*Branchamphinome antarctica* Hartman, 1967, by original designation.

*Branchamphinome antarctica* Hartman, 1967, pp. 42–43, Plate 12, fig. A.

*Branchamphinome antarctica*.-Kudenov, 1993, pp. 95–99, Figures 1A–H, 2A–L, 6.

?*Branchamphinome antarctica*.-Amoureux, 1982, p. 34, Figure 2 (North Atlantic).

Not *Branchamphinome islandica* Detinova, 1985, pp. 104–105, Figure 1u–10 (North Atlantic).

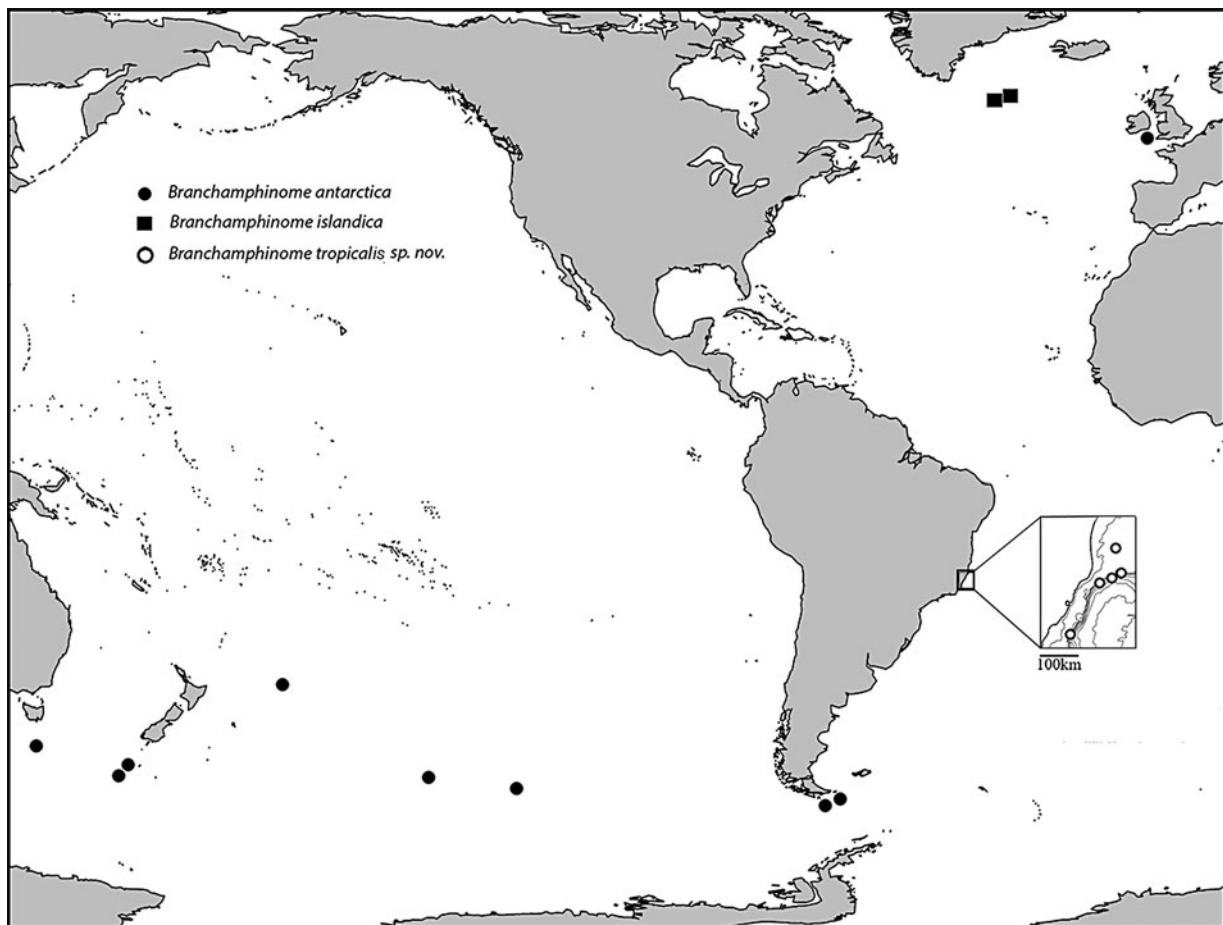


Fig. 1. Distribution of *Branchamphinome* species.

*Euphosine armadilloides*.-Hartman, 1967, p.45 (in part).-Not Ehlers, 1900.

*Euphosine magellanica*.-Hartman, 1967, p. 45 (in part). Not Ehlers, 1900.

*Euphosine notialis*.-Hartman, 1967, p. 45 (in part). Not Ehlers, 1900.

#### DIAGNOSIS

Body oval to elongate, rectilinear. Prostomium with anterior and posterior lobes present bearing five cephalic appendages. Caruncle chevron-shaped, with median keel and paired lateral lamellae. Parapodia biramous. Notochaetae include spurred and non-spurred capillaries and harpoons; notopodial hooks present in chaetiger 1. Neurochaetae include spurred and non-spurred capillaries plus bifurcate chaetae. Notoacacula and neuroacacula hastate, former sometimes spinous. Branchiae dichotomously branching tufts from chaetiger 1, continuing to end of body. Dorsal cirri cirriform; ventral cirri conical to subulate. Dorsal anus opening on last one or two chaetigers. Pygidial cirrus medial, unpaired.

#### EMENDED DESCRIPTION

The emended description by Kudenov (1993) is updated here to include the presence of a single delicate and inconspicuous hook in each notopodial fascicle of chaetiger 1.

#### REMARKS

The discovery of notochaetal hooks in chaetiger 1 of *B. tropicalis* sp. nov. from the South Atlantic (see below), led JDK to re-examine the lectotype of *B. antarctica* and confirm their presence (Figure 2N). The presence of hooks in *Branchamphinome* is interesting because it has long been considered a singularly diagnostic character of the genus *Paramphinome*. Whereas the presence of hooks remains a diagnostic generic trait, the two above taxa are readily distinguished from one another by the form of their caruncles (less developed in *Paramphinome*) and distribution of branchiae (confined to anterior region in *Paramphinome*). Interestingly, a primary anatomical difference between *Paramphinome* and *Linopherus* is the absence of notopodial hooks in the latter genus.

#### DISTRIBUTION

Southern Ocean: Drake passage (384–494 m), Macquarie Ridge (333–798 m), South-west Pacific Basin (531–659 m), Pacific Antarctic Ridge (362–1153 m), Tierra del Fuego (771–903 m), South Tasman Rise (1028–1034 m) (Kudenov, 1993); Atlantic Ocean: North Atlantic: off Iceland (1413–1605 m) (Detinova, 1985), off Bretagne-Ireland (1200 m) (Amoureux, 1982); South Atlantic: Brazilian coast (134–163 m) (this study).

*Branchamphinome tropicalis* sp. nov.

#### TYPE MATERIAL

Holotype: complete specimen, 6 mm long, 0.5 mm wide (19°45'54.71"S 39°30'24.91"W; 138 m depth) (MNUFRJP-1196); coll. 15 January 2012.

Paratypes: 2 specimens. (19°36'4.32"S 39°10'34.07"W; 134 m depth) (MNUFRJP-1197); coll. 15 January 2012. 1 specimen. (19°36'3.57"S 39°10'33.64"W; 142 m depth) (MNUFRJP-1198); coll. 20 June 2013. 1 specimen. (19°36'5.08"S 39°10'32.85"W; 145 m depth) (MNUFRJP-

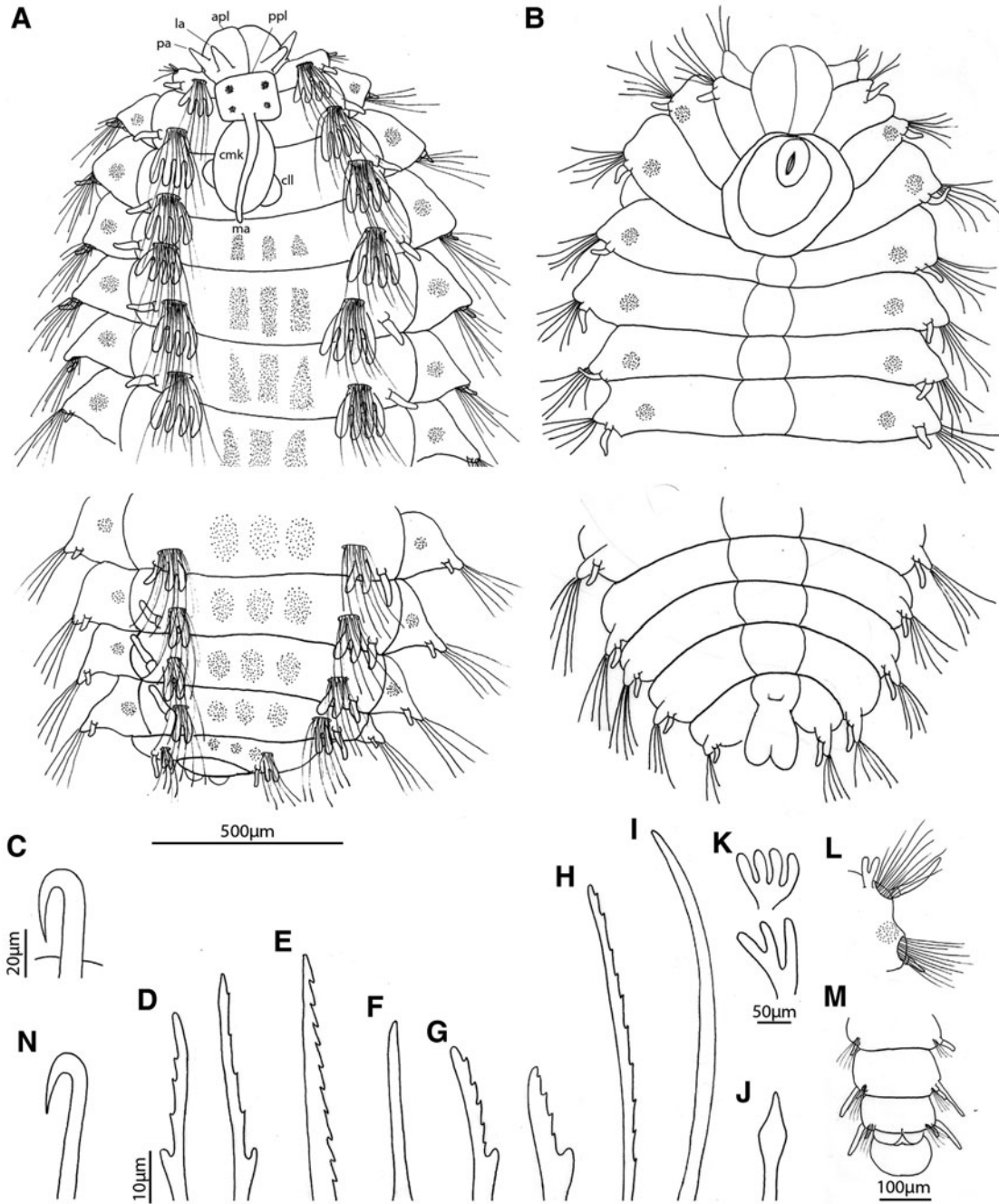
1199); coll. 15 January 2012. 1 specimen. (19°36'5.17"S 39°10'32.93"W; 145 m depth) (ZUEC-191883); coll. 15 January 2012. 1 specimen. (19°31'51.52"S 39°3'4.3"W; 140 m depth) (MNUFRJP-1200); coll. 9 December 2011. 1 specimen. (19°31'51"S 39°3'4.79"W; 163 m depth) (MNUFRJP-1121); coll. 29 June 2013.

#### COMPARATIVE MATERIAL EXAMINED

*Branchamphinome antarctica* Hartman, 1967. Lectotype: USNM 55502; USNS 'Eltanin' Cruise 15 to Pacific Antarctic Ridge, Station 1343 (54°50'S 129°50'W to 54°51'S 129°46'W); collected 7 November 1964 with Menzies trawl, 915–1153 m depth. Paralectotypes: USNM 99503, 139256–139260 (287 specimens); USNS 'Eltanin' Cruise 15 to Pacific Antarctic Ridge, Station 1343 (54°50'S 129°50'W to 54°51'S 129°46'W); collected 7 November 1964 with Menzies trawl, 915–1153 m depth. USNM 55934, 99308, 139095 (21 specimens); USNS 'Eltanin' Cruise 9 to Drake Passage, Station 740 (56°06'S 066°19'W to 56°07'S 066°30'W); collected 18 September 1963 with Blake trawl, 384–494 m depth. USNM 139098 (3 specimens); USNS 'Eltanin' Cruise 16 to Macquarie Ridge, Station 1411 (51°00'S 162°01'E to 51°01'S 162°01'E); collected 8 February 1965 with Blake trawl, 333–371 m depth. USNM 139099 (1 specimen); USNS 'Eltanin' Cruise 16 to Macquarie Ridge, Station 1414 (52°17'S 160°40'E to 52°22'S 160°34'E); collected 9 February 1965 with Blake trawl, 659–798 m depth. USNM 99305, 99307, 139096 (11 specimens); USNS 'Eltanin' Cruise 15 to Pacific Antarctic Ridge, Station 1343 (54°50'S 129°50'W to 54°51'S 129°46'W); collected 7 November 1964 with Menzies trawl, 915–1153 m depth. USNM 55904 (5 specimens); USNS 'Eltanin' Cruise 15 to Pacific Antarctic Ridge, Station 1345 (54°50'S 129°48'W to 54°51'S 129°46'W); collected 7 November 1964 with Menzies trawl, 915–1153 m depth. USNS 55903, 139097, LACM 00000 (65 specimens); USNS 'Eltanin' Cruise 15 to Pacific Antarctic Ridge, 1346 (54°49'S 129°48'W to 54°50'S 129°46'W); collected 7 November 1964 with Blake trawl, 549 m depth. USNM 139100-139101 (26 specimens); USNS 'Eltanin' Cruise 16 to Pacific Antarctic Ridge, Station 1691 (53°56'S 140°19'W to 53°56'S 140°17'W); collected 14 May 1966 with Blake trawl, 362–567 m depth. USNM 139102 (1 specimen); USNS 'Eltanin' Cruise 24 to South-west Pacific Basin, Station 1718 (38°27'S 168°07'W to 38°30'S 168°04'W); collected 12 July 1966 with Blake trawl, 531–659 m depth. USNM 139103 (1 specimen); USNS 'Eltanin' Cruise 27 to South-west Pacific Basin, Station 1983 (47°11'S 147°47'E to 47°10'S 147°46'E); collected 12 July 1966 with Blake trawl, 531–659 m depth. USNM 139104 (2 specimens); RV 'Hero' Cruise 715 to Tierra del Fuego, Station 875 (54°55'S 064°00'W to 54°54'S 063°53'W); collected 26 October 1971 with trawl, 771–903 m depth.

#### DIAGNOSIS

Body elongate, short, fusiform to long, rectilinear; longitudinal midventral groove absent. Three rectangular brown patches on dorsum of each chaetiger, a round interparapodial patch and two ventral rounded patches near each neuropodium. Prostomium moderately developed, with anterior and posterior lobes, bearing five cephalic appendages including: paired lateral antennae and palps on anterior lobe; a median antenna on posterior lobe. Eyes numbering two pairs, typically well-developed. Caruncle chevron-shaped,



**Fig. 2.** *Branchamphinome tropicalis* sp. nov. A. Holotype, anterior and posterior regions, dorsal view; B. Holotype, anterior and posterior regions, ventral view; C. notohook; D–F. notochaetae; H–J. Neurochaetae; K. branchiae; L. Paratype terminal chaetiger, lateral view; M. Paratype pygidium, ventral view; N. *Branchamphinome antarctica* (lectotype). notohook (not to scale). apl, anterior prostomial lobe; ca, caruncle; cmk, caruncle median keel; cli, caruncle lateral lobe; la, lateral antenna; ma, median antenna; ppl, posterior prostomial lobe.

including median keel with up to two paired, simple secondary lamellae, latter directed posteriorly; arising from posterior border of prostomium, not fused to body wall; confined to chaetiger 2. Mouth opening between chaetigers 2 and 3. Branchiae dichotomously branching tufts from chaetiger 1, continuing to end of body. Filaments digitiform, reaching the maximum number 4–6 filaments per branchiae in middle body chaetigers. Dorsal anus opening on terminal one or two chaetigers. Pygidium as a median unpaired papilla.

#### DESCRIPTION BASED ON HOLOTYPE

Holotype with 20 chaetigers, 6 mm long, 0.5 mm wide without chaetae (Figures 1A–C & 2A, B). Body subrectangular in cross section, with a specific pattern of pigmentation. Three rectangular brown patches on dorsum of each chaetiger, a round interparapodial patch and two ventral rounded patches near each neuropodium – totalling 7 pigmented patches on each chaetiger (Figure 2A, B). These patches are least pigmented in the first 2–3 anterior and the last several body chaetigers. Prostomium quadrangular, consisting of



anterior and posterior lobes. Anterior lobe is large, with paired lateral antennae arising from its posterior region and paired palps, similar in form to lateral antennae, inserted ventrolaterally on anterior region; lateral antennae and paired palps are smooth and conical (Figure 2A). Posterior lobe of prostomium with two pairs of large, conspicuously rounded and well-separated eyes and a median antenna. First pair of eyes largest, median antenna similar in form to the lateral antennae and palps, inserted on posterior region of the prostomium, aligned between second pair of eyes and exceeding caruncle in length (Figures 2A & 3A, C). Caruncle pinnate; a medial keel with one lateral lobe each side, attached to the posterior edge of prostomium and free of body wall. Mouth composed of chaetigers 2–3, posterior lip formed by chaetiger 3 (Figures 2B & 3B). Pharynx muscular, eversible, with a longitudinal aperture when everted. Parapodia biramous with well separated rami. Notopodia circular in outline with marginal collars; dorsal cirri well developed, cirrophores longer than wide, distal cirrostyles smooth, tapering, emerging at apex of chaetal fascicles; neuropodia conical, with raised collars, conical, ventral cirri arising from body wall, posteroventral to fascicle, with cirrophores, increasing in length in posterior chaetigers, but shorter than dorsal cirri along entire body (Figures 2A & 4D). Branchiae present in all chaetigers, branching dichotomously, with each branch producing a palmate array of filaments posterior and superior to notopodia. Filaments digitiform, reaching the maximum number 4–6 filaments per branchiae in middle body chaetigers (Figures 2A & 3A, K).

Notochaetae of four types: One recurved and diminutive, inconspicuous hook is present on superior margin of each notofascicle of first chaetiger, located between each notopodium and the prostomium (Figures 2C & 3G); long thick harpoon chaetae (Figure 2E) – the least abundant kind of notochaeta; spurred and non-spurred capillaries with inner cutting margins serrated (Figures 2D & 4E, G); notoacacula of two types: hastate (2 per fascicle), and stout, abruptly tapered spines (4–5 per fascicle) (Figures 2F & 4F); all distally emergent. Neurochaetae of three types: bifurcate chaetae with the inner margin of long prong serrated (Figures 2G & 4H), serrated capillaries with dentate cutting edges lacking spurs (Figure 2H) and smooth capillaries (Figure 2I); neuroacacula hastate (Figures 2J & 4I), confined to upper margins of fascicle, numbering 2–4 per neuropodia. Anus dorsal on terminal chaetiger, pygidium with a median unpaired, distally incised papilla (Figure 2A, B).

#### VARIATION

Great variation in the caruncle, branchiae, dorsal pigmentation pattern, pygidium and presence of the notohooks on the first chaetiger was observed in the paratypes. For example, the caruncle varies from a simple, globular median keel lacking paired axial ridges (Figures 3A, C, D & 4B) to one having two pairs of axial ridges arising from each side of the median keel (Figures 2F, G & 4C). Although all specimens are distinctly pigmented, the typical dorsal pigmentation pattern described above is the presence of three dorsal patches per segment, each with the same intensity (Figure 3A, C, E, H); otherwise, the median patch is sometimes larger and more darkly pigmented than the lateral ones (Figure 3D, F). Specimens with more segments tend to be more pigmented. While branchiae are palmate and

dichotomously branched, they are either symmetrical (Figures 3A & 4D) to asymmetrically divided (Figures 3E & 4C).

The notopodial hook on the first chaetiger is very difficult to detect. For example, we observed it in just four out of 12 specimens of *B. tropicalis* sp. nov., and do not know whether hooks are simply absent in some specimens or if they could have been broken or whether they are located internally in the parapodia, being engulfed with the growing of the animal (Figure 3E, H, I).

While the pygidium of the holotype is incised (Figures 2A, B & 3A, B), it is not incised in a complete paratype (Figures 2F & 3M). A possible explanation is that this bilobed structure could be an artefact of a regeneration process of terminal chaetigers, as observed in some specimens.

#### ETYMOLOGY

The name of this species, *tropicalis*, refers to the tropical region of Brazil (19°S), from where this species is described. This represents the first report of the genus *Branchamphinome* from the tropics.

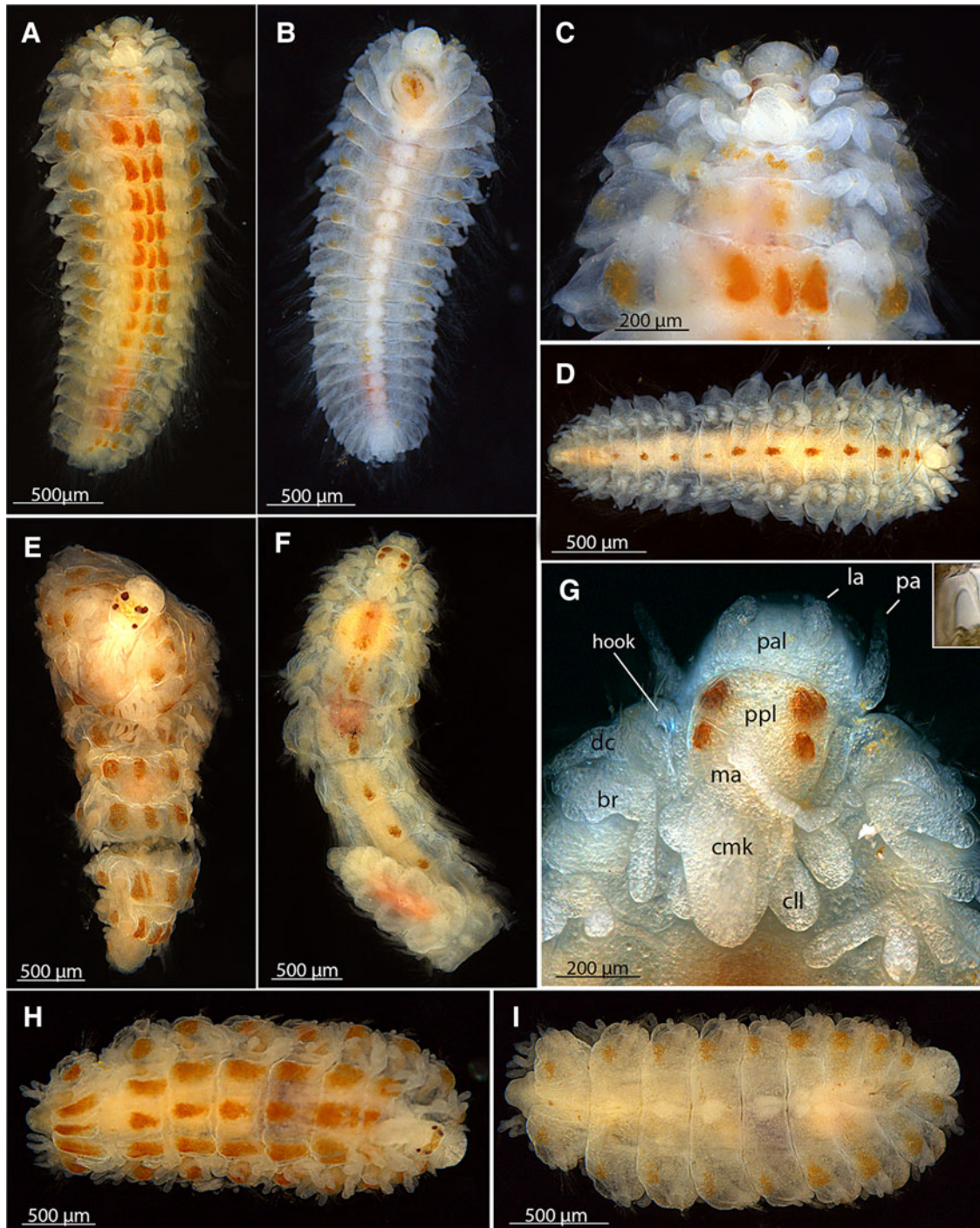
#### REMARKS

The existence of a notopodial hook on the first chaetiger of *Branchamphinome tropicalis* sp. nov., which was also observed in the lectotype of *B. antarctica*, is described here for the first time and confirmed as a generic characteristic. As noted above, their presence is phylogenetically interesting in that it long has been considered to be a primary diagnostic feature of the genus *Paramphino*, and the main anatomical difference separating *Paramphino* and *Linopherus*. We speculate that the presence of notopodial hooks in chaetiger 1 may represent a size-related feature present in small-bodied species and/or specimens that may ultimately be lost during the later developmental stages of large-bodied amphinomids. Similarly, differences in mouth placement whereby chaetiger 3 forms the posterior lip in *B. tropicalis* in contrast to chaetiger 4 in *B. antarctica* is also probably an ontogenetic phenomenon; the latter species is considerably larger (size and segments) compared with the former. Similar trends in other size-dependent morphological features such as the ventral scutes of *Archinome* have also been documented (Borda *et al.*, 2013).

*Branchamphinome tropicalis* sp. nov. further differs from *B. antarctica* in having poorly developed branchiae, maximally with 5–8 filaments emerging from one main stem in the midbody region of large specimens; those of *B. antarctica* have up to 20 branchial filaments emerging from two main stems, forming an ‘L’ pattern (when viewed from above).

*Branchamphinome tropicalis* sp. nov. is similar to *B. islandica* regarding the shape of branchiae and number of branchial filaments, but differs from this species due to its well separated pair of eyes, while those of *B. islandica* appear to be fused, giving an impression of a figure ‘8’. Due to its characteristics plus the geographic location, we strongly suspect that Amoureux’s (1982) specimen represents *B. islandica*. We have not examined Amoureux’s material, and note that he identified his specimen before Detinova (1985) described *B. islandica*.

The caruncles of *B. tropicalis* sp. nov., *B. antarctica* and *B. islandica* all arise from the posterior margin of the prostomium, and are not fused to the body wall in the first two taxa; it is probably also not fused to the body wall in *B. islandica*,



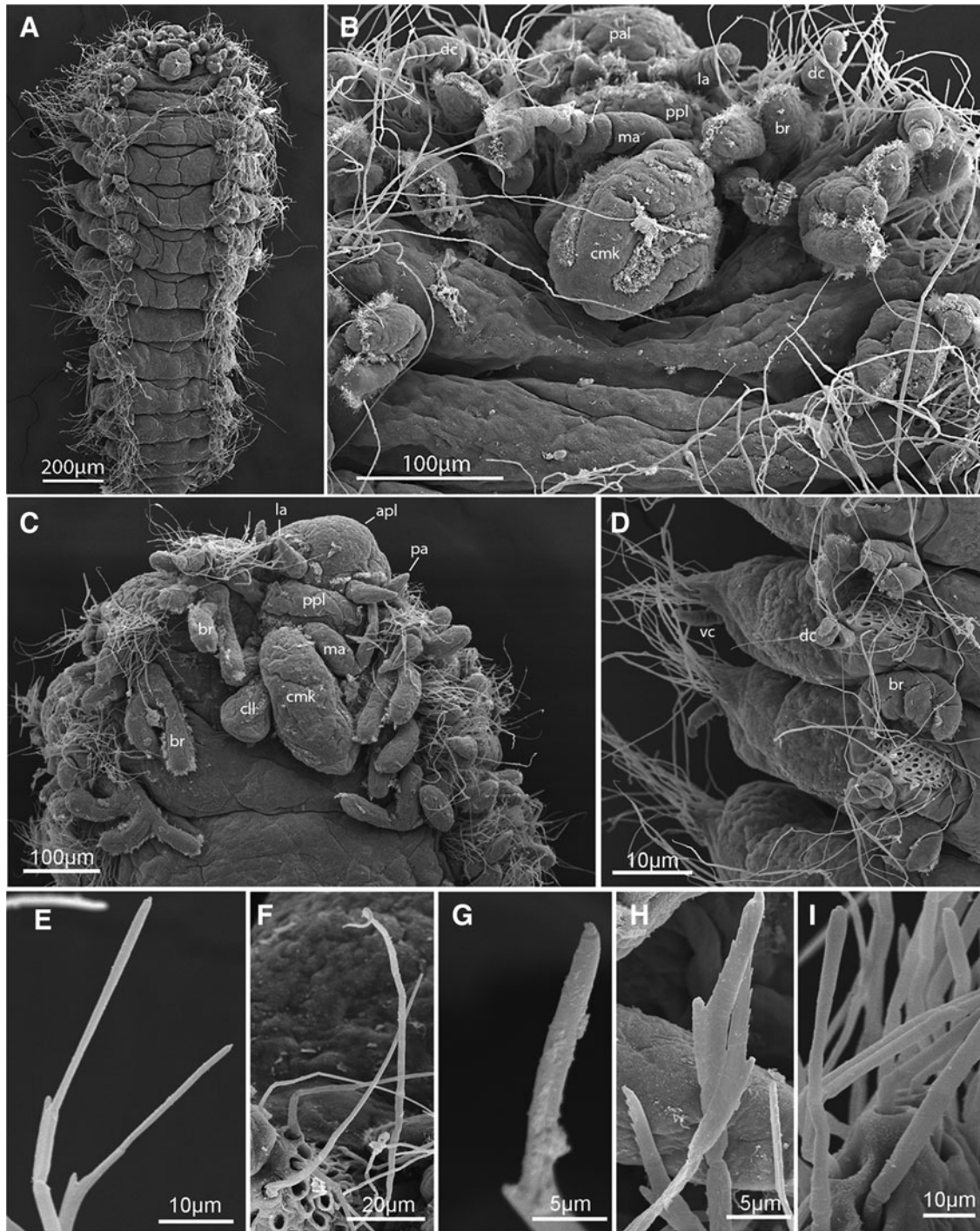
**Fig. 3.** *Branchamphinome tropicalis* sp. nov. stereomicroscope images. A. Holotype, dorsal view; B. Holotype, ventral view; Holotype, anterior region. D. specimen prepared to SEM; E. Paratype, entire body, dorsal view; F. Paratype. Entire body, dorsal view; G. same specimen, prostomium, notohook in detail; H. paratype, dorsal view; I. same specimen, ventral view. Abbreviations: apl, anterior prostomial lobe; br, branchia; cmk, caruncle median keel; cll, caruncle lateral lobe; dc, dorsal cirri; la, lateral antenna; ma, median antenna; ppl, posterior prostomial lobe.

although the holotype should be re-examined to verify our surmise. However, the caruncles of these taxa vary in the degree of their development, with *B. tropicalis* sp. nov. having up to two lateral lobes on either side of the median keel; *B. islandica* with two lateral lobes (four total); and *B. antarctica* with six lateral lobes (12 total). Interestingly, *Branchamphinome* and *Pherocardia* are the only known amphinomids having similarly configured caruncles, although the simple caruncle of the former taxon lacks the intricate

array of lateral lobes that are secondarily folded into a foliose plicate array.

*Branchamphinome tropicalis* sp. nov. was found in the Brazilian continental shelf at a depth of 150 m, and this report represents the first record of the genus from both shallow and tropical waters. *Branchamphinome tropicalis* sp. nov. differs from *B. antarctica* and *B. islandica* Detinova, 1985, mainly due to the highly developed body pigmentation pattern; the other species are apparently unpigmented.





**Fig. 4.** *Branchamphinome tropicalis* sp. nov. SEM images. A. Entire body, dorsal view; B. Prostomium and caruncle, dorsal view; C. Anterior region, dorsal view; Parapodia of midbody, dorsal view; E–F. Notochaetae; G–I. Neurochaetae. Abbreviations: apl, anterior prostomial lobe; br, branchia; ca, caruncle; cmk, caruncle median keel; cl, caruncle lateral lobe; dc, dorsal cirri; la, lateral antenna; ma, median antenna; ppl, posterior prostomial lobe; vc, ventral cirri.

The highly developed pigmentation pattern in *B. tropicalis* sp. nov. may be due to the shallow depth from where this species lives, in contrast to all previous depth records for this genus. Furthermore, it appears that *B. tropicalis* sp. nov. is restricted geographically to shelf depths (134–163 m); it has not been collected from numerous slope stations (up to 3000 m).

It is likely that shallow-water species are more intensely pigmented compared with their deep-water congeners. For

example, Nygren *et al.* (2010) found shallow species (*Notophyllum foliosum*) to be more pigmented than its deeper congener (*N. crypticum*). Similar findings were also reported by Barroso & Paiva (2011) for a deep-water species of *Chloeia* (Amphinomidae), which tend to be much less pigmented compared with shallower *Chloeia* species. Furthermore, pigmentation patterns have been demonstrated to be an important taxonomic character in the genus *Notopygos* (Yáñez-Rivera & Carrera-Parra, 2012).

TAXONOMIC KEY FOR *BRANCHAMPHINOME* SPECIES

1. Branchiae with 15 to 18–20 filaments in midbody segment ..... *B. antarctica*
  - Branchiae with 4–8 filaments in midbody segment ..... 2
2. Two pair of eyes nearly coalescent, forming a figure ‘8’; body not characteristically pigmented; caruncle with up to 4 lateral lobes arising from either side of the median keel ..... *B. islandica*
  - Two pairs of eyes, not coalescent and not forming a figure ‘8’; body characteristically pigmented; caruncle with up to 2 lateral lobes arising from either side of the median keel ..... *B. tropicalis* sp. nov.

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