A new species of the genus *Terebellides* (Polychaeta, Trichobranchidae) from the Iranian coast

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Abstract

Based on specimens collected during several sampling programmes along the Iranian coast, Persian Gulf, a new species of the genus *Terebellides* (Polychaeta, Trichobranchidae) is herein described as *Terebellides persiae* **spec. nov.** The new species is primarily characterised by the presence of a large dorsal thoracic hump in larger specimens and ciliated papillae on the branchial lamellae. The new species is compared with other taxa belonging to *Terebellides* described or reported with any of both characters. SEM and micro-CT have been used to study *T. persiae* **spec. nov.** and provide several new details on external characters and internal organs, respectively. A key for the identification of the species of *Terebellides* with dorsal hump is provided.

Key words: Persian Gulf, *Terebellides persiae* **spec. nov.**, morphology, SEM, micro-CT

Introduction

The relative low marine biodiversity of the Persian Gulf is often attributed to the natural stress induced in the ecosystem by its extreme environmental conditions (Price *et al*. 1993). Alternatively, it may also rely on the short geological history of the Gulf as such, due to its complete drying out in the late Pleistocene (Sheppard 1993). However, it may also be caused by the lack of dedicated taxonomic approaches. In fact, several studies revealed that different groups studied in the area included new species that appear to be either endemic or only known to date, from the Gulf. Among them, there are four new species of cumaceans (Corbera *et al*. 2005) and nine species of polychaetes (Mohammad 1971, 1980; Bhaud *et al*. 2003; Martin *et al*. 2006).

The present paper, framed within a series of monitoring studies sponsored by TOTAL and carried out by Créocéan, contains the description of a new species of trichobranchid polychaete, *Terebellides persiae* **spec. nov.**, which supports the aforementioned hypothesis. A detailed study of both external and internal body morphology is conducted, using stereomicroscope, Scanning Electron Microscopy (SEM) and micro computed tomography (micro-CT). This paper is a new contribution to the effort done by several authors in last decade to unveil the true diversity of the genus *Terebellides* in the world oceans (see Parapar & Moreira 2008; Schüller & Hutchings 2010, 2012, 2013; Parapar *et al*. 2011, 2013; Parapar & Hutchings 2015; Hutchings *et al*. 2015).

Materials and Methods

Study area

The area studied is located along the Iranian shoreline of the eastern Persian Gulf (Fig. 1). The Persian Gulf is a shallow (36 m mean depth) semi-enclosed sea with a low water exchange rate (up to 5 years) (Sheppard 1993). Evaporation is much higher than freshwater inputs (i.e. precipitation and river inflow) and surface waters increase their density, sink to the bottom and move out of the Gulf through the deeper portion of the Strait of Hormuz. This generates a reverse estuary circulation, similar to that of the Mediterranean Sea (Reynolds 1993). The environmental conditions are often considered as extreme (Price *et al*. 1993), with surface temperatures ranging from <15°C (winter, north coast) to 30°C (summer, Strait of Hormuz) and reaching more than 35°C at 30 m deep in the Iranian coast. Salinity is always high, ranging from around 37‰ near the Strait of Hormuz to around 40‰ due to evaporation when drifting along the Iranian coast, but reaching 50‰ or even 70‰ off the South and West coasts of the Gulf.

Sample collection

Sampling campaigns were done from 1998 to 2006. Samples were collected in 1998 and 2002 near Assaluyeh at the north of the Nay Band Bay, 250 km south of Bandar Bousher, in 2005 in Tomback and in 2006 near Akhtar (Table 1). Samples were taken along transects positioned perpendicular to the coast at successively increasing depths, from North to South along the shoreline (five in 1998 and 2002, four in 2005 and two in 2006). On each transect, three stations were distributed from the shallowest to the deepest bottoms, and three replicates were collected at each station. Sediments were sampled using a Van Veen grab (about 0.1 m^2 per grab). A one-litre volume of sediment was taken from one grab for physico-chemical analyses (for details see Bhaud *et al*. 2003; Martin *et al*. 2006). For faunistic studies, the sediment was sieved on board through a 1-mm mesh sieve. The retained sediment was fixed with a 4% formaldehyde/seawater solution, stained with Rose Bengal and stored until sorted. Later, material was rinsed with fresh water and transferred to 70% ethanol.

Most of the type material of *T. persiae* **spec. nov.** (holotype and paratypes) was deposited in the Museo Nacional de Ciencias Naturales of Madrid (MNCN); some additional paratypes were also deposited in the collections of the Natural History Museum of Denmark (Copenhagen; ZMUC) and the Natural History Museum, London (BMNH). Two specimens used for examination with SEM were prepared by critical point drying, covered with gold and examined and photographed at the Servizos de Apoio á Investigación-SAI (Universidade da Coruña-UDC, Spain). SEM was also used to study the internal morphology of the species based on one abdominal fragment. The specimen studied with the micro-CT scan at the Marine Biology Station of A Graña (University of Santiago de Compostela-USC, Spain) was preserved in 70% ethanol, dehydrated through successive baths of 80%, 90% and 96% ethanol, then immersed for 2 hours in hexamethyldisilazane (HMDS) and allowed to air dry overnight (Alba Tercedor & Sánchez-Tocino 2011; Faulwetter *et al.* 2013).

Abbreviations used in text and figures:

BL—branchial lobes
BLBV—branchial lobes blood vessels
br—brain

BSBV—basal stem blood vessel
BT—buccal tentacles
CH—chaetiger
coel—coelom
cp—ciliated papilla
cr—ciliated row
DBV—dorsal blood vessel
dg—digestive gland
FI—fore intestine
FS—fore stomach
gd—gonad
go—genital opening
HB—heart body
HS—hind stomach
ll—lower lip
LL—lateral lappets
LML—longitudinal muscle layer
m—mouth
ne—nephridial tubes
nl—notopodial lobe
NP—neuropodial pinnule
npa—nephridial papillae
OE—oesophagus
OM—oblique muscle
php—pharyngeal pouch
SBV—segmental blood vessel
SG—segment
TC—thoracic chaetiger
TDH—thoracic dorsal hump
tdp—thoracic dorsal papillae
tp—terminal projection
TWT—thoracic wrinkled tegument
ul—upper lip
VG—ventral gutter
vl—ventral lappets
vnc—ventral nerve cord

Results

Taxonomic account

Family Trichobranchidae Malmgren, 1866

Genus *Terebellides* Sars, 1835, emended by Schüller & Hutchings 2013

Type species. *Terebellides stroemii* Sars, 1835, redescribed by Parapar & Hutchings 2015

***Terebellides persiae* spec. nov.**
(Figs 1–11, Tables 1–2)

Material examined. A total of 81 specimens were collected from 25 samples along the Iranian coasts of the Persian Gulf in years 1998, 2002, 2005 and 2006 (Table 1).

MNCN. Holotype: MNCN 16.01/16969 (St. B2-20B). **Paratypes collected in this study**: MNCN 16.01/16970 (St. 10, 1 spec.); MNCN 16.01/16971 (St. 13, 13 specs); MNCN 16.01/16972 (St. 13, 1 spec. in SEM stub); MNCN 16.01/16973 (St. 14, 1 spec.); MNCN 16.01/16974 (St. 20, 1 spec.); MNCN 16.01/16975 (St. 23, 1 spec.); MNCN 16.01/16976 (St. 25, 1 spec.); MNCN 16.01/16977 (St. 10-1, 1 spec.); MNCN 16.01/16978 (St. 15-1, 1 spec.); MNCN 16.01/16979 (St. 25-1, 2 specs); MNCN 16.01/16980 (St. B1-15C, 2 specs); MNCN 16.01/16981 (St. B1-15C, 1 spec. in two SEM stubs); MNCN 16.01/16982 (St. B2-10B, 1 spec.); MNCN 16.01/16983 (St. B2-15A, 2 specs); MNCN 16.01/16984 (St. B2-20A, 2 specs); MNCN 16.01/16985 (St. B2-20A, 1 spec. used for micro-CT); MNCN 16.01/16986 (St. B2-20B, 1 spec.); MNCN 16.01/16987 (St. B3-15A, 1 spec.); MNCN 16.01/16988 (St. B3-15C, 2 specs); MNCN 16.01/16989 (St. B3-20A, 1 spec.); MNCN 16.01/16990 (St. B3-20B, 1 spec.); MNCN 16.01/16991 (St. E15-1, 9 specs); MNCN 16.01/16992 (St. E20-1, 6 specs); MNCN 16.01/16993 (St. F25-3, 11 specs).

ZMUC. Paratypes, specimens previously identified by Wesenberg-Lund (1949) as *T. stroemii*: ZMUC-POL-002403 (7 specs); ZMUC-POL-002400 (1 spec.); ZMUC-POL-002402 (12 specs). **Paratypes collected in this study:** ZMUC-POL-2422 (St. F20-2, 8 specs).

BMNH. Paratypes collected in this study: BMNH 2016-000 (St. F10-3, 02/2006; 7 specs).

Additional non-type material: MNCN 16.01/16994 (St. 18-1, 2 specs); MNCN 16.01/16995 (St. 23-1, 2 specs). ZMUC-POL-002399 (1 spec.); ZMUC-POL-002401 (1 spec.).

Other material examined. BMNH 1969-245 (*Terebellides stroemii*, Arabian Gulf, Kuwait, coll. and det. by Dr. M. Muhammad). One specimen 20 mm long and 1 mm width with 32 abdominal chaetigers. Specimen previously dissected and in bad conditions. General body characteristics agree with *T. persiae* **spec. nov.** but a definitive identification cannot be done. BMNH 1990-41-51 (*Terebellides parvus*, Stn. 12 West Bay, Twin Cays, Belize, coll. Fauchald & Kensley, 31/10/79).

Description (based on holotype and paratypes). Complete individuals ranging from 7 to 50 mm in length (40 mm in holotype; Fig. 2A) and 1.0 to 4.0 mm in maximum width at thoracic region (3.5 mm in holotype, excluding parapodia). Body tapering posteriorly with segments increasingly shorter and crowded towards pygidium. Prostomium compact; peristomium forming a tentacular membrane with large upper and lower lips surrounding the mouth, sometimes devoid of buccal tentacles (Figs 2B, 3). Buccal tentacles of two types, short tentacles uniformly cylindrical, slightly expanded at tips, long tentacles more expanded at tips (Fig. 3B). Lateral lappets on TC1–6 (SGIII–VIII), being larger in TC1–3 (Figs 2B, 3A). No conspicuous dorsal rounded projection on anterior chaetigers or oval-shaped glandular region in TC3. TC2 more developed and shifted dorsally (Figs 2B, 3A).

Branchiae arising as single structure from SGII–III, consisting of a single stalked structure situated mid-dorsally and made up of two pairs of unfused lobes; lower (=ventral) pair smaller (BL3–4) and shorter than upper (=dorsal) pair of lobes (BL1–2) (Figs 2–4). Anterior projection of dorsal pair of branchial lobes (fifth lobe; BL5) large (Figs 3A, 4B, 9A–B). Upper and lower lobes with a very short pointed projection on posterior region (although deciduous and sometimes damaged) (Fig. 3). Loss of branchial lobes not observed. Both sides of branchial lamellae with parallel bent rows of cilia and well-developed ciliated papillae at edge of one side of each branchial lamella (Fig. 5B–F).

Eighteen thoracic chaetigers (SGIII–XX), all with notopodia and with neuropodia from SGVIII. Notopodia of TC1 slightly smaller; TC2 displaced dorsally (Figs 2–3); all remaining notopodia similar in size. Thoracic neuropodia as sessile pinnules, from TC6 (SGVIII) to TC18, with uncini in single rows from TC7 (SGIX) throughout. First thoracic neuropodia (TC6) with geniculate acicular hooks (Figs 2, 3, 6A–B). Thoracic notochaetae similar in length, arranged in two rows (Fig. 6C–D), with textured surface (Fig. 6E). One ciliated papilla dorsal to each thoracic notopodia (Figs 4D, 6F). First neuropodium with 4–7 geniculate chaetae, with minute teeth forming a *capitium* easily overlooked without SEM (Fig. 6A–B); sharply bend in larger specimens but with a more open angle in smaller specimens. Subsequent thoracic neuropodia with one row of about 8–10 uncini per torus (Fig. 7A); uncini as shafted denticulate hooks with long, thin, pointed *rostrum* surmounted by 2–4 teeth and an upper crest of several smaller denticles of different sizes (Fig. 7B–C). One finger-shaped nephridial papilla basal to branchial stem (Figs 3B, 4D, 5A); blackberry-shaped genital openings, dorsal to notopodia and ventral to thoracic dorsal papilla in TC4 and TC5 (Fig. 4E–F).

Twenty seven to 36 abdominal chaetigers (12 in holotype but incomplete). Abdominal neuropodia as erect pinnules, with about 35 uncini per torus (Fig. 7D). Uncini with 3–4 teeth above main fang (Fig. 7E), surmounted by a row of an irregular number of shorter teeth and an upper crest of minute teeth. Pygidium blunt, funnel-like depression (Fig. 7F). Colour in alcohol pale brown.

Gross internal morphology (MNCN 16.000/16985). (Figs 8, 10–11). Body wall sustained by a thick layer of longitudinal musculature; thick bundles of oblique musculature separating ventro-lateral areas corresponding to uncinal pinnules (Fig. 8A). Intestine filling most of coelom, with one long ventral gutter (Fig. 8A); dorsal area bearing a wide sinus, probably related to the circulatory system (heart body) (Fig. 8B), connected with dorsal blood vessel and smaller segmental blood vessels.

3D images (Fig. 9) clearly show external body appearance and relevant taxonomic characters: shape and size of fifth branchial lobe, thoracic lateral lappets at TC1–5, geniculate chaetae at TC6, tegument shrinking at the top of the thoracic hump. Internal features also well distinguished: muscle fibres at tentacular lobe and branchial blood vessels, two in branchial stem and one below each big branchial lobe (BL1 and BL2) (Fig. 9B). Sagittal and frontal plane (Fig. 10) and transversal images (Fig. 11) showing highly-regionalized anterior part of digestive tract typical of *Terebellides*, occupying most thoracic region, with four well defined areas: 1) oesophagus, 2) anterior-most stomach (= fore stomach), with a voluminous digestive gland, 3) posterior-most stomach (= hind stomach), with thick wall, and 4) beginning of large wrinkled intestine (= fore intestine), with a very thin wall (Fig. 10). Brain at base of tentacular lobe (Fig. 10A). Empty coelomic space surrounding digestive tube. Gametes absent.

Transverse views (Fig. 11) showing an internal organization typical of *Terebellides*. Remarkably thick and twisted nephridial ducts near oesophagus and fore stomach; lumen apparently filled by electro dense material (Fig. 11B–C) and a wide venous sinus likely corresponding to heart body (Figs 10A, 11D). Gonad remains likely corresponding to thin sacs associated to ventro-lateral oesophagus and fore stomach areas (Fig. 11B–C; see Discussion).

Biological notes. Sampling methodology does not allow to obtain reliable data about life cycle of *T. persiae* **spec. nov.** However, examination of specimen sizes shows (Fig. 12 A) a wide size range: 4–49 mm in length and 0.5–3.5 mm in width. Sampling was done in summer (two occasions), autumn and winter and apparently there is no relationship between season and sizes. Summer specimens, however, show a wider length range: 10–17 mm long specimens were more abundant in 1998, while 30–50 mm long ones were more frequent in 2005. A few mid-sized specimens (25–30 mm long) were found in autumn 2002, while in

February 2002, specimens were more abundant and corresponded to small (3–12 mm) and middle (20–25 mm) sizes.

Several patterns were determined according to the presence of TDH, TWT and oocytes in body cavity (Fig. 12B). Most 4–12 mm long specimens lack both TDH and TWT (empty circles in Fig. 12B), but many of them contained oocytes (filled circles), the only exception being a 20-mm long specimen which also had them. Many 13–30 mm long specimens (diamonds in Fig. 12B) show TWT but lack TDH and oocytes instead. TDH is present in >30 mm long specimens (empty squares), which also lack oocytes. Therefore, it is here confirmed that 7–12 mm long specimens lacking TDH and TWT usually correspond to mature females.

Type locality. Tomback, coast of Iran.

Distribution and habitat. Specimens of *T. persiae* **spec. nov.** were found in shallow water bottoms (10–30 m depth) in the central Iranian coasts of the Persian Gulf (Table 1, Fig. 1). Its distribution extends to the Strait of Hormuz / Oman Gulf because specimens found there and identified as *T. stroemii* by Wesenberg-Lund (1949) (stored in ZMUC) actually correspond to *T. persiae* **spec. nov.** One specimen from Kuwait coasts (Mohammad 1971, 1980) was here examined, but its identity could not be confirmed due to preservation state.

Etymology. The species epithet refers to its presence in the Iran coasts of the Persian Gulf (lat. gen. *persiae* ="from Persia").

Remarks. *Terebellides persiae* **spec. nov.** can be distinguished from any other species in the genus by the large TDH of larger specimens and by the ciliated papillae on branchial lamellae. Apart from *T. persiae* **spec. nov.**, four species of *Terebellides* have been described as bearing TDH: *T. anguicomus* Müller, 1858, *T. carmenensis* Solís-Weiss, Fauchald and Blankestein, 1991, *T. lanai* Solís-Weiss, Fauchald and Blankestein, 1991 and *T. totae* Bremec and Elías, 1999; all them occurring in American Atlantic coasts, from the Mexican Caribbean (one species) to Brazilian-Argentinian coasts (three species). A fifth species, *T. klemani* Kinberg, 1867 is also proposed to have TDH by Schüller & Hutchings (2013) (see Table 3 and key to *Terebellides* in Schüller & Hutchings 2013). However, these authors did not examine the types (see Table 4 in Schüller & Hutchings 2013), while Solís-Weiss *et al*. (1991) who did examine the syntypes, reported the absence of this body feature, observation also confirmed later by Garraffoni & Lana (2003) after examining more specimens. The presence of TDH in *T. anguicomus* from Brazil was illustrated by Müller (1858) and confirmed by Solís-Weiss *et al*. (1991), who also reported a conspicuous TDH in *T. carmenensis* from México. Later, Bremec & Elías (1999) also recorded the presence of TDH in some specimens of *T. lanai* so that they did not consider this feature as diagnostic. After examining the variability found in specimens of *T. persiae* **spec. nov.** (Table 2), we certainly agree with Bremec & Elías (1999). These authors also described *T. totae* as bearing an "anterior dorsum smoothly curved ... resembling a hump", which was later considered as TDH by Garraffoni & Lana (2003) and Schüller & Hutchings (2013). Schüller & Hutchings (2013) further suggest that TDH may have developed at least twice during the evolution of *Terebellides*. Anyway, when present, TDH is always located in TC7, as in *T. persiae* **spec. nov.** Garraffoni & Lana (2003) point out that the presence and appearance of TDH would depend on whether the specimen is alive or not, disappearing completely in preserved specimens (Figs 11–12 in Garraffoni & Lana 2003). We did not examine living specimens of *T. persiae* **spec. nov.** but the TDH is always conspicuous in the largest preserved individuals.

On the other hand, the presence of ciliated papillae in branchial lamellae of *T. persiae* **spec. nov.** seems to be only shared with *Terebellides akares* Hutchings, Nogueira and Carrerette, 2015 from Australia, but the latter lacks TDH.

Wehe & Fiege (2002) mention reports of *Terebellides stroemii* in Red Sea areas, the Sinai Peninsula (Amoureux *et al*. 1978) and Sudan coasts (Rosenfeldt 1989) (Fig. 1), based on a single specimen each and including superficial descriptions with no drawings. Gravier

(1905a, b, 1906) described *Aponobranchus perrieri* Gravier, 1905 from Djibouti (Aden Gulf), later synonymised to *T. stroemii* by Hartman (1959); the type material was deposited in the Muséum National d'Histoire Naturelle of Paris, but it could not be located for examination. Finally, a third species of *Terebellides* was described from the Red Sea coasts of Egypt (El-Tor, west Sinai Peninsula), namely *Terebellides umbela* Ehrenberg and Grube in Grube, 1869. This species was considered as indeterminable by Hartman (1974) and Holthe (1986) and therefore categorized as *nomen dubium* by Wehe & Fiege (2002).

Discussion

Branchial features have frequently been used in the taxonomy of *Terebellides*. However, little attention was paid to its morphological diversity until the recent works by Schüller & Hutchings (2010, 2012, 2013), Parapar *et al*. (2011, 2013) and Parapar & Hutchings (2015). In this context, Parapar *et al*. (in press) summarize the branchial variability and define several morphotypes. In turn, the presence of branchial ciliated papillae in *T. akares* (Hutchings *et al*. 2015), similar to those of *T. persiae* **spec. nov.** (see above), demonstrates that branchial morphology should be studied in detail across the genus, as it may be very helpful in elucidating its actual species diversity. This kind of papillae agree with the structures described by Solís-Weiss *et al.* (1991) for several species from the Gulf of Mexico, such as *Terebellides parvus* Solís-Weiss, Fauchald and Blankestein, 1991, one of which paratypes we have had the opportunity to study. Interestingly, the five species of the genus described as having TDH (see remarks) also bear branchial lamellae provided with a distal row of papillar projections. Furthermore, Parapar *et al*. (2013) describe marginal papillae in branchial lamellae in specimens identified as *T. stroemii* from the Adriatic Sea (Parapar *et al*. 2013, Fig. 9C). However, these papillae do not lay at the internal border of lamellae and are not ciliated, like in the aforementioned species. As this terminology seem confuse, we propose to use "branchial lamellae with a distal row of scattered papillae with ciliated tips" for the Atlantic Ocean and Persian Gulf species, and "branchial lamellae with papillar projections on marginal edge" for the aforementioned specimens of "*T. stroemii*", probably a still unnamed species.

On the other hand, our data suggest that *T. persiae* **spec. nov.** may exhibit a life span of several years, with spawning occurring late in the year (see Biological notes). Accordingly, the presence of TDH seems not to be related with the reproductive state but to the size itself, as large specimens (i.e. 30–49 mm long) consistently show conspicuous TDH. The biological role of TDH (if any) remains unknown and no hypotheses have been postulated on this topic, including its possible relation with the reproduction. In fact, the reproductive biology of *Terebellides* remains largely unknown, with a few exceptions. Among them, Mediterranean *T. stroemii* from Banyuls (France) show a life span of up of three years, with an annual spawning in spring (Duchêne 1977, 1980), while the same species from west Greenland spawned for the first time when two-year old and then continued to spawn annually along its five-year life span, with a breeding season from October to November (Curtis 1977). Finally, Hutchings & Peart (2000) found gravid specimens of several *Terebellides* species in Australia, some restricted to summer and autumn months (December to May) while others were found throughout the year.

The internal anatomy studied by means of the micro-CT allowed to find eventual, subtle differences that may help to separate species. The studied specimen of *T. persiae* **spec. nov.** shows the same pattern of digestive regionalization as previously observed by Michel *et al*. (1984), Williams (1984) and Penry & Jumars (1990) in Mediterranean, NE and NW Atlantic specimens of *T. stroemii*. The same pattern was also found by Parapar & Hutchings (2015) when redescribing *T. stroemii* and by Parapar *et al*. (in press) in a new species from NE

Atlantic waters. All these species, including *T. persiae* **spec. nov.** and excluding *T. distincta* Williams, 1984, show two stomach regions (FS and HS) similar in size. The examination of *T. persiae* **spec. nov.** also allow us to confirm several elements that were first suggested by Steen (1883) and Jouin-Toulmond & Hourdez (2006). Among them, those associated to the circulatory (including branchiae and heart body dorsal to the stomach), nervous (e.g. the ventral nerve cord) and excretory (e.g. the very well developed nephridial system located antero-ventrally to the fore stomach) systems. On the contrary, several structures (e.g. gonads) were not clearly observed (maybe because the specimen was inmature) and others such as the gular membrane were not identified at all.

There has been numerous recent efforts addressed to carefully describe the morphological characteristics of different populations of *Terebellides* worldwide (Hutchings & Peart 2000; Parapar & Moreira 2008; Schüller & Hutchings 2010, 2012, 2013; Parapar *et al*. 2011, 2013, in press; Parapar & Hutchings 2015; Hutchings *et al*. 2015), some of them including synthetic analyses on critical morphological characters such as the branchiae. These studies usually lead to the description of new species, many of them being previously reported as the "cosmopolitan" *T. stroemii*. Despite the obvious merits of these studies, it seems evident that a deep revision of the genus is desirable in order to review and clearly delimitate valid, robust characters among those traditionally used, as well as in assessing whether they are depending on size, sexual maturity or state of preservation. The present paper clearly highlights this assertion by showing, for instance, the relevancy attributed to the ciliated branchial papillae (visible only under SEM) and the high variability reported for the presence and development of the TDH.

Key of *Terebellides* species with TDH

The key has been modified from Garraffoni & Lana (2003) and Schüller & Hutchings (2013), taking into account the confusing reports on the presence of TDH. We agree with Bremec & Elías (1999) in that TDF should not be considered as a species diagnostic character, at least for *T. lanai* and *T. persiae* **spec. nov.** However, we think that this restricted key may be useful because when present, this character is rather conspicuous.

Previous keys by Garraffoni & Lana (2003) and Schüller & Hutchings (2013) use diagnostic characters partly differing from those used here. Garraffoni & Lana (2003) propose the degree of development of TC1, the relative size of branchial lobes and the number of thoracic segments with lateral lappets, while Schüller & Hutchings (2013) propose those referring to TC1 and lateral lappets plus the bending degree of geniculate chaetae and the presence/absence of filamentous tips in branchial lobes. In the present key, we consider the characters used in both keys, but also the number of branchial lobes (i.e. presence and degree of development of fifth lobe) which, according to Parapar *et al*. (in press), is more easily detectable than the other previously used characters. When possible, the key was based on original descriptions, while the possible differences were supported by relevant references. *Terebellides klemani* is considered as having TDH by Schüller & Hutchings (2013) but it has not been included in the key (see Discussion).

1. 17 thoracic segments with notopodia; TC1 on segment SG4 ..... *T. anguicomus* Müller, 1858
- 18 thoracic segments with notopodia; TC1 on segment SG3 2

2. Fifth branchial lobe long, pointed ..... *T. persiae* **spec. nov.**
- Fifth branchial lobe short, rounded 3
3. Both branchial lobes similar in size; lateral lappets on TC1–6[1] .... *T. totae* Bremec and Elias, 1999
- Ventral branchial lobes slender than dorsal, lateral lappets less present 4
4. Lateral lappets on TC1–3[2, 4] ..... *T. carmenensis* Solís-Weiss *et al*., 1999
- Lateral lappets on TC1–5[3, 4] ..... *T. lanai* Solís-Weiss *et al*., 1999

(1) Garraffoni & Lana (2003) report SG3–7, i.e. TCH1–5.
(2) Data extracted from Garraffoni & Lana (2003). The original description is ambiguous: "*Rounded ear shaped projections of lateral lappets best developed in setigers 1 and 2*" (cfr. Solís-Weis *et al*. 1991, p. 151).
(3) Schüller & Hutchings (2013) indicate "*lateral lappets until TC8*".
(4) Joao M. Matos Nogueira (*per. comm.*) revised the types and suggests lateral lappets on TC1−5 in *T. carmenensis* and TC1−7 in *T. lanai*.

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Figure and table legends

FIGURE 1. Map of the Persian Gulf and Red Sea showing locations where specimens of *Terebellides persiae* **spec. nov.** were found and previous reports of the genus *Terebellides*.

FIGURE 2. *Terebellides persiae* **spec. nov.**, Holotype, MNCN 16.01/16969. A, left lateral view; B, right anterior body end.

FIGURE 3. *Terebellides persiae* **spec. nov.**, stereomicroscope images. A, Holotype, MNCN 16.01/16969, left anterior body end; B, paratype MNCN 16.01/16991, right anterior body end. Arrowhead pointing to dorsal hump in A and to low transversal thoracic elevation in B; circles in B: position of TC6 neuropodia with geniculate chaetae and nephridial papilla.

FIGURE 4. *Terebellides persiae* **spec. nov.**, paratypes MNCN 16.01/16972 and MNCN 16.01/16981, SEM micrographs. A, anterior end, right lateral view, showing lateral lappets; B, anterior end, dorsal view of branchial lobes; C, detail of dorsal hump; arrow heads showing pair of depressions on thoracic wrinkled tegument; D, SG3 nephridial papillae and TC2–3; E, TC4–5 notopodia with dorsal genital openings; F, Detail of TC5 genital papilla opening.

FIGURE 5. *Terebellides persiae* **spec. nov.**, paratypes MNCN 16.01/16972 and MNCN 16.01/16981, SEM micrographs. A, left lateral view of branchial lobes 1–4, lobe 5 in dorsal view; framed area showed in B; B, detail of L1 branchial lamellae edge showing position of ciliated papillae; C, detail of edge of two branchial lamellae showing interior position of ciliated rows and lateral ciliated papillae; D, detail of one ciliated papilla; E–F, two views of inner face and edge of several branchial lamellae showing position of ciliated papillae.

FIGURE 6. *Terebellides persiae* **spec. nov.**, paratypes, paratypes MNCN 16.01/16972 and MNCN 16.01/16981, SEM micrographs. A, four TC6 geniculate chaetae in upper view; B, detail of bending zone of TC6 geniculate chaetae showing semi-worn teeth of *capitium* (arrowhead); C, TC5 notopodium showing notopodial lobe; D, TC6 notochaetae; E, detail of pilose surface of thoracic notochaetae; F, detail of cilia of one papilla dorsal to thoracic notopodia.

FIGURE 7. *Terebellides persiae* **spec. nov.**, paratypes MNCN 16.01/16972 and MNCN 16.01/16981, SEM micrographs. A, row of uncini of thoracic torus in lateral view; B, detail of three thoracic uncini in lateral view; C, detail of a thoracic uncinus in upper view; D, abdominal neuropodial pinnule; E, detail of abdominal uncini in upper view; F, posterior body end in right lateral view.

FIGURE 8. *Terebellides persiae* **spec. nov.**, paratypes, MNCN 16.01/16981, SEM micrographs. A, dissected abdominal region at level of hindgut (intestine) showing position of ventral gutter, oblique muscles and longitudinal muscle layer; framed area showed in B; B, detail of dorsal region of intestine showing heart body over intestine connected to dorsal blood vessel and segmental blood vessel.

FIGURE 9. *Terebellides persiae* **spec. nov.**, paratype MNCN 16.01/16985, micro-CT 3D images. A, anterior body region, left lateral view showing internal muscular fibres of expanded tentacular membrane and below upper lip; TC6 geniculate chaetae encircled; arrowhead pointing to dorsal hump; B, anterior body region in dorsal view showing wrinkled

tegument associated with dorsal hump (arrowheads) and internal anatomy of tentacular membrane and branchial stem and lobes.

FIGURE 10. *Terebellides persiae* **spec. nov.**, paratype, MNCN 16.0116985, micro-CT images. A–B, longitudinal (A) and frontal body (B) sections showing several internal body characters, in A arrow marking position of thoracic dorsal hump; dotted lines showing position of transversal sections in Fig. 11.

FIGURE 11. *Terebellides persiae* **spec. nov.**, paratype, MNCN 16.01/16985, micro-CT images. A–E, transversal sections at different body levels from anteriormost to posteriormost (dotted lines in Fig. 10B) showing several internal body characters.

FIGURE 12. A, size frequency distribution of *T. persiae* **spec. nov.** specimens according to sampling dates; B, size frequency distribution of *T. persiae* **spec. nov.** specimens showing presence (+) / absence (-) of thoracic dorsal hump (TDH), thoracic wrinkled tegument (TWT) and eggs.

Table 1. Main abiotic characteristics of the samples where *Terebellides persiae* **spec. nov.** was collected in the Iranian coasts of the Persian Gulf. Org. car.: organic carbon content.

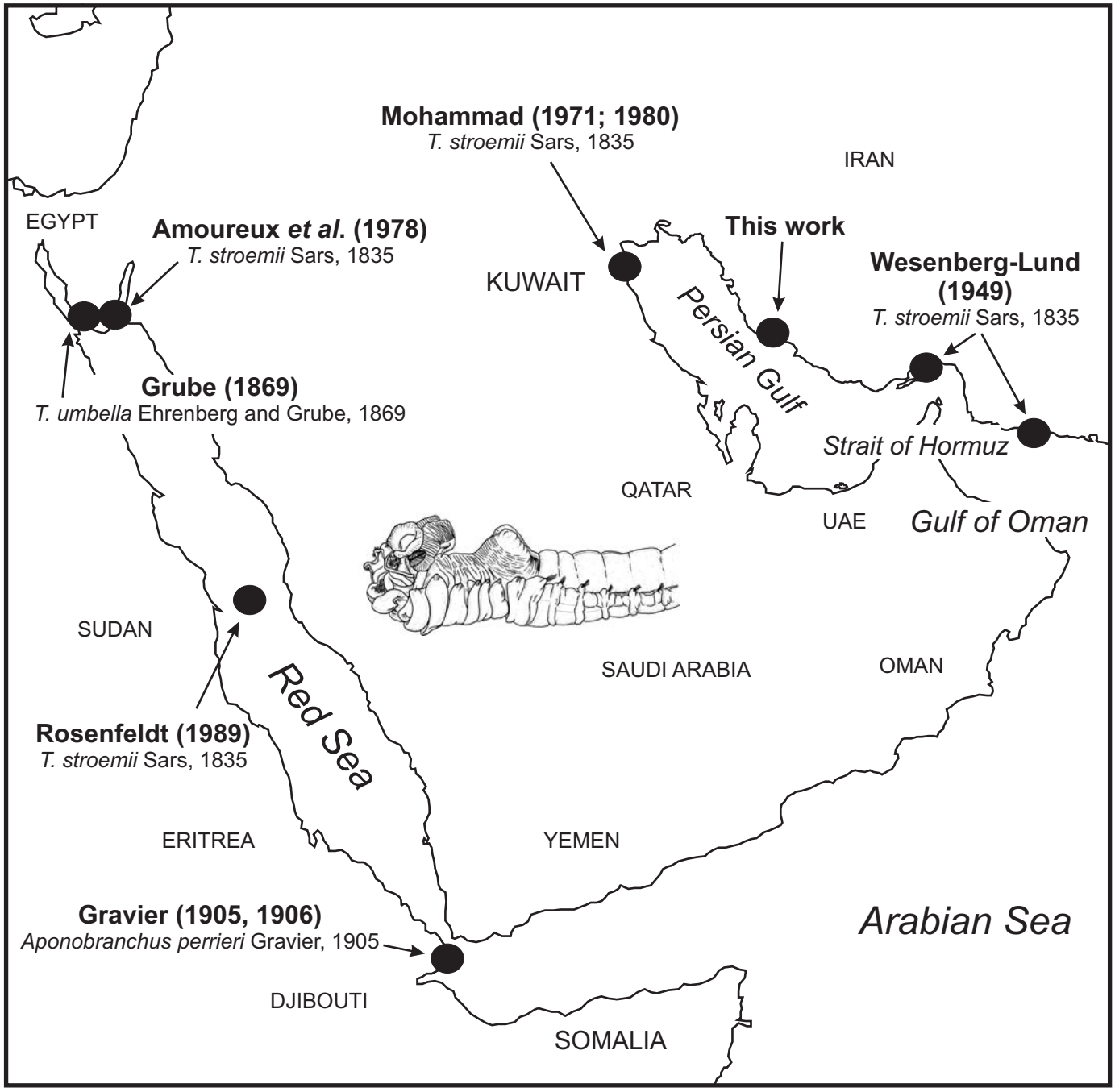
Table 2. Comparison of several body characters of the species of *Terebellides* described with TDH (modified from Garraffoni & Lana 2003). (1) CH7 in Garraffoni & Lana (2003); (2) data from Bremec & Elías (1999); (3) "anterior dorsum smoothly curved resembling a hump". NTUT: Number of thoracic uncini per torus; NRTAU: Number of rows of teeth in abdominal uncini; NAUP: Number of abdominal uncini per pinnule; NACH: Number of abdominal chaetigers.

Table 1.

Date	Station	Longitude N	Latitude E	Depth (m)	Silt+Sand (%)	Org. car. (%)
August 1998	10	27°29.796'	52°33.069'	30	38.1–54.2	1.10
	13	27°29.948'	52°33.831'	15	5.96–92.0	0.70
	14	27°29.677'	52°33.591'	19	4.41–92.6	0.47
	20	27°20.193'	52°33.763'	27	28.1–62.9	3.40
	23	27°29.065'	52°34.429'	14	3.8–95.2	0.46
	25	27°28.547'	52°33.921'	27	44.0–45.6	1.48
November 2002	10-1	27°29.796'	52°33.069'	30	24.4–70.1	0.66
	15-1	27°29.421'	52°33.344'	27	11.9–81.8	0.51
	18-1	27°29.406'	52°33.244'	16	3.5–93.9	0.33
	23-1	27°29.065'	52°34.429'	14	3.4–96.6	0.39
	25-1	27°28.547'	52°33.921'	27	19.4–50.7	0.68
August 2005	B1-15C	27°42.901'	52°10.643'	15	32.0–58.0	0.47
	B2-10B	27°42.730'	52°11.061'	10	8.0–64.0	0.31
	B2-15A	27°42.602'	52°10.954'	15	20.0–72.0	0.39
	B2-20A	27°42.510'	52°10.820'	20	26.0–64.0	0.47
	B2-20B	27°42.510'	52°10.820'	20	26.0– 64.0	0.47
	B3-15A	27°42.308'	52°11.229'	15	28.0–68.0	0.27
	B3-15C	27°42.308'	52°11.229'	15	28.0–68.0	0.27
	B3-20A	27°42.215’	52°11.118’	20	22.0–70.0	0.51
	B3-20B	27°42.215’	52°11.118’	20	22.0–70.0	0.51
February 2006	E15-1	27°41.421’	52°13.358’	15	57.2–35.8	1.42
	E20-1	27°41.352’	52°13.317’	20	56.5–35.9	1.52
	F10-3	27°41.155’	52°14.188’	10	27.7–70.5	1.47
	F20-2	27°41.099’	52°14.134’	20	56.4–36.1	1.41
	F25-3	27°41.035’	52°14.159’	25	56.1–36.8	1.51

Table 2.

Species	Nephridial papillae	Dorsal hump	Chaetigers with lateral lappets	Branchial lobes: Appearance	Branchial lobes: Number	CH6 acicular chaetae bending	Notopodia in CH1	NTUT	NRTAU	NAUP	NACH
T. anguicomus Müller, 1858	Yes	CH5[(1)]	CH1–6	All similar	5	Almost right angle, curved pointed tips	Absent	6–8	2	19–49	40–42
T. carmenensis Solís-Weiss *et al.,* 1991	Yes	CH7	CH1–5	VL thinner than DL	5	Obtuse angle, pointed tips	Smaller than following	12	?	39–54	37
T. lanai Solís-Weiss *et al.*, 1991	Yes	CH7[(2)]	CH1–8	VL thinner than DL	5	Almost right angle, pointed tips	Smaller than following	8–10	3	25–29	38
T. totae Bremec and Elías, 1999	?	CH7[(3)]	CH1–6	All similar	5	Obtuse angle, pointed tips	Smaller than following	8–17	?	23–72	39
T. persiae **spec. nov.**	S1+CH4–5	CH7	CH1–5	VL thinner than DL	5	Almost right angle, pointed tips	Smaller than following	≈10	1	≈30	≈37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Amoureux et al. (1978)
T. stroemii Sars, 1835
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Wesenberg-Lund (1949)
T. stroemii Sars, 1835
Persian Gulf
Grube (1869)
T. umbella Ehrenberg and Grube, 1869
Strait of Hormuz
QATAR
UAE
Gulf of Oman
SUDAN
SAUDI ARABIA
OMAN
Red Sea
Rosenfeldt (1989)
T. stroemii Sars, 1835
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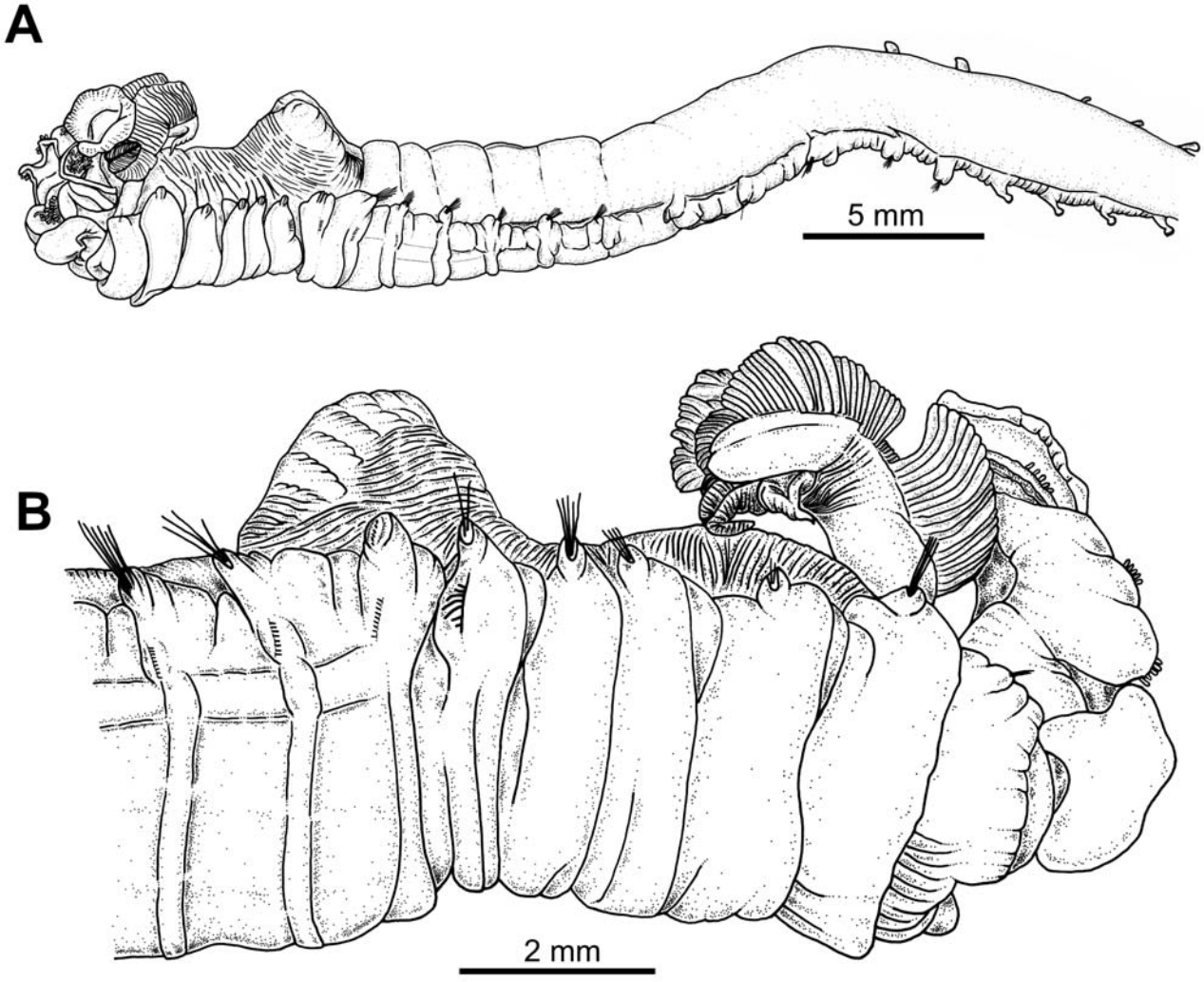
YEMEN
Arabian Sea
Gravier (1905, 1906)
Aponobranchus perrieri Gravier, 1905
DJIBOUTI
SOMALIA

Figure 1



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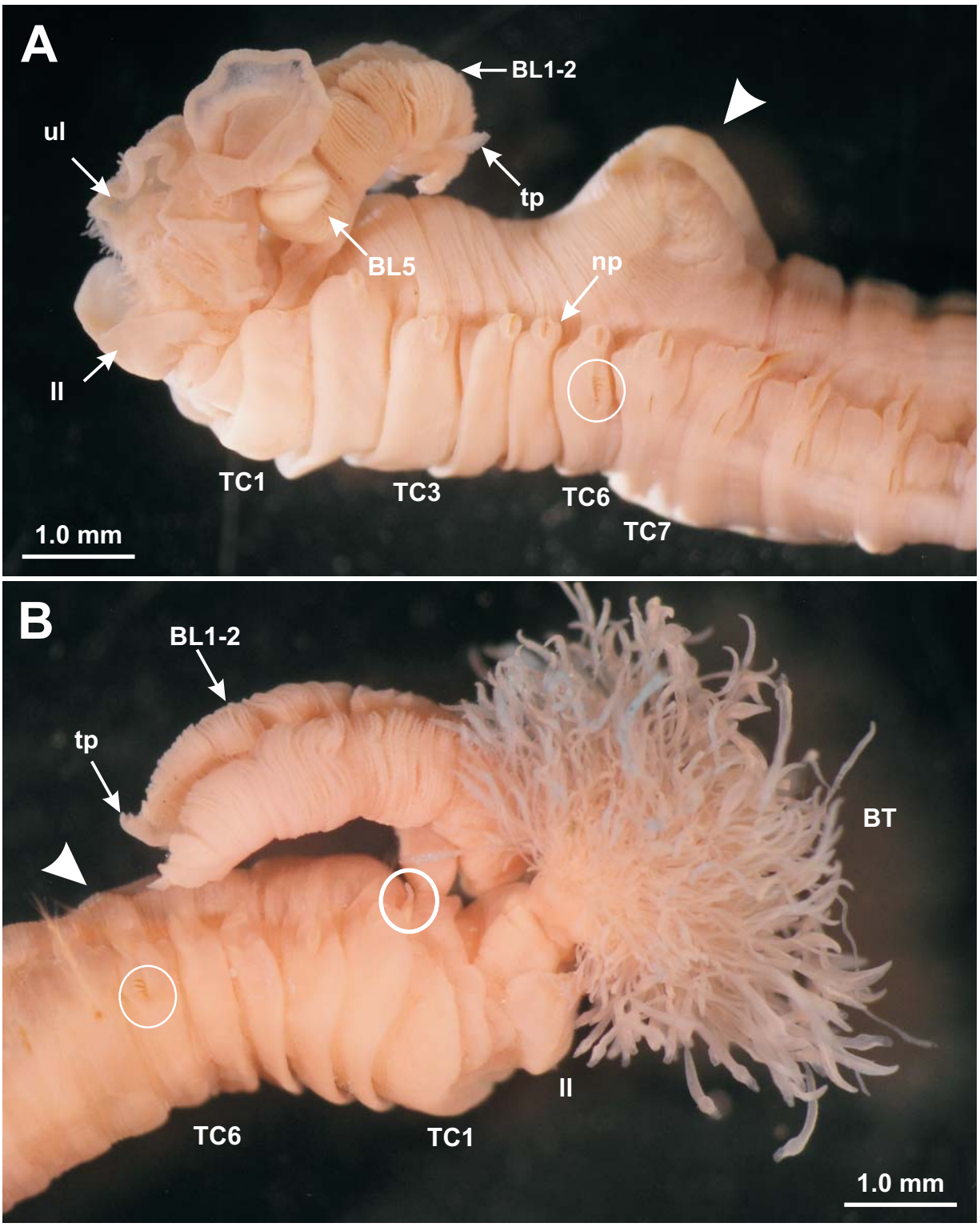
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Figure 3

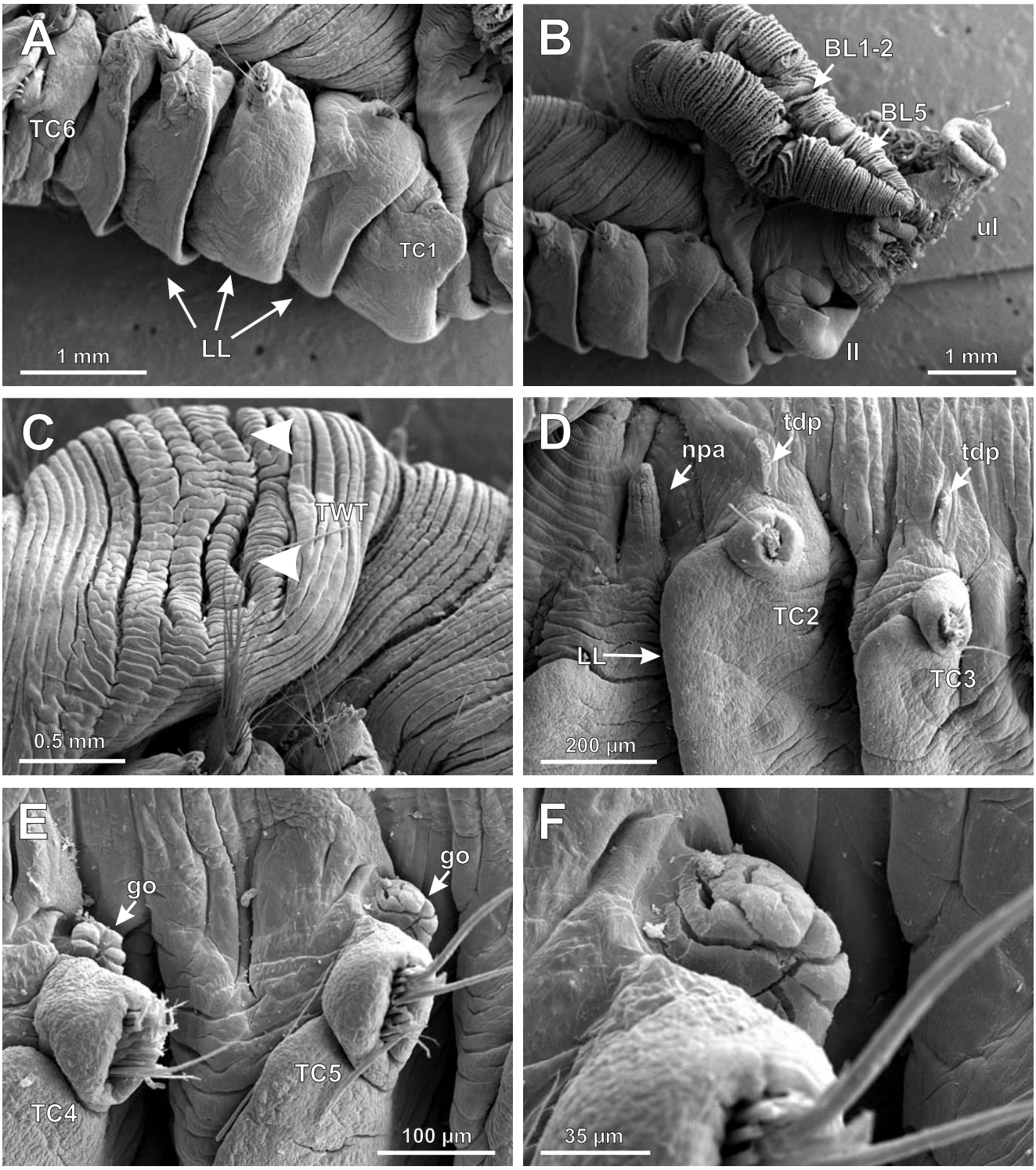
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Figure 4

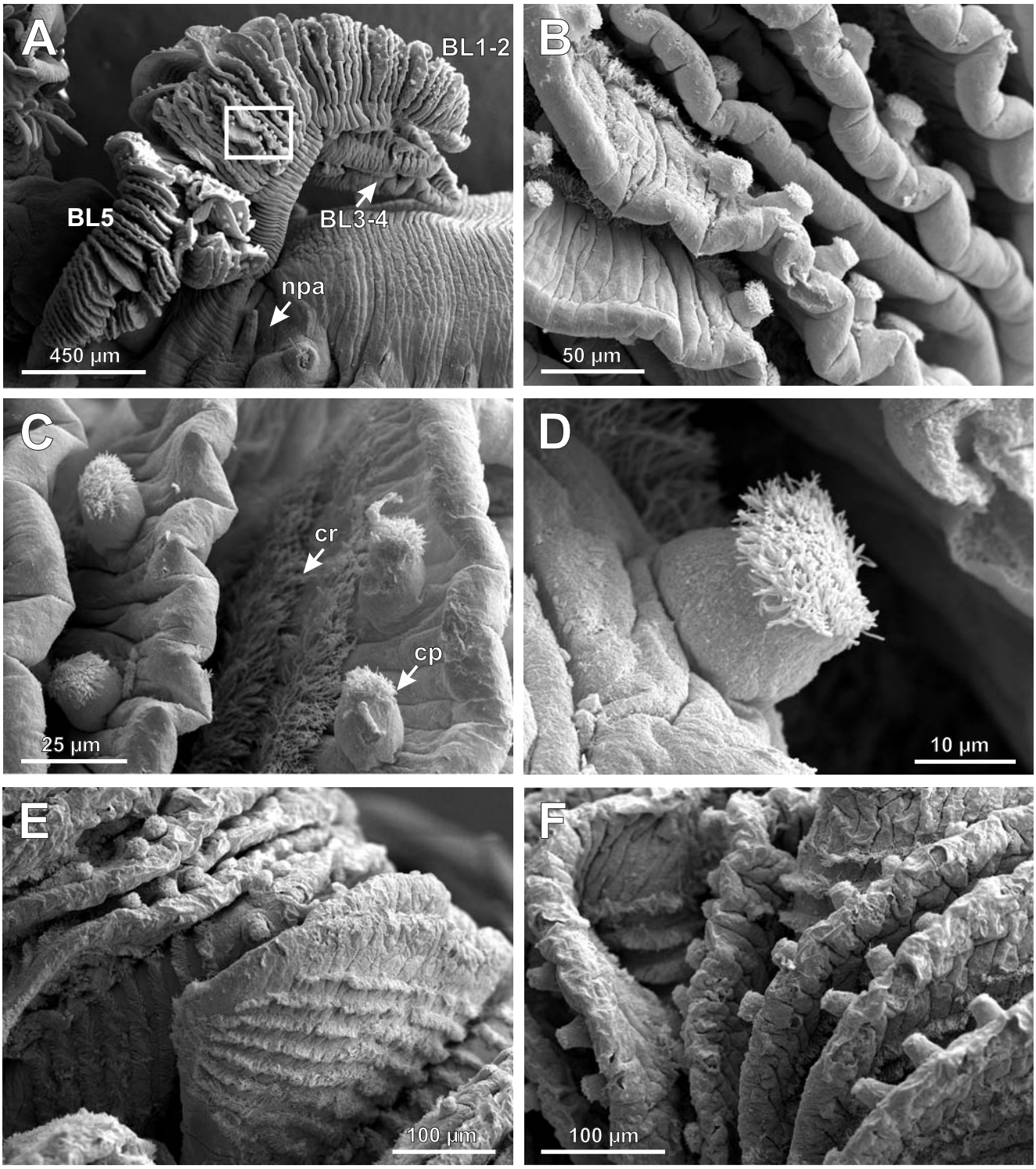
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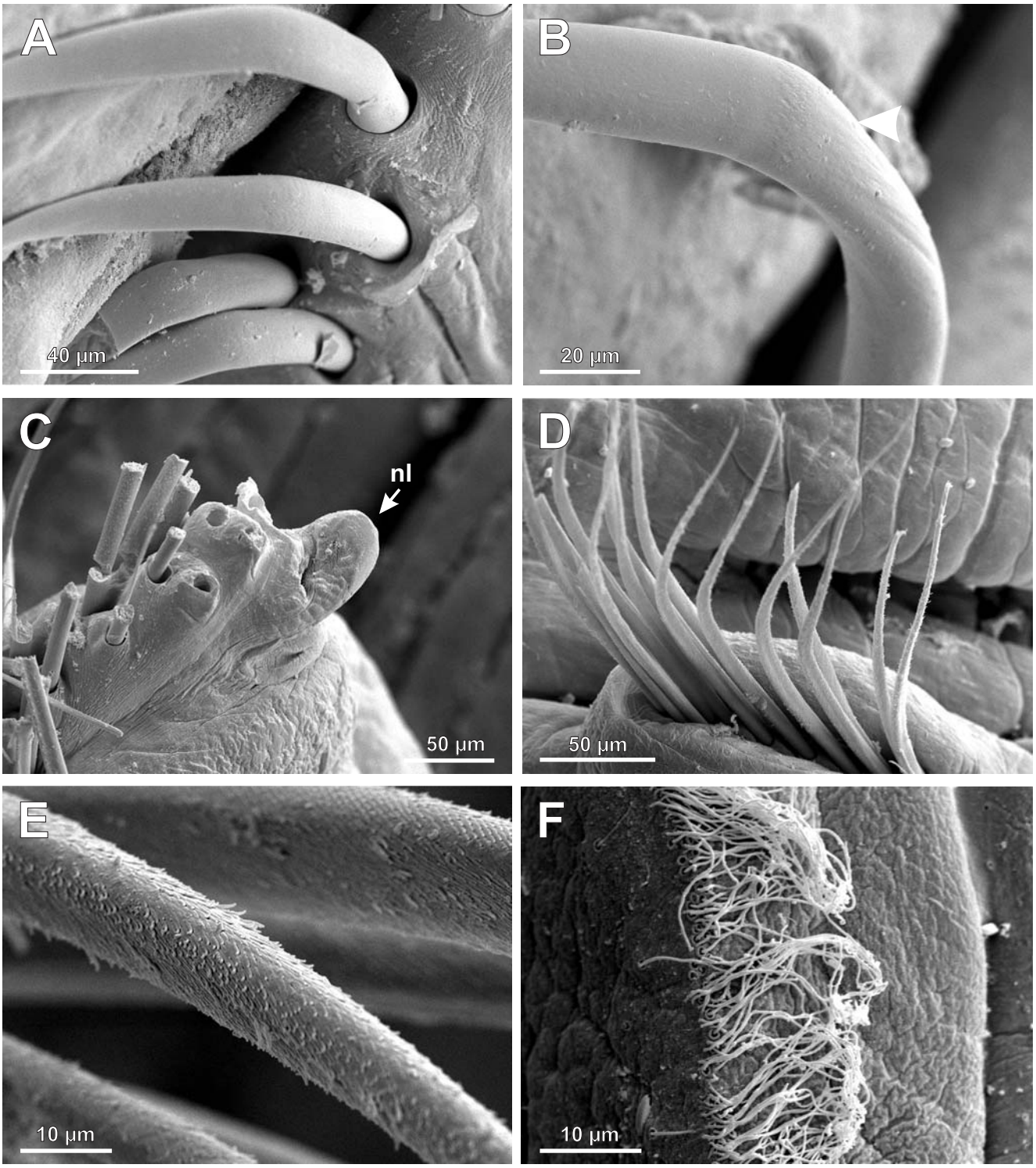
Figure 5



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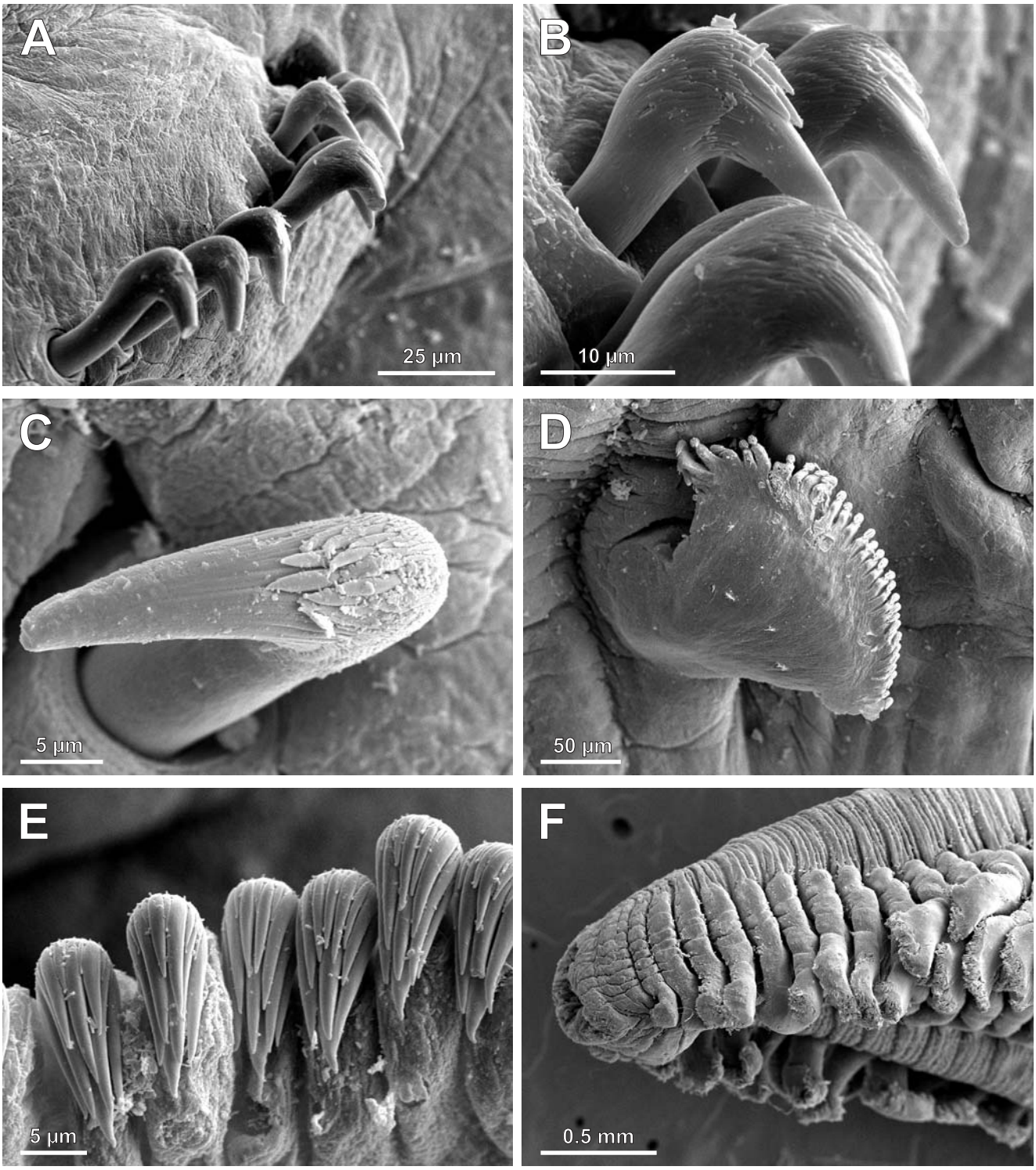

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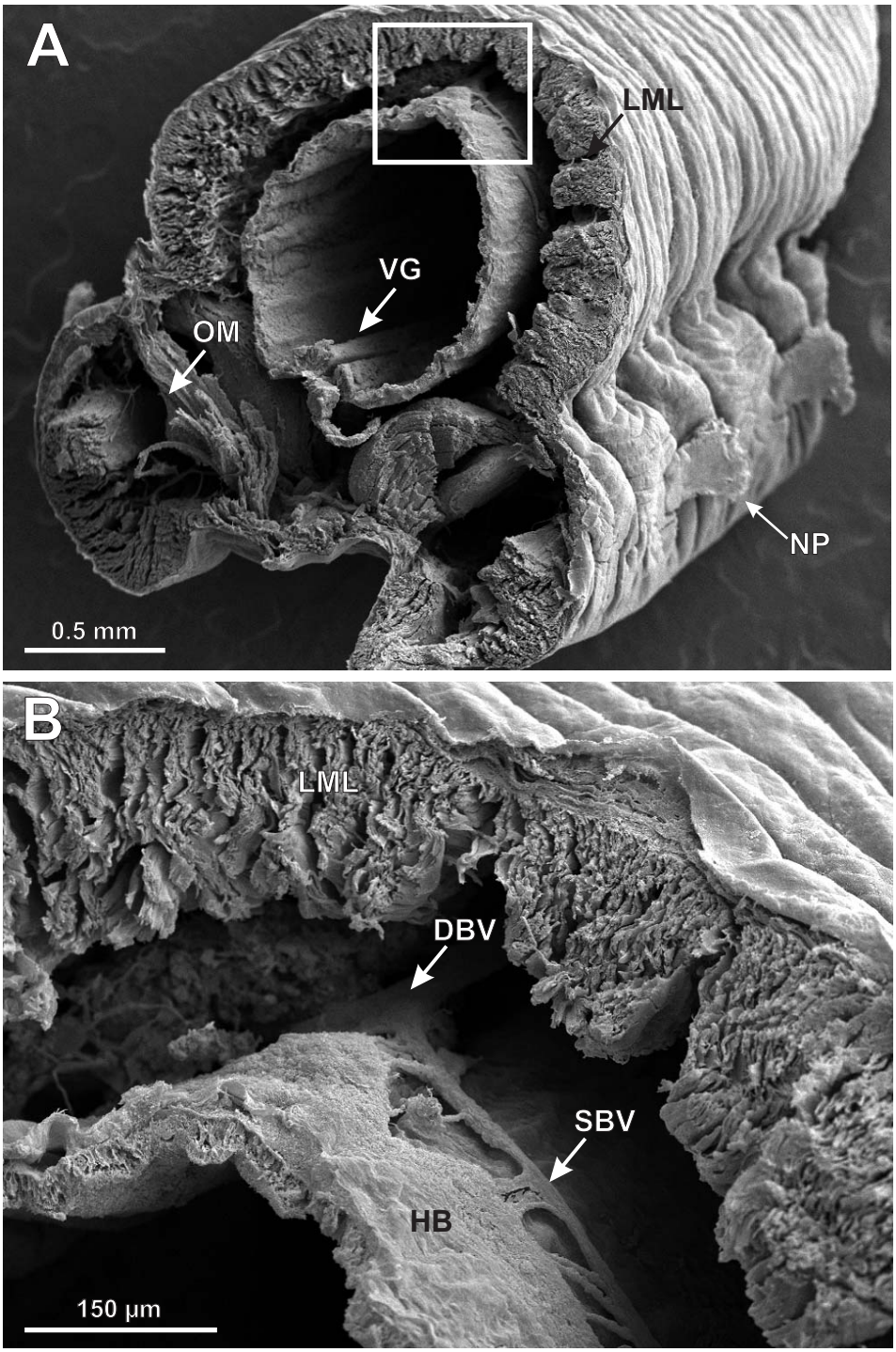

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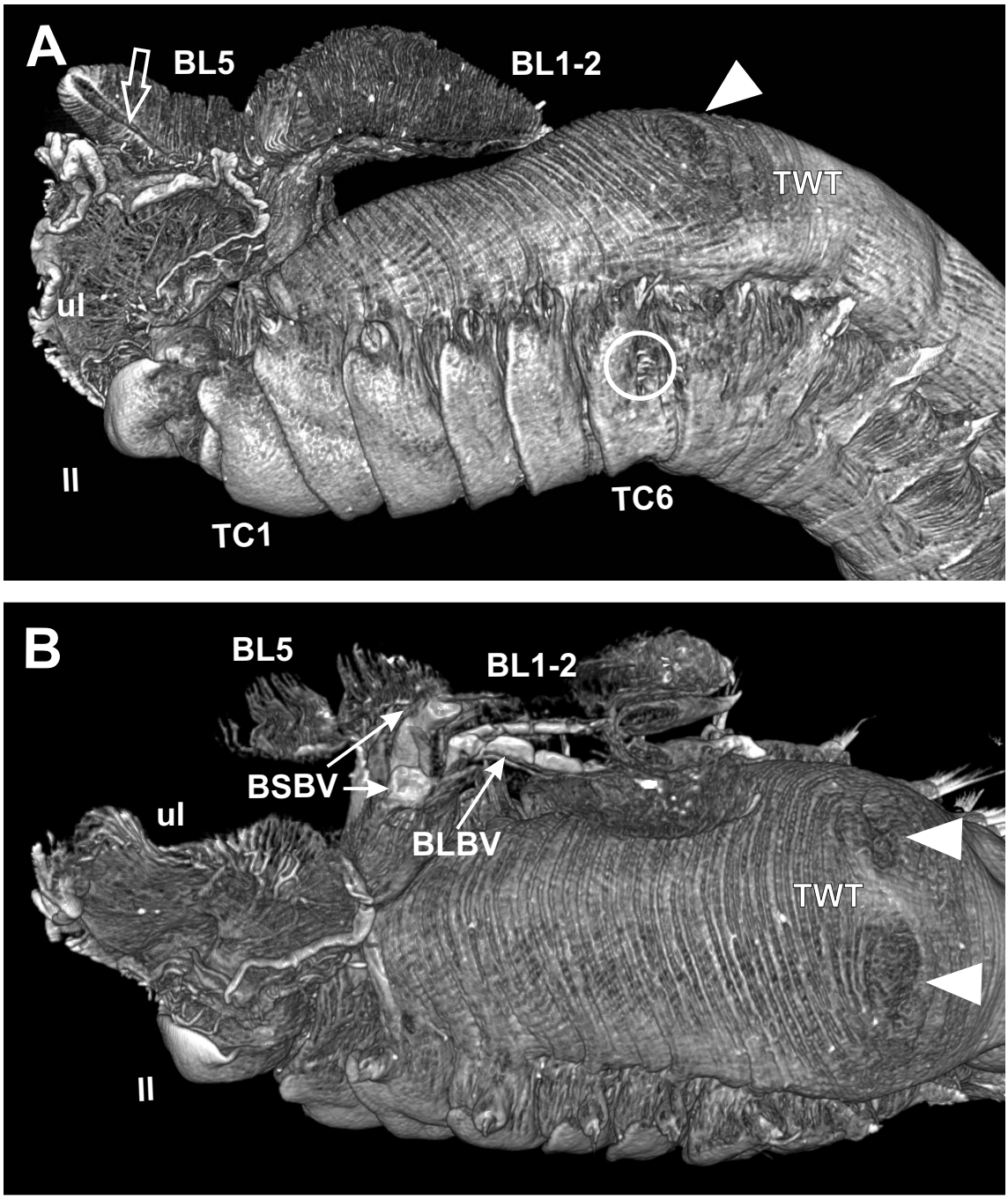

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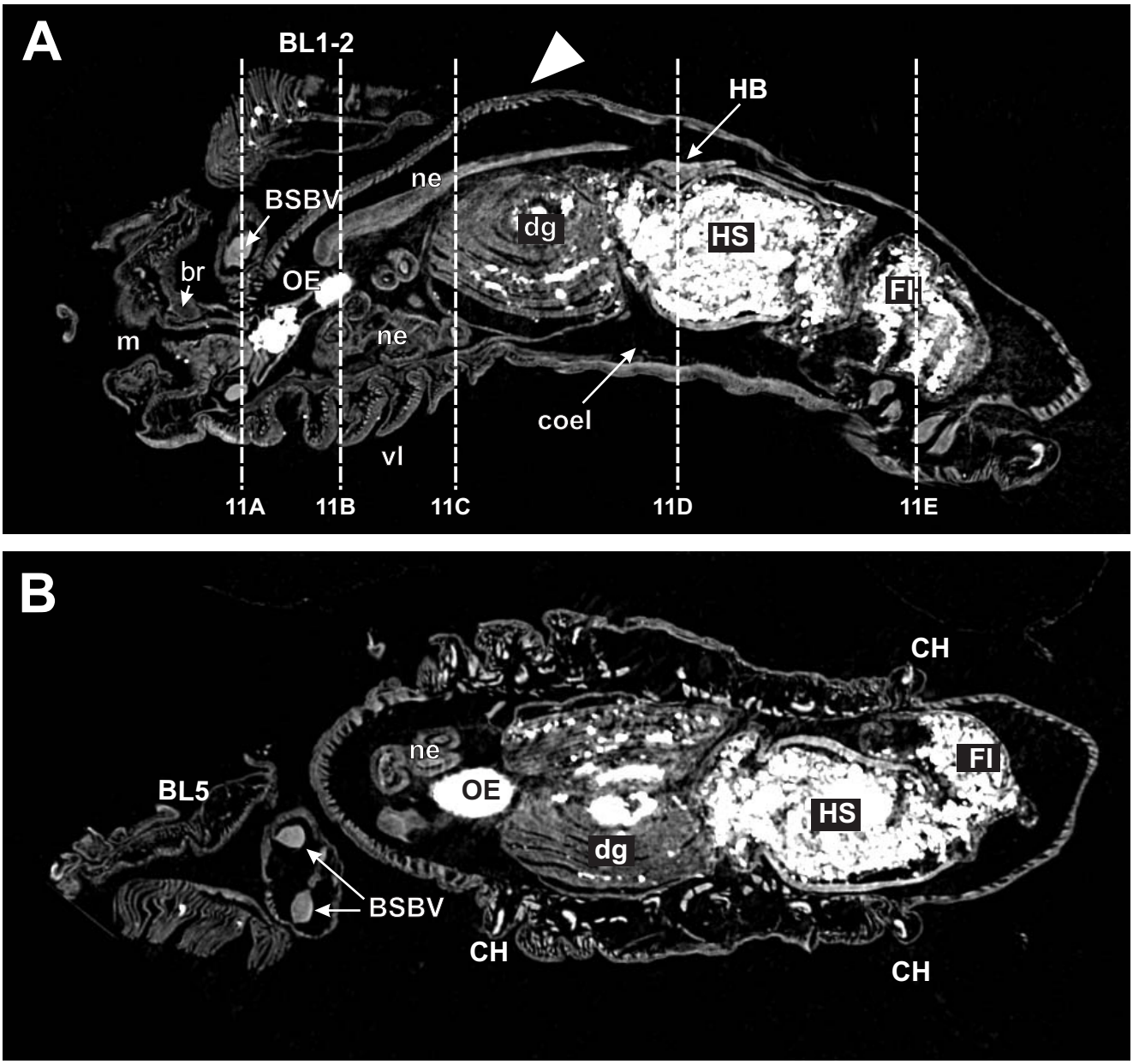
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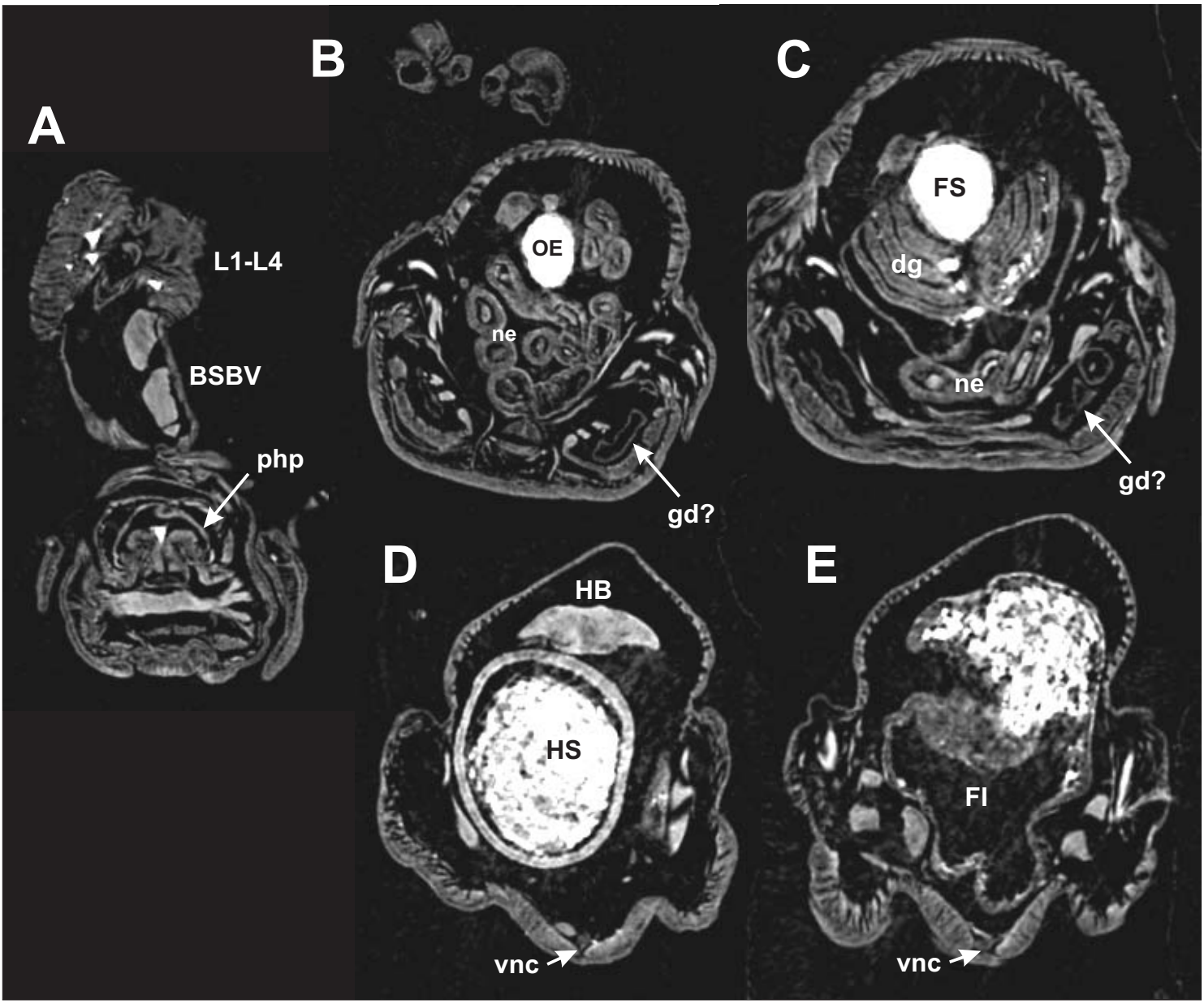
Figure 10



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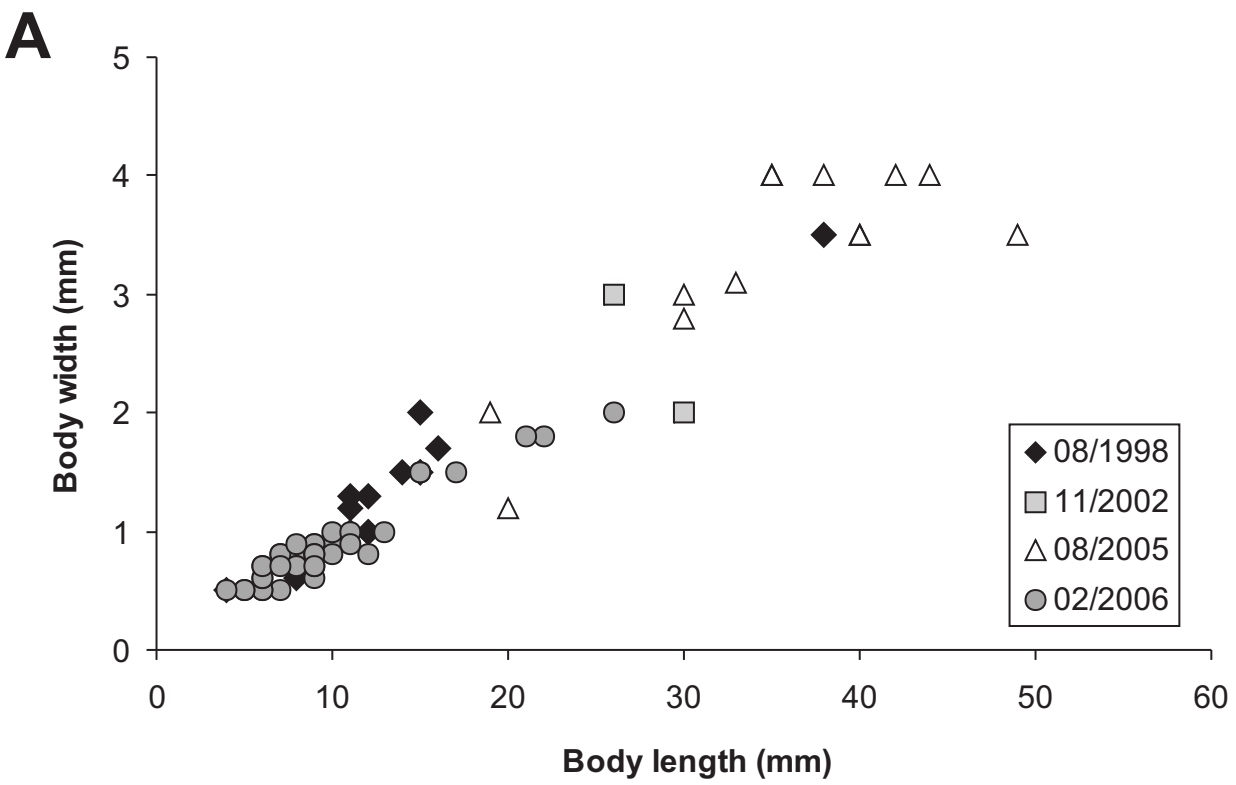
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08/1998
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08/2005
02/2006

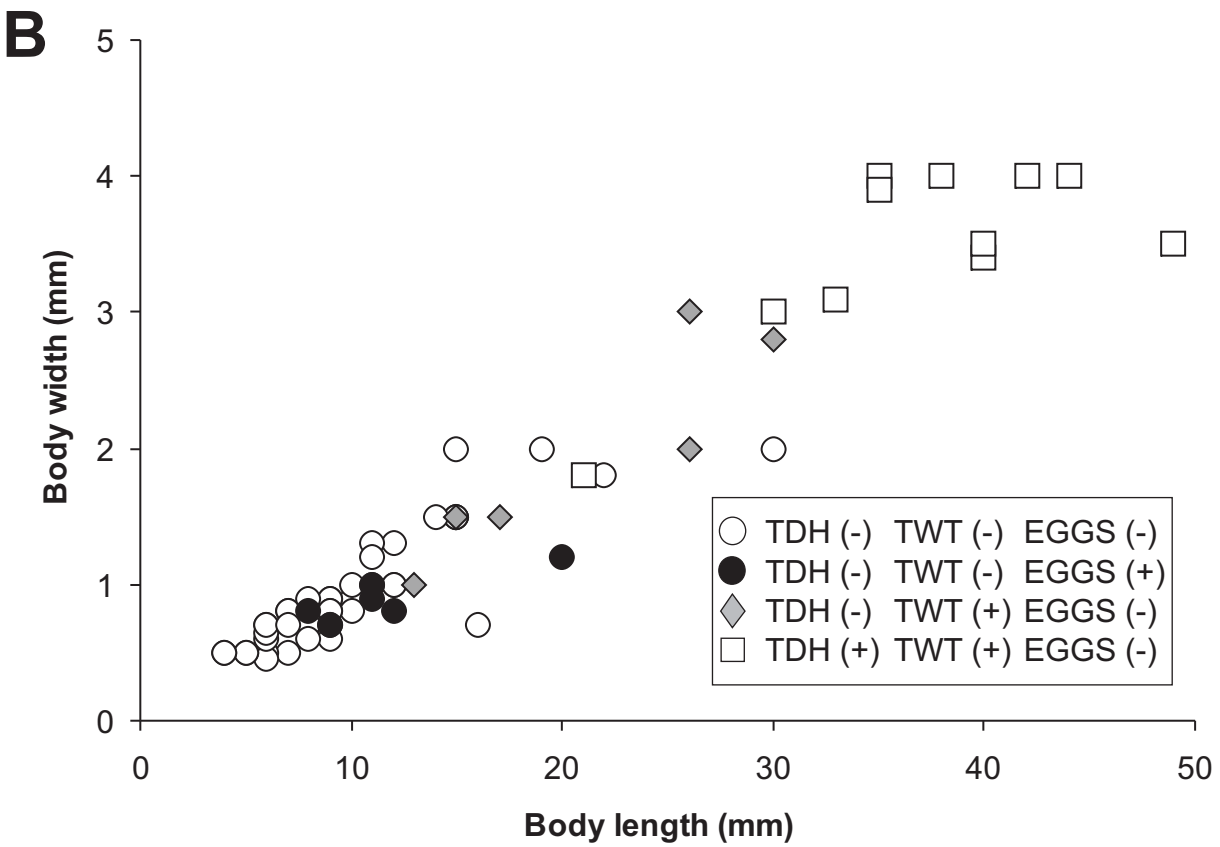
B
Body width (mm)
Body length (mm)
0
1
2
3
4
5
0
10
20
30
40
50
TDH (-) TWT (-) EGGS (-)
TDH (-) TWT (-) EGGS (+)
TDH (-) TWT (+) EGGS (-)
TDH (+) TWT (+) EGGS (-)

Figure 12