Zoologischer Anzeiger
Article In Press
Acceptation date : June 2019
https://doi.org/10.1016/j.jcz.2019.05.017
https://archimer.ifremer.fr/doc/00502/61325/

First report of the family Zelinkaderidae (Kinorhyncha: Cyclorhagida) for the Caribbean Sea, with the description of a new species of *Triodontoderes* Sørensen and Rho, 2009 and an identification key for the family

Cepeda Diego [1, *], Sanchez Nuria [1, 2], Pardos Fernando [1]

[1] Departamento de Biodiversidad, Ecología y Evolución, Facultad de Ciencias Biológicas, Universidad Complutense de Madrid, José Antonio Novais St. 12, 28040 Madrid, Spain
[2] Laboratoire Environnement Profond, Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), Centre Bretagne - ZI de la Pointe du Diable, CS 10070 - 29280 Plouzané, France

* Corresponding author : Diego Cepeda, email address : diegocepeda@ucm.es

Abstract :

A new species of Kinorhyncha, *Triodontoderes lagahoo* sp. nov., is described from Tobago Island, Caribbean Sea (western Atlantic Ocean) from a coastal, sandy habitat using both light and scanning electron microscopy. The species is characterized by the presence of middorsal acicular spines on segments 1–11 (that on segment 10 crenulated in males), laterodorsal crenulated spines on segment 10 only in males, lateroventral acicular spines on segments 3–4 and 6–8 (lateroventral spines also on segment 10 in females), lateroventral cuspidate spines on segments 5 and 9, lateral accessory acicular spines on segments 5 and 9, lateral accessory cuspidate spines on segment 8, ventrolateral acicular spines on segment 2 and ventrolateral cuspidate spines on segment 2. Females furthermore possess short papillae in ventrolateral position on segment 8 and ventromedial position on segment 9. The absence of cuspidate spines in lateral accessory position on segment 6 easily distinguishes *T. lagahoo* sp. nov. from the single known congener, *T. anulap*. Moreover, also the arrangement of female papillae and sensory spots differ between the species. The finding of a new species of *Triodontoderes* in the Caribbean Sea is the first report of the genus for American waters and the Atlantic Ocean since its original description. Additionally, a dichotomous key for identification of the family Zelinkaderidae to species level, as well as systematic remarks on some morphological characters of the new species are included herein.

Keywords : Kinorhynchs, Biodiversity, Meiofauna, Morphology, Taxonomy, *Triodontoderes lagahoo* sp. nov.

1. Introduction

Kinorhynchs are small-sized, holobenthic, free-living, marine invertebrates that inhabit sandy and muddy sediments (Higgins and Thiel, 1988; Neuhaus, 2013; Sørensen and Pardos, 2008). Currently, the phylum comprises near 300 species distributed worldwide and arranged in two classes, Allomalorhagida and Cyclorhagida (Sørensen et al. 2015). The cyclorhagid family Zelinkaderidae was originally erected by Higgins (1990) to accommodate the newly described species *Zelinkaderes floridensis* Higgins, 1990 from Fort Pierce, Florida (western Atlantic Ocean) and the reassigned *Cateria submersa* (Gerlach, 1969), originally described from the North Sea. Not much later, *Zelinkaderes klepali* Bauer-Nebelsick, 1995 was described from the Red Sea and, more recently, *Zelinkaderes brightae* Sørensen et al., 2007 also from Fort Pierce. Two years later, the second genus of the family was erected with the description of *Triodontoderes anulap* Sørensen and Rho, 2009 from the Chuuk Islands, Micronesia (western Pacific Ocean). Finally, *Zelinkaderes yong* Altenburger et al., 2015 was described from the Korean Peninsula (western Pacific Ocean).

Zelinkaderid kinorhynchs are morphologically characterized by having an introvert with one ring of spinoscalids followed by three or four regular scalids rings, fourteen or sixteen distally tripartite placids, trunk vermiform and conspicuously circular in cross-section, at least segments 5 to 11 composed of a single tergal plate with midventral joint, acicular spines present in dorsal and lateral positions, cuspidate spines present in lateral position on some segments, segment 11 with lateral terminal, lateral terminal accessory and midterminal spines, at least some large and oval sensory spots with two pores in the anterior body region, scale-like cuticular hairs medially depressed and males with crenulated spines on segment 10 (Sørensen and Rho, 2009). In the present contribution, a new *Triodontoderes* species, *Triodontoderes lagahoo* sp. nov., is described from Tobago Island (Caribbean Sea) using light and scanning electron microscopes. This finding is the first report of the genus for American waters and the western Atlantic Ocean since its original description from the Chuuk Archipelago, Pacific Ocean (Sørensen and Rho, 2009). Additionally, a key to species level identification for Zelinkaderidae is included.

2. Material and methods

Specimens of *Triodontoderes lagahoo* sp. nov. were collected at Tyrrel's Bay, Tobago Island, Caribbean Sea (western Atlantic Ocean): 11º18´00´´N, 60º30´00´´W (Fig. 1). The Archipelago of Trinidad and Tobago is situated at the verge of the Lesser Antilles (Fig. 1) and is part of the so-called Southern Caribbean marine ecoregion. Sampling was originally done on 13 May 1991 by Dr R. P. Higgins using a meiobenthic dredge (Higgins and Thiel, 1988) at 5 m depth in very fine sand. After sampling, meiofauna was extracted from sediment using the bubble and blot method defined by Higgins (1964). Meiofaunal specimens were fixed in 4% formalin, preserved in Carosafe® and deposited in unsorted vials at the Smithsonian National Museum of Natural History (NMNH), Washington.

The aforementioned vials were loaned to the authors for the present study. Fixed kinorhynchs were picked up under a Motic® SMZ-168 stereo zoom microscope with the help of an Irwin loop and washed with distilled water in order to remove formalin. For light microscopy (LM), specimens were dehydrated through a graded series of 25%, 50%, 75% and 100% glycerin and finally mounted on a glass slide in Fluoromount G® sealed with Depex®. Mounted specimens were studied and photographed using an Olympus® BX51-P microscope equipped with differential interference contrast (DIC) optics and an Olympus® DP-70 camera. Morphological measurements were obtained with Olympus cellSens® software. For scanning electron microscopy (SEM), specimens were transferred to 70% ethanol and then progressively dehydrated through a series of 80%, 90%, 95% and 100% ethanol. Specimens were sonically cleaned during 5–7 s. Hexamethyldisilazane (HMDS) was used for chemical drying through a HMDS-ethanol series. Specimens were coated with gold and mounted on aluminium stubs to be examined with a JSM 6335-F JEOL SEM at the ICTS Centro Nacional de Microscopía Electrónica (Complutense University of Madrid, Spain). Line drawings, images and plates plates composition were done using Adobe® Photoshop CC-2014 and Illustrator CC-2014 software.

3. Results

Taxonomic account

Class **Cyclorhagida** (Zelinka, 1896) Sørensen et al., 2015

Order **Kentrorhagata** Sørensen et al., 2015

Family **Zelinkaderidae** Higgins, 1990

Genus ***Triodontoderes*** Sørensen and Rho, 2009

Triodontoderes lagahoo sp. nov.

(Figs. 2–6 and Tabs. 1–3)

The species was registered in Zoobank under: zoobank.org:pub:7699F0E0-3F1B-451C-8E43-EB548773D1C0.

3.1 Type material

Holotype, adult female, collected on 13 May 1991 at Tyrrel's Bay, Tobago Island, western Atlantic Ocean: 11º18´00´´N, 60º30´00´´W at 5 m depth in very fine sand; mounted in Fluoromount G®, deposited at NMHN under accession number: XXXXX. Paratypes, seven adult males and four adult females, all of them with same collecting data as holotype, mounted in Fluoromount G®, deposited at NMHN under accession numbers: XXXXX–XXXXX.

3.2 Non-type material

Five additional specimens with same collecting data as holotype and paratypes, mounted for SEM, deposited at the Invertebrates Collection of the Meiofaunal Laboratory at the Universidad Complutense de Madrid (UCM), Spain.

3.3 Diagnosis

Triodontoderes with middorsal acicular spines on segments 1–11 (that on segment 10 crenulated in males), laterodorsal crenulated spines on segment 10 only in males, lateroventral acicular spines on segments 3–4 and 6–8 (lateroventral spines also on segment 10 in females), lateroventral cuspidate spines on segments 5 and 9, lateral accessory acicular spines on segments 5 and 9, lateral accessory cuspidate spines on segment 8, ventrolateral acicular spines on segment 2 and ventrolateral cuspidate spines on segment 2. Females with short papillae in ventrolateral position on segment 8 and ventromedial position on segment 9. Neck and trunk segments superficially covered by small, scale-like, medially depressed cuticular hairs arranged in slightly irregular longitudinal bands. Primary pectinate fringe short on segment 1, strongly serrated with

bifid tips on the remaining trunk segments. Dorsal extensions of segment 11 elongated, distally pointed, horn-like; ventral extensions of segment 11 short, wide, distally rounded.

3.4 Etymology

The species is named after the mythical shapeshifting monster “Lagahoo” (also known as “Ligahoo” or “Lugarhou”) from the folklore of Trinidad and Tobago, the location where the species was found. According to the legend, Lagahoo can shapeshift into various creatures, which resembles the different trunk shapes reported herein for the species.

3.5 Description

See Tables 1–2 for measurements and dimensions, and Table 3 for summary of acicular, crenulated and cuspidate spines, papillae and sensory spots location.

Head with narrow, retractable mouth cone and introvert with five rings plus an extra ring of trichoscalids attached to the neck (Figs. 3 and 4A-H). Mouth cone presumably with four rings of oral styles, incompletely observed (Fig. 3). Ring of helioscalids and the first ring of inner oral styles (rings -03 and -02) barely visible in the examined specimens. Second ring of inner oral styles (ring -01) with ten styles (Fig. 3). Observed inner oral styles of ring -01 composed of a single unit, with a trapezoidal, enlarged base bearing a short fringe and a triangular, hook-like, inwards-pointed, distal tip (Fig. 4C). Ring 00 with nine equally-sized outer oral styles that morphologically resemble the inner oral styles but much longer and flexible at their distal tips, with a fringe and paired spines arising from their bases (Figs. 3, 4C-D and 6B). Outer oral styles composed of a single unit, located anterior to each introvert sector, except in the middorsal section 6 where a style is missing (Fig. 3). Triangular, cuticular thickenings flanking the outer oral styles’ bases (Fig. 4D). Posterior part of mouth cone elongated, forming a long tube (Fig. 4A-B).

Heads were only everted in the holotype (mounted for LM) and one paratype, (mounted for SEM), which disabled precise examination of the arrangement and morphology of scalids in the remaining specimens. Ring 01 with ten primary spinoscalids (Fig. 3) composed of a basal sheath and a distal elongated end-piece; basal sheath equipped with a median dense fringe with long tips (Fig. 4E-F). Tips of the

fringe slightly protrude outwards when the introvert is retracted inside the trunk, and lay on top of the primary spinoscalids when the introvert is completely everted (Fig. 4F). Ring 02 with fifteen regular-sized scalids, arranged as two in the odd-numbered sectors and one in the even-numbered sectors (Figs. 3 and 4G-H). Scalids on this and remaining rings are composed of a basal sheath and a distal, elongated, hook-like end-piece (Fig. 4G-H). Ring 03 with fifteen regular-sized scalids, arranged as one in the odd-numbered sectors and two in the even-numbered sectors (Figs. 3 and 4G-H). Ring 04 similar to ring 02 (Figs. 3 and 4G-H). Ring 05 similar to ring 03 (Figs. 3 and 4G-H). The location of scalids in rings 01–05 follows a strict pattern around the introvert, and each sector carries six scalids, five following a quincunx arrangement plus a single scalid that appears anterior (in even-numbered sectors) or posterior (in odd-numbered sectors) (Figs. 3 and 4G-H).

Neck with fourteen inconspicuous, elongated, distally tripartite, soft placids of uniform size; placids are fused with the segment 1 and a transverse articulation between placids and segment 1 is missing (Figs. 2A-B, 4A-B and 6A, C). Fourteen small, triangular trichoscalids attached to the neck, whose occurrence is directly associated with the placids position (Figs. 3 and 4E). Trichoscalid plates absent.

Trunk vermiform, circular in cross-section, spindle-shaped, composed of eleven segments (Figs. 2A-B, 4A-B and 6A). Body outline variable from longer and slender to shorter and chubby (Figs. 2A-C and 4A-B, J-L). Cuticle along the whole trunk thin, soft and flexible, making the intersegmental junctions barely visible. First trunk segment with one tergal and one sternal plate (Fig. 2A-B); segments 2–4 with one tergal and two sternal plates with lateroventral and midventral joints (Fig. 2A-B); remaining segments with a single tergal plate with midventral joint (Fig. 2A-B, D-E). Segment 1 fused with the neck, without distinct articulation (Figs. 2A-B, 5A and 6A, C). Neck and all trunk segments superficially covered by small, scale-like, medially depressed cuticular hairs arranged in slightly irregular longitudinal bands (Figs. 2A-B, D-E and 6D, G, I); cuticular hairs absent at ventrolateral and ventromedial regions of trunk (Fig. 2B, E). Trunk segments with longitudinal folds on the dorsal and lateral sides that are most certainly a fixation artefact (Figs. 2A, C, D, 4A-B, 5A-B, D-E, G-H and 6A). Posterior margin of segments straight, with long primary pectinate fringes (except that of segment 1 that is conspicuously shorter); primary pectinate fringes with very weak serration on first segment, with strong serration and bifid tips on remaining segments (Figs. 2A-B,

D-E and 4I). Secondary pectinate fringes on segments 2–11 less conspicuous than primary ones but also long, ventrally extending near the posterior margin of segment, also serrated and with bifid tips (Figs. 2A-B, D-E and 4I).

Segment 1 with a small, very short, extremely flexible acicular spine in middorsal position (Figs. 2A and 5A). Acicular spines on this and following segments are composed of a single flexible, elongated piece with pointed tip that basally articulates in a swollen cuticular thickening (Figs. 2A-B, D-E, 4I, 5A-K and 6A, D-F, H, J); basal swollen articulation of acicular spines with paired cuticular protuberances that flank the spine (Figs. 2A and 5A). Paired sensory spots in paradorsal position, on top of the protuberances beside the spine's basal articulation (Figs. 2A and similar to 6D). Sensory spots on this and most following segments are composed of an oval patch of numerous micropapillae surrounding a central pore (similar to 6G).

Segment 2 with acicular spine in middorsal position (Figs. 2A and 5A); paired small, very short, extremely flexible acicular spines in ventrolateral position (Figs. 2B and 5B). Paired cuspidate spines also in ventrolateral position, but located between tergosternal junction and acicular spine (Figs. 2B and 5B). Cuspidate spines on this and following segments are composed of a single syringe-like piece with broadened base, of which the latter constitutes more than 50% of the spine dimension, basally articulated (Figs. 2B, E, 5B, E, H and 6E). Paired sensory spots in paradorsal position, similar to those of the precedent segment (Figs. 2A and 5A).

Segment 3 with acicular spine in middorsal position and paired acicular spines in lateroventral position (Figs. 2A-B and 5A-B). Paired sensory spots in paradorsal, laterodorsal and ventrolateral positions (Figs. 2A-B and 5A-B).

Segment 4 with acicular spine in middorsal position and paired acicular spines in lateroventral position (Figs. 2A-B and 5D-E). Paired sensory spots in paradorsal, laterodorsal, midlateral and ventrolateral positions (Figs. 2A-B, 5D and 6G). Midlateral sensory spots on this and following segments are composed of an oval patch of numerous micropapillae surrounding two pores (similar to Fig. 6I).

Segment 5 with acicular spine in middorsal position and paired acicular spines in lateral accessory position (Figs. 2A-B, 5D-E and 6E); paired cuspidate spines in lateroventral position (Figs. 2B, 5E and 6E). Paired sensory spots in paradorsal, laterodorsal, midlateral and ventrolateral positions (Figs. 2A-B, 5D-E and 6G).

Segment 6 with arrangement of spines and sensory spots similar to segment 4 (Figs. 2A-B, 5D-E and 6F, I).

Segment 7 with arrangement of spines and sensory spots similar to segments 4 and 6 (Figs. 2A-B, 5D, H and 6F).

Segment 8 with acicular spine in middorsal position and paired acicular spines in lateroventral position (Figs. 2A-B, D-E, 5G-H and 6D, F); paired cuspidate spines in lateral accessory position (Figs. 2B, E and 5H). Paired sensory spots in paradorsal, laterodorsal and midlateral positions (Figs. 2A-B, D-E, 5G and 6D). Females with paired, small papillae in ventrolateral position (Figs. 2B and 5H); papillae on this and following segment are rounded areas with a minute tubular structure carrying a basal collar of short, flexible hairs.

Segment 9 with acicular spine in middorsal position and paired acicular spines in lateral accessory position (Figs. 2A-B, D-E and 5G-H); paired cuspidate spines in lateroventral position (Figs. 2B, E and 5H). Paired sensory spots in paradorsal, subdorsal and laterodorsal positions (Figs. 2A, D and 5G). Females with paired, small papillae in ventromedial position (Fig. 2B and 5H).

Segment 10 differing between males and females. Males with an unpaired, crenulated spine in middorsal position and paired, crenulated spines in laterodorsal position (Figs. 2D, 5J and 6H). Females with an unpaired, acicular spine in middorsal position and paired acicular spines in lateroventral position (Figs. 2A-B and 5G-H). Females with paired, large, strongly cuticularized, rounded gonopores at the intersegmental junction between segments 10 and 11 (Fig. 5I). Both males and females with paired sensory spots in paradorsal and subdorsal positions (Figs. 2A, D and 5G).

Segment 11 tapering to the base of the midterminal spine, with acicular spine in middorsal position and paired lateral terminal and lateral terminal accessory spines (Figs. 2A-B, D-E, 5C, F, G, I-K and 6A, J). Tergal plate of segment 11 carrying two elongated, distally pointed, horn-like dorsal extensions (Figs. 2A, D, 5F and 6J) as well as two short, wide, distally rounded ventral extensions (Figs. 2B, E and 5I). Paired sensory spots arranged on top of the paired cuticular protuberances beside the middorsal spine's basal articulation, in paradorsal position (Figs. 2A, D, 5G-J and 6J). Two pairs of type 3 sensory spots in subdorsal position, one posterior to the paradorsal sensory spots, another near the posterior margin of segment (Figs. 2A, D, 5C, J and 6J). Two

pairs of sensory spots in laterodorsal position, one near the base of the dorsal cuticular extensions, another near the basal insertion of the lateral terminal spines (Figs. 2A, D and 6J), barely visible under LM.

4. Discussion

4.1 Remarks on morphological features

Triodontoderes lagahoo sp. nov. fits well into the genus *Triodontoderes* by the combination of the following characters: oral styles of mouth cone composed of a single piece; neck composed of fourteen soft, elongated, inconspicuous, equally-sized, distally tripartite placids fused with segment 1; neck and trunk with small, scale-like, medially depressed cuticular hairs irregularly arranged in longitudinal bands; segment 1 with one tergal and one sternal plate, segments 2–4 with one tergal and two sternal plates and remaining segments with a single tergal plate with midventral joint; unpaired middorsal spines on all trunk segments; segment 2 with paired, small, very flexible acicular spines in ventrolateral position plus paired cuspidate spines also in ventrolateral position; segments 3–9 with lateral acicular and/or cuspidate spines; males with middorsal and paired laterodorsal crenulated spines on segment 10; females with paired, lateroventral acicular spines on segment 10 and paired ventral papillae on some segment from 7 to 9; segment 11 with midterminal, lateral terminal and lateral terminal accessory spines (Sørensen and Rho, 2009).

Until now, the genus *Triodontoderes* was composed of a single species, *T. anulap*, from the Chuuk Archipelago, Micronesia, western Pacific Ocean (Sørensen and Rho, 2009). The main morphological discrepancies between the two congeners are summarized in Table 4. Both species may be easily distinguished by their patterns of spines, female papillae and sensory spots. *Triodontoderes anulap* is characterized by having paired cuspidate spines in lateral accessory position on segment 6 (Sørensen and Rho, 2009), absent in *T. lagahoo* sp. nov. Moreover, females of *T. anulap* have paired papillae in ventrolateral position on segments 7–8 and in ventromedial position on segment 9 (Sørensen and Rho, 2009), while females of *T. lagahoo* sp. nov. possess papillae in ventrolateral position only on segment 8 and in ventromedial position on segment 9. Additionally, the main differences between both species in sensory spot are the presence of paired sensory spots in laterodorsal position on segments 3–9 and 11 in

T. lagahoo sp. nov. (only on segment 10 in *T. anulap*), in midlateral position on segments 4–8 (only on segment 2 in *T. anulap*) and in ventrolateral positions on segments 3–7 (displaced to ventromedial position and on segments 4, 6–8 and 10–11 in *T. anulap*) (see Sørensen and Rho, 2009, for complete sensory spots arrangement of *T. anulap*).

Another morphological discrepancy between both species refer to the trunk pectinate fringes and cuticular hairs. *Triodontoderes anulap* only possesses serrated posterior margin of segments with long pectinate fringes on segments 7–11 (Sørensen and Rho, 2009), whereas *T. lagahoo* sp. nov. has serrated posterior margin of segments and long pectinate fringes on segments 2–11. Moreover, *T. anulap* is characterized by having several wavy secondary pectinate fringes composed of tiny scales mixed with slightly longer aciculae from segment 2 (Sørensen and Rho, 2009), while *T. lagahoo* sp. nov. has a single straight secondary pectinate fringe strongly serrated and with bifid tips, also from segment 2. Finally, *T. anulap* has cuticular hairs arranged all over the integument (Sørensen and Rho, 2009), whereas those of *T. lagahoo* sp. nov. are absent at ventrolateral and ventromedial regions of trunk.

A striking morphological feature of *T. lagahoo* sp. nov. is the presence of two different body outlines. Of the seventeen examined specimens, twelve belong to the slender body outline and five to the chubby one. Both females and males were found in the two different body outlines. Specimens with short and chubby body outline possess the same number of trunk segments and arrangement of cuticular structures than those with long and slender body outline (Fig. 4J). Moreover, these specimens also possess developed gonads and, in case of females, conspicuous gonopores (Fig. 4L). Though the abundance of the slender specimens were higher than that of the chubby ones, the latter body outline could be an artefact of the fixation process. As both types of body outlines were found in the vial containing non-mounted animals (Fig. 4K), the chubby shape is not result of the mounting process for LM. Nevertheless, two possibilities must be considered. On the one hand, the species may have the ability of kindly modifying its body outline due to the soft cuticle that characterizes this genus. This could be related to the proposed hypothesis by Yamasaki (this issue) of thin-cuticle body kinorhynchs, as this kind of cuticle would allow the animal being more flexible to seep through sediment interstices more easily and absorbing physical damage when sand grains are disturbed. On the other hand, the chubby specimens may correspond to the latest

juvenile stages of the species. Though both chubby females and males were found with completely developed gonads, and gonopores in case of females (Fig. 4L), the latest juvenile stages of kinorhynchs often begin to develop gonads (Neuhaus, 2013).

4.2 Remarks on systematic features

Triodontoderes, together with the genus *Zelinkaderes*, belongs to the family Zelinkaderidae, whose monophyly was supported by a total-evidence analysis (Sørensen et al. 2015). This family is morphologically characterized by possessing an introvert with one ring of primary spinoscalids followed by three or four rings of regular scalids, a trunk conspicuously circular in cross-section, at least segments 5 to 10 composed of a single tergal plate with midventral joint, acicular spines present in dorsal and lateral positions, cuspidate spines present on some segments, a segment 11 with lateral terminal, lateral terminal accessory and midterminal spines, at least some large, oval sensory spots with two pores in the anterior trunk region, scale-like cuticular hairs with a medial depression and male sexually dimorphic crenulated spines on segment 10 (Sørensen and Rho, 2009).

The introvert of Zelinkaderidae is characterized by the reduction of, at least, one ring of scalids. Regular scalids are completely absent on rings 02–03 in *Z. brightae* and *Z. klepali* (Bauer-Nebelsick, 1995; Sørensen et al. 2007); on ring 06 in *T. anulap* and *T. lagahoo* sp. nov. (Sørensen and Rho, 2009; this paper); on rings 05–06, odd sectors of ring 03 and even sectors of ring 02 in *Z. floridensis* (Higgins, 1990); and on ring 02, even sectors of ring 06 and odd sectors of ring 03 in *Z. yong* (Altenburger et al. 2015). In summary, species of *Zelinkaderes* generally shows a strong reduction of the introvert scalids, as this reduction involves more than a single ring, whereas *Triodontoderes* only shows scalid reduction in the last ring. Additionally, *Zelinkaderes* seems to show more variability in the scalid arrangement (Sørensen et al. 2007) than the genus *Triodontoderes*, with identical disposition of scalids in the two known species (Sørensen and Rho, 2009; this paper). The only other cyclorhagid genus with a considerably lower number of scalids is *Cateria* Gerlach, 1956, that, besides the ten primary spinoscalids, possesses 35 regular scalids (Herranz et al., this issue; Neuhaus and Kegel, 2015). Furthermore, a newly described genus of Franciscideridae also possesses a reduction in the number of scalids, lacking these structures in ring 06 and the even-numbered sectors of ring 05 (Yamasaki, this issue). It seems that *Cateria*, *Triodontoderes* and the new genus of Franciscideridae lost its more posterior scalid

rings (Herranz et al., this issue; Sørensen and Rho, 2009; Yamasaki, this issue), whereas *Zelinkaderes* reduced the scalids in its more anterior rings (Altenburger et al. 2015; Sørensen et al. 2007). The reduction of scalids could have occurred independently in the four genera, as also proposed by Herranz et al. (this issue). However, this hypothesis cannot be tested until a more complete systematic analysis of Kentrorhagata is performed.

The presence of distally tripartite placids seems also to be a synapomorphic feature of the family Zelinkaderidae (Sørensen and Rho, 2009), with the exception of *Z. yong* that has very reduced placids (Altenburger et al. 2015). Both species of *Triodontoderes* also share the former feature (Sørensen and Rho, 2009; this paper). According to the most recent phylogenetic analysis (Sørensen et al. 2015), it is likely that the plesiomorphic condition for placid morphology in Zelinkaderidae is the possession of distally tripartite placids. Then, *Z. yong* would have suffered a reversion of the character state through the placid reduction as an autapomorphy of the species. Again, this hypothesis cannot be tested until more morphological, and especially molecular phylogenetic data is available for the whole family.

One of the important morphological differences between species of *Triodontoderes* and *Zelinkaderes* is the number and arrangement of both acicular and cuspidate spines. The former genus is characterized by having middorsal acicular spines along all trunk segments (Sørensen and Rho, 2009; this paper), whereas the latter has middorsal spines on segments 4, 6 and 8–11 (Sørensen et al. 2007). Additionally, lateral acicular and/or cuspidate spines are present on segment 2 and 4–9 in *Zelinkaderes* (Altenburger et al. 2015; Bauer-Nebelsick, 1995; Higgins, 1990; Sørensen et al. 2007), while they are present in at least one sex on segments 2–10 in *Triodontoderes* (Sørensen and Rho, 2009; this paper). Thus, a greater number of dorsal and lateral spines characterizes the genus *Triodontoderes* within the family Zelinkaderidae. However, it is still too early to infer an evolutionary trend towards increasing or decreasing the number of spines in Zelinkaderidae.

4.3 Key to species of Zelinkaderidae

1. Segment 1 composed of one tergal and one sternal plate; segments 2 to 4 composed of one tergal and two sternal plates; segments 5 to 11 composed of a single plate with midventral joint; neck consisting of 14 distally tripartite placids; middorsal spines

present on all trunk segments; cuticular hairs irregularly arranged in scattered bands … 2 (genus *Triodontoderes*)

- Segments 1 to 2 composed of one closed cuticular ring; segments 3 to 11 composed of a single plate with midventral joint; neck consisting of 16 entire or distally tripartite placids; middorsal spines present on segments 4, 6 and 8 to 11; cuticular hairs regularly arranged in longitudinal bands …3 (genus *Zelinkaderes*)

2. Lateral accessory cuspidate spines present on segment 6; female, sexually dimorphic papillae present in ventrolateral position on segments 7 to 8 and in ventromedial position on segment 9; long, conspicuous pectinate fringes on segments 7 to 11 … *T. anulap*

- Lateral accessory cuspidate spines absent on segment 6; female, sexually dimorphic papillae present in ventrolateral position on segment 8 and in ventromedial position on segment 9; long, conspicuous pectinate fringes on segments 2 to 11 … *T. lagahoo* sp. nov.

3. Spines present in various lateral positions on segment 2 … 4

- Spines absent on segment 2 … *Z. floridensis*

4. Lateroventral or lateral accessory acicular spines present on segment 9 … 5

- Lateroventral or lateral accessory acicular spines absent on segment 9 … *Z. yong*

5. Cuspidate spines present in lateral series on segments 4 and 6 … 6

- Cuspidate spines absent in lateral series on segments 4 and 6 … *Z. klepali*

6. Cuspidate spines present in lateroventral position on segment 7… *Z. submersus*

- Cuspidate spines absent in lateroventral position on segment 7 … *Z. brightae*

5. References

Altenburger, A., Rho, H.S., Chang, C.Y., Sørensen, M.V., 2015. *Zelinkaderes yong* sp. nov. from Korea – the first recording of *Zelinkaderes* (Kinorhyncha: Cyclorhagida) in Asia. Zool. Stud. 54: 25. https://doi.org/10.1186/s4055-014-0103-6.

Bauer-Nebelsick, M., 1995. *Zelinkaderes klepali* sp. n., from shallow water sands of the Red Sea. Ann. Naturhist. Mus. Wien 97(B): 57–74.

Gerlach, S.A., 1969. *Cateria submersa* sp. n., ein cryptorhager Kinorhynch aus dem sublitoralen Mesopsammal der Nordsee. Veröff. Inst. Meeresf. Bremerhaven 12: 161–168.

Herranz, M., Di Domenico, M., Sørensen, M.V., Leander, B.S., this issue. The enigmatic kinorhynch *Cateria styx* Gerlach, 1956 – a sticky son of a beach. Zool. Anz., this issue.

Higgins, R.P., 1964. Three new kinorhynchs from the North Carolina Coast. Bull. Mar. Sci. 14: 479-493.

Higgins, R.P., 1990. Zelinkaderidae, a new family of cyclorhagid Kinorhyncha. Smithson. Contrib. Zool. 500: 1–26. https://doi.org/10.5479/si.00810282.500.

Higgins, R.P., Thiel, H., 1988. Introduction to the study of meiofauna, first ed. Smithsonian Institution Press, Washington D.C.

Neuhaus, B., 2013. Kinorhyncha (=Echinodera), in: Schmidt-Rhaesa, A. (Ed.), Handbook of Zoology, Gastrotricha, Cycloneuralia and Gnathifera, Volume 1 Nematomorpha, Priapula, Kinorhyncha, Loricifera. De Gruyter, Hamburg, pp. 181–350.

Neuhaus, B., Kegel, A., 2015. Redescription of *Cateria gerlachi* (Kinorhyncha, Cyclorhagida) from Sri Lanka and of *C. styx* from Brazil, with notes on *C. gerlachi* from India and *C. styx* from Chile, and the ground pattern of the genus. Zootaxa 3965, 1–77.

Sørensen, M.V., Dal Zotto, M., Rho, H.S., Herranz, M., Sánchez, N., Pardos, F., Yamasaki, H., 2015. Phylogeny of Kinorhyncha based on morphology and two molecular loci. PLoS ONE 10(7), e0133440. https://doi.org/10.1371/journal.pone.0133440.

Sørensen, M.V., Heiner, I., Ziemer, O., Neuhaus, B., 2007. *Tubulideres seminoli* gen. et sp. nov. and *Zelinkaderes brightae* sp. nov. (Kinorhyncha, Cyclorhagida) from Florida. Helgol. Mar. Res. 61: 247–265. https://doi.org/10.1007/s10152-007-0073-8.

Sørensen, M.V., Pardos, F., 2008. Kinorhynch systematics and biology – An introduction to the study of kinorhynchs, inclusive identification keys to the genera. Meiofauna Marina 16: 21–73.

Sørensen, M.V, Rho, H.S., 2009. *Triodontoderes anulap* gen. et sp. nov. – a new cyclorhagid kinorhynch genus and species from Micronesia. J. Mar. Biol. Assoc. U. K. 89(6): 1269–1279. https://doi.org/10.1017/S0025315409000526.

Yamasaki, H., this issue. *Gracilideres mawatarii*, a new genus and species of Francisciderida (Allomalorhagida: Kinorhyncha) from Japan with morphological comparison of head characters, and special attention to thin-cuticle body of Kinorhyncha in relation to adaptation to interstitial environment. Zool. Anz., this issue.

Zelinka, C., 1896. Demonstration der Tafeln der *Echinoderes* – Monographie. Verh. Dtsch. Zool. Ges. 6: 197–199.

ACKNOWLEDGEMENTS

We would like to thank Dr Jon Norenburg and Kathryn Ahlfeld for loaning the material that made the present study possible.

FUNDING SOURCES

Cepeda was supported by a predoctoral fellowship of the Complutense University of Madrid (CT27/16-CT28/16).

The authors declare no conflicts of interest.

469

470

471

472

473

474

475

476

477

478

479 TABLES

480 Table 1. Measurements of body size, lateral terminal, lateral terminal accessory and
481 midterminal spines of adult *Triodontoderes lagahoo* sp. nov., including number of
482 measured specimens (*n*), mean of data and standard deviation (SD). There were no
483 remarkable differences in sizes or dimensions between the two sexes. Abbreviations:
484 LTAS, lateral terminal accessory spine; LTS, lateral terminal spine; MTS, midterminal
485 spine; S, segments lengths (number after S indicates the corresponding segment); TL,
486 total length of trunk.

Character	**Range**	**Mean (SD; *n*)**
TL (µm)	319.0–540.2	428.0 (62.0; 12)
S1 (µm)	35.5–72.8	51.1 (13.1; 12)
S2 (µm)	21.2–57.4	43.1 (12.0; 12)
S3 (µm)	25.4–62.9	47.4 (11.3; 12)
S4 (µm)	29.8–63.8	52.3 (11.9; 12)
S5 (µm)	29.4–67.2	55.4 (12.8; 12)
S6 (µm)	39.5–63.7	52.1 (7.8; 12)
S7 (µm)	37.5–65.9	53.4 (8.8; 12)
S8 (µm)	47.8–76.0	56.6 (12.0; 12)
S9 (µm)	31.5–76.2	58.4 (12.4; 12)
S10 (µm)	34.3–71.2	56.7 (11.9; 12)
S11 (µm)	26.0–51.1	43.8 (11.6; 12)

LTS (µm)	52.8–78.8	60.8 (6.9; 12)
LTS/TL (%)	10.6–21.5	14.5 (3.1; 12)
LTAS (µm)	33.7–42.4	39.7 (3.8; 12)
LTAS/TL (%)	8.2–13.3	9.5 (1.9; 12)
LTAS/LTS (%)	55.4–74.4	65.6 (4.5; 12)
MTS (µm)	117.6–288.2	214.8 (51.7; 9)
MTS/TL (µm)	27.8–72.3	39.5 (27.5; 9)

Table 2. Measurements of middorsal, laterodorsal, lateral accessory and lateroventral spines of adult *Triodontoderes lagahoo* sp. nov., including number of measured specimens (*n*), mean of data and standard deviation (SD). Abbreviations: ac, acicular (spine); cr, crenulated (spine); cu, cuspidate (spine); f, female condition of sexually dimorphic character; LAS, lateral accessory spine; LDS, laterodorsal spine; LVS, lateroventral spine; m, male condition of sexually dimorphic character; MDS, middorsal spine.

Character	**Range**	**Mean (SD; *n*)**
MDS 1 (ac) (µm)	5.0–10.5	7.5 (1.8; 11)
MDS 2 (ac) (µm)	14.3–34.2	24.9 (7.6; 12)
MDS 3 (ac) (µm)	24.5–53.2	38.9 (7.4; 11)
MDS 4 (ac) (µm)	32.5–57.7	46.1 (8.6; 11)
MDS 5 (ac) (µm)	37.6–60.5	48.9 (7.9; 12)
MDS 6 (ac) (µm)	42.5–64.5	53.3 (8.4; 12)
MDS 7 (ac) (µm)	41.3–71.9	58.6 (9.0; 12)
MDS 8 (ac) (µm)	47.9–71.1	60.8 (7.9; 12)
MDS 9 (ac) (µm)	39.3–73.4	59.9 (10.5; 11)
MDS 10 (cr, m; ac, f) (µm)	22.3–65.9	42.8 (13.2; 12)
MDS 11 (ac) (µm)	25.4–51.7	46.0 (7.6; 12)
LDS 10 (cr, m) (µm)	26.1–34.8	31.6 (3.3; 7)
VLS 2 (ac) (µm)	11.4–22.0	16.1 (4.9; 12)
VLS 2 (cu) (µm)	13.6–24.2	18.3 (5.2; 12)
LVS 3 (ac) (µm)	19.9–50.0	34.0 (8.8; 12)
LVS 4 (ac) (µm)	31.0–55.6	41.9 (7.6; 11)
LVS 5 (cu) (µm)	18.8–27.4	23.4 (3.1; 12)
LAS 5 (ac) (µm)	32.3–55.6	43.2 (8.4; 12)
LVS 6 (ac) (µm)	36.1–56.1	48.9 (6.4; 12)
LVS 7 (ac) (µm)	40.0–65.7	54.8 (8.6; 12)
LVS 8 (ac) (µm)	38.2–47.5	42.7 (2.9; 12)
LAS 8 (cu) (µm)	20.5–30.5	26.0 (3.5; 12)

LVS 9 (cu) (µm)	22.5–31.7	28.2 (2.5; 12)
LAS 9 (ac) (µm)	34.9–50.4	43.1 (6.0; 12)
LVS 10 (ac, f) (µm)	21.7–28.1	24.0 (2.8; 5)

Table 3. Summary of nature and arrangement of sensory spots, papillae and spines in *Triodontoderes lagahoo* sp. nov. Abbreviations: ac, acicular spine; cr, crenulated spine; cu, cuspidate spine; f, female condition of sexually dimorphic character; LA, lateral accessory; LD, laterodorsal; ltas, lateral terminal accessory spine; lts, lateral terminal spine; LV, lateroventral; m, male condition of sexually dimorphic character; MD, middorsal; mt, midterminal spine; ML, midlateral; pa, papilla; PD, paradorsal; SD, subdorsal; ss, sensory spot; ss3, type 3 sensory spot; VL, ventrolateral; VM, ventromedial.

Segment	**MD**	**PD**	**SD**	**LD**	**ML**	**LA**	**LV**	**VL**	**VM**
1	ac	ss							
2	ac	ss						cu, ac	
3	ac	ss		ss			ac	ss	
4	ac	ss		ss	ss		ac	ss	
5	ac	ss		ss	ss	ac	cu	ss	
6	ac	ss		ss	ss		ac	ss	
7	ac	ss		ss	ss		ac	ss	
8	ac	ss		ss	ss	cu	ac	pa(f)	
9	ac	ss	ss	ss		ac	cu		pa (f)
10	cr (m)/ac (f)	ss	ss	cr (m)			ac (f)		
11	ac, mt	ss	ss3, ss3	ss, ss		ltas	lts		

Table 4. Summary of main morphological differences between *Triodontoderes anulap* and *T. lagahoo* sp. nov.

Character	***T. anulap***	***T. lagahoo* sp. nov.**
Cuspidate spines in lateral accessory position on segment 6	Present	Absent
Female papillae arrangement	Ventrolateral on segments 7–8 and ventromedial on segment 9	Ventrolateral on segment 8 and ventromedial on segment 9
Laterodorsal sensory spots	Segment 10	Segments 3–9 and 11
Midlateral sensory spots	Segment 2	Segments 4–8
Ventral sensory spots	Ventromedial on segments 4, 6–8 and 10–11	Ventrolateral on segments 3–7

Long and conspicuous trunk pectinate fringes	Segments 7–11	Segments 2–11

507

508

509

510

511

512

513

514

515

516 FIGURE LEGENDS

517 **Fig. 1**. Map showing the sampling locality on Tobago Island (Trinidad and Tobago),
518 Lesser Antilles, Caribbean Sea (western Atlantic Ocean).

519 **Fig. 2.** Line art illustrations of *Triodontoderes lagahoo* sp. nov. (A) Female, dorsal
520 overview; (B) Female, ventral overview; (C) Female, dorsal overview showing the fat
521 shape of the species; (D) Male, segments 8-11, dorsal overview; (E) Male, segments 8-
522 11, ventral overview. Abbreviations: de, dorsal extension (of segment 11); dpl, dorsal
523 placid; f, female condition of sexually dimorphic feature; go, gonopore; laac, lateral
524 accessory acicular spine; lacu, lateral accessory cuspidate spine; ldcr, laterodorsal
525 crenulated spine; ldss, laterodorsal sensory spot; ltas, lateral terminal accessory spine;
526 lts, lateral terminal spine; lvac, lateroventral acicular spine; lvcu, lateroventral cuspidate
527 spine; m, male condition of sexually dimorphic feature; mdac, middorsal acicular spine;
528 mdcr, middorsal crenulated spine; mlss, midlateral sensory spot; mts, midterminal
529 spine; mvj, midventral junction; pdss, paradorsal sensory spot; ppf, primary pectinate
530 fringe; S, segment followed by number of corresponding segment; sdss, subdorsal
531 sensory spot; sdss3, subdorsal type 3 sensory spot; spf, secondary pectinate fringe; tsj,
532 tergo-sternal junction; ve, ventral extension (of segment 11); vlac, ventrolateral acicular
533 spine; vlcu, ventrolateral cuspidate spine; vlpa, ventrolateral papilla; vlss, ventrolateral
534 sensory spot; vmpa, ventromedial papilla; vpl, ventral placid.

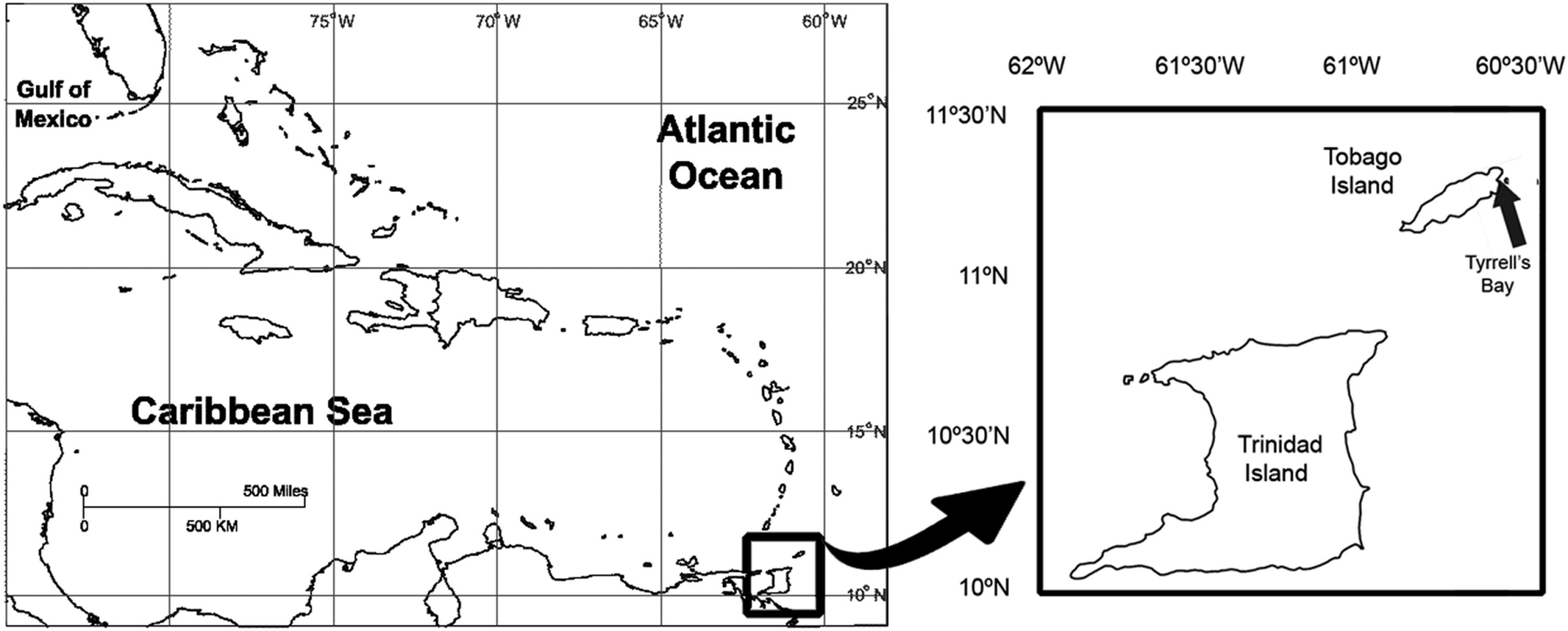
Fig. 3. Diagram of mouth cone, introvert and trichoscalids in *Triodontoderes lagahoo* sp. nov., with indication of oral style, scalid and trichoscalid arrangement. The outermost bold lines refers to the placids.

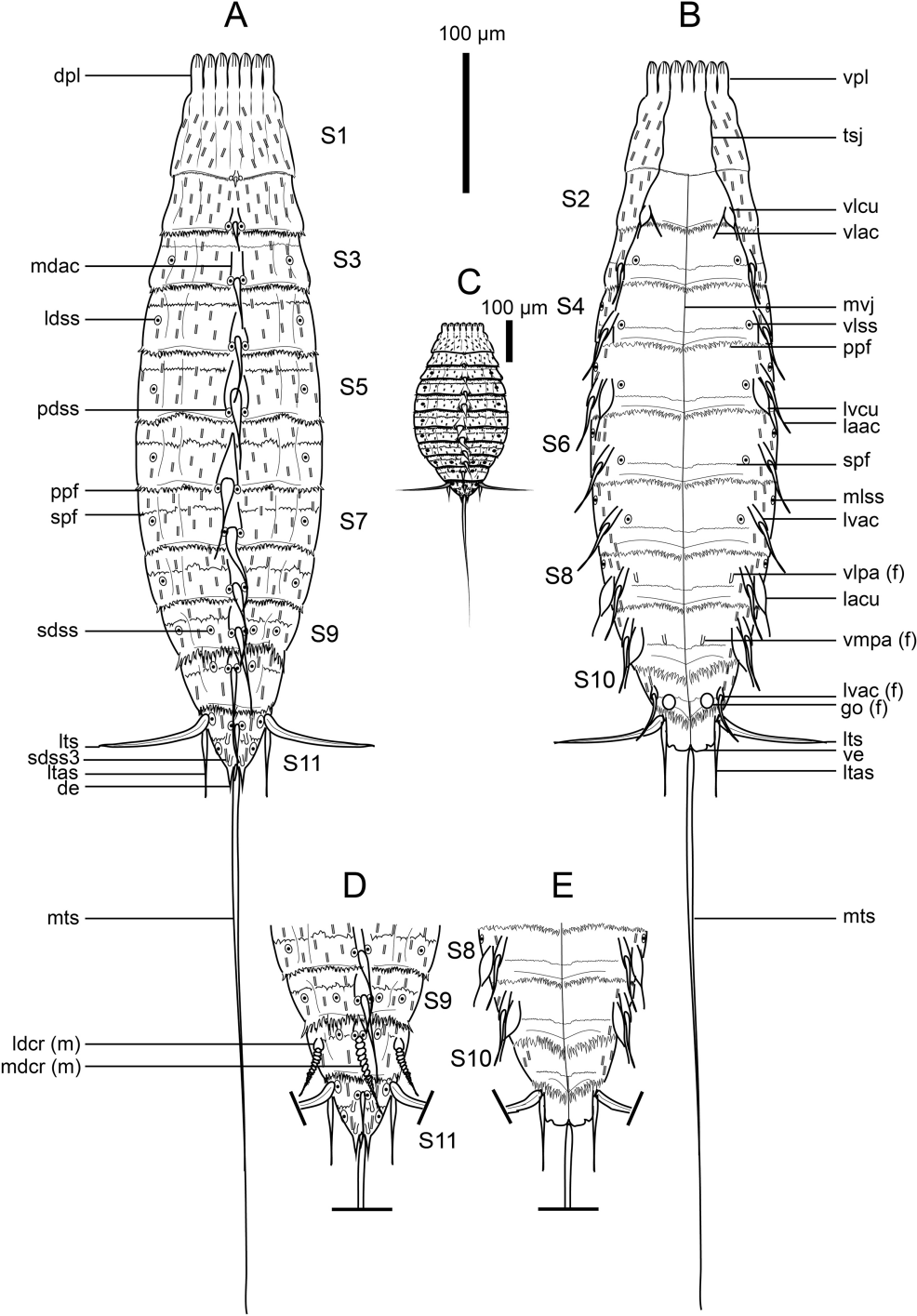
Fig. 4. Light micrographs (A-J, L) and stereomicroscope photo (K) showing trunk overviews and details in the mouth cone, introvert and general cuticular trunk characters of the female holotype NMNH XXXXX (A-I), a male paratype NMNH XXXXX (J), a female paratype NMNH XXXXX (L) and non-mounted additional specimens (K) of *Triodontoderes lagahoo* sp. nov. (A) Dorsal overview of trunk; (B) ventral overview of trunk; (C) mouth cone, with detail of the last ring of inner oral styles (ring -01); (D) mouth cone, with detail of the ring of outer oral styles (ring 00); (E) introvert, showing the first ring of primary spinoscalids (ring 01) and trichoscalids; (F) detail of a primary spinoscalid, showing the rigid spine that extends from its basal plate; (G) sector 5 of introvert, with detail of scalids of rings 02-05; (H) sector 6 of introvert, with detail of scalids of rings 02-05; (I) midlateral and lateroventral regions on right half of tergal plate of segments 8-10, with detail of primary and secondary pectinate fringes; (J) ventral overview of a chubby body outline male; (K) slender body outline (right) and chubby body outline (left) non-mounted specimens; (L) ventral view of segments 7-11 of a chubby body outline female, showing the gonads and the gonopores . Abbreviations: bs, basal sheath; dp, distal piece; f, female condition of sexually dimorphic character; g, gonad; go, gonopore; ios, inner oral style; oos, outer oral style; ppf, primary pectinate fringe; psc, primary spinoscalid; r, ring; S; segment followed by number of corresponding segment; sp, spine; sc, scalid; spf, secondary pectinate fringe; tct, triangular cuticular thickening; ts, trichoscalid.

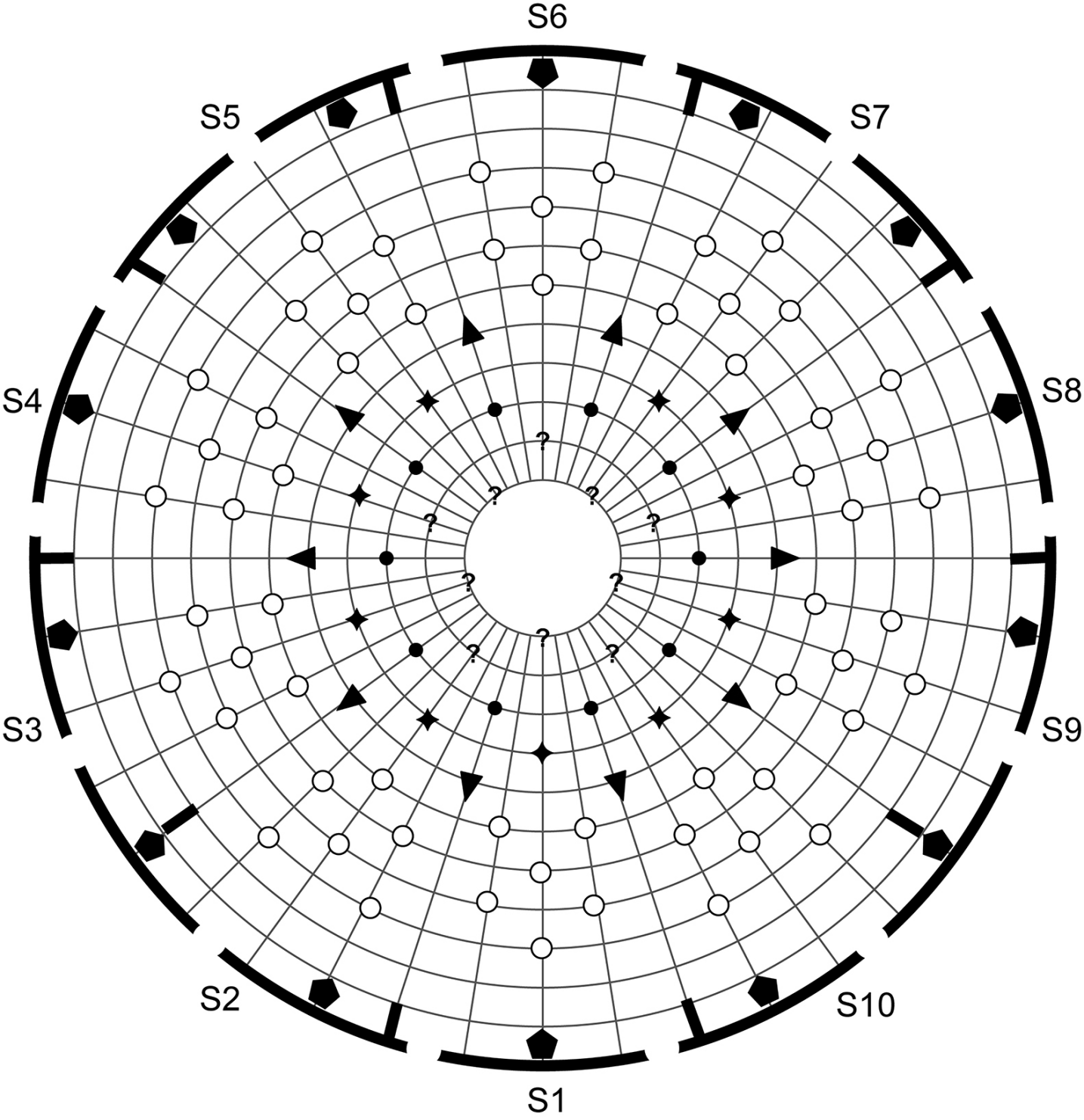
Fig. 5. Light micrographs showing details of cuticular trunk characters of female holotype NMNH XXXXX (A-I, K) and male paratype NMNH XXXXX (J) of *Triodontoderes lagahoo* sp. nov., with main focus on spines, sensory spots, sexually dimorphic features and segment 11 cuticular extensions. (A) Dorsal view of segments 1-3; (B) lateral view of right half of segments 2-3; (C) dorsal view of segment 11, showing the two pairs of type 3 sensory spots; (D) dorsal view of segments 4-7; (E) lateral accessory to ventromedial regions on right half of tergal and sternal plates of segments 4-6; (F) dorsal view of segment 11, showing the tergal extensions (in arrows); (G) dorsal view of segments 8-11; (H) lateral accessory to ventromedial regions on right half of tergal plates of segments 7-10; (I) ventral view of segment 11, showing the

sternal extensions (in arrows) and the female gonopores; (J) lateral view of right half of a male segment 11; (K) ventral view of segment 11, showing the midterminal spine. Abbreviations: f, female condition of sexually dimorphic character; go, gonopore; laac, lateral accessory aciculate spine; lacu, lateral accessory cuspidate spine; ldcr, laterodorsal crenulated spine; ltas, lateral terminal accessory spine; lts, lateral terminal spine; lvac, lateroventral acicular spine; lvcu, lateroventral cuspidate spine; m, male condition of sexually dimorphic character; mdac, middorsal acicular spine; mdcr, middorsal crenulated spine; mts, midterminal spine; pa, papilla; vlac, ventrolateral acicular spine; vlcu, ventrolateral cuspidate spine; sensory spots are marked as continuous circles and papillae as dotted circles; numbers after spines indicate the corresponding segment.

Fig. 6. Scanning electron micrographs showing general overview and details of the cuticular trunk morphology of non-type specimens of *Triodontoderes lagahoo* sp. nov. (A) Dorsal overview of trunk; (B) mouth cone, showing the outer oral styles; (C) dorsal view of neck, showing the distally tripartite placids; (D) detail of middorsal spine of segment 8, showing the swollen cuticular thickenings of its basal articulation with the paired paradorsal sensory spots; (E) lateroventral and lateral accessory regions on right half of tergal plates of segment 5; (F) middorsal and paradorsal regions of tergal plates of segments 6-8; (G) laterodorsal region on left half of tergal plates of segments 4-5; (H) dorsal view of a male segment 10, showing the crenulated middorsal and laterodorsal spines; (I) detail of midlateral sensory spot of segment 6; (J) lateral view of left half of segment 11 tergal plate, showing all sensory spots on left side. Abbreviations: de, dorsal extension (of segment 11); laac, lateral accessory acicular spine; ldcr, laterodorsal crenulated spine; ldss, laterodorsal sensory spot; lvcu, lateroventral cuspidate spine; m, male condition of sexually dimorphic character; mdac, middorsal acicular spine; mdcr, middorsal crenulated spine; pdss, paradorsal sensory spot; sdss3, subdorsal type 3sensory spot; sensory spots are marked as continuous circles; numbers after spines indicate the corresponding segment.


75° W
70° W
65° W
60° W
25° N
20° N
15° N
10° N
Gulf of Mexico
Atlantic Ocean
Caribbean Sea
0
500 Miles
0
500 KM
62°W
61°30'W
61°W
60°30'W
11°30'N
11°N
10°30'N
10°N
Tobago Island
Tyrrell's Bay
Trinidad Island


A
B
C
D
E
100 µm
100 µm
dpl
S1
mdac
S3
ldss
S4
S5
pdss
ppf
spf
S7
sdss
S9
lts
sdss3
ltas
de
S11
mts
ldcr (m)
mdcr (m)
vpl
tsj
S2
vlcu
vlac
mvj
vlss
ppf
lvcu
laac
S6
spf
mlss
lvac
S8
vlpa (f)
lacu
vmpa (f)
S10
lvac (f)
go (f)
lts
ve
ltas
mts
S8
S9
S10
S11



Oral style and scalid arrangement

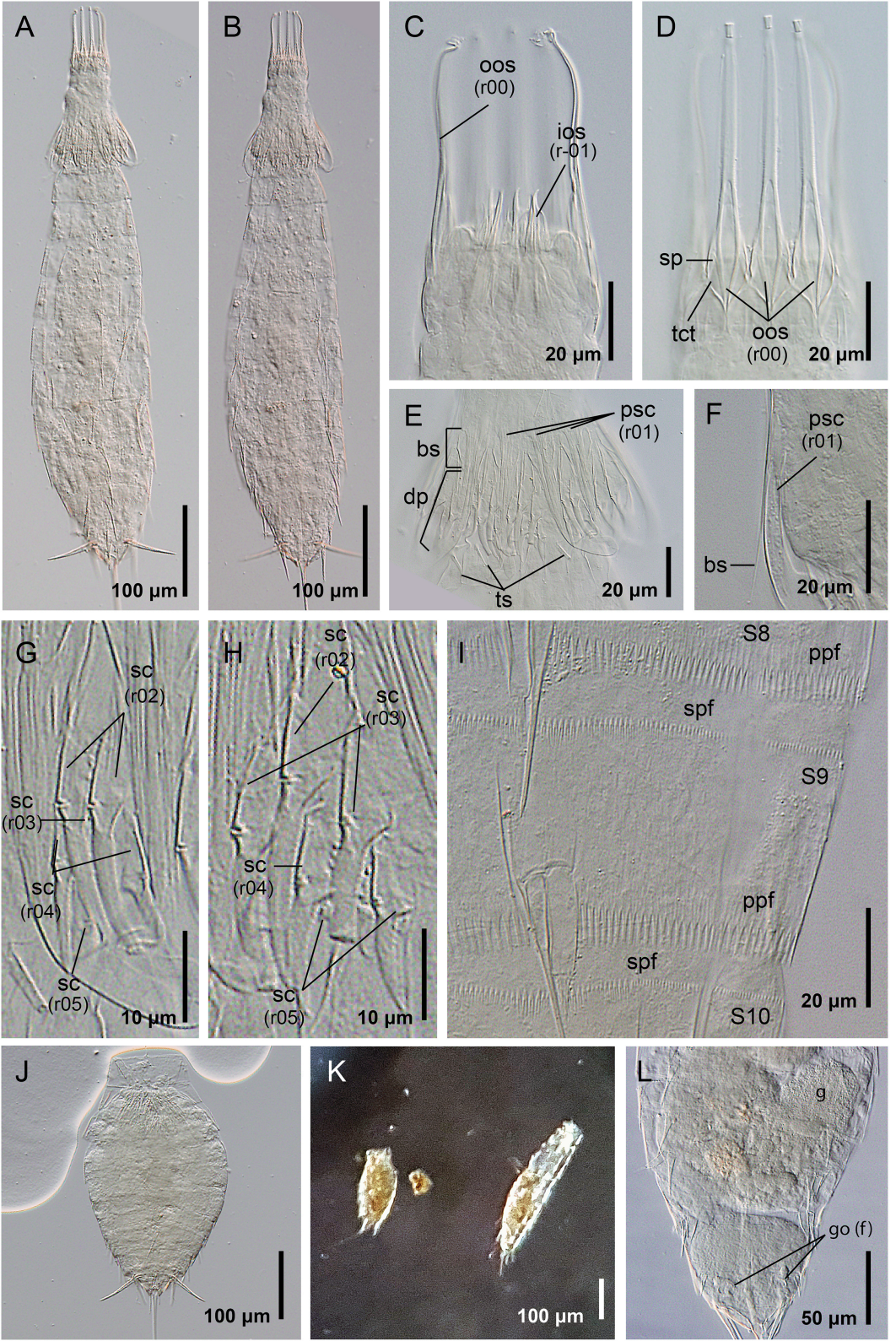
By ring:

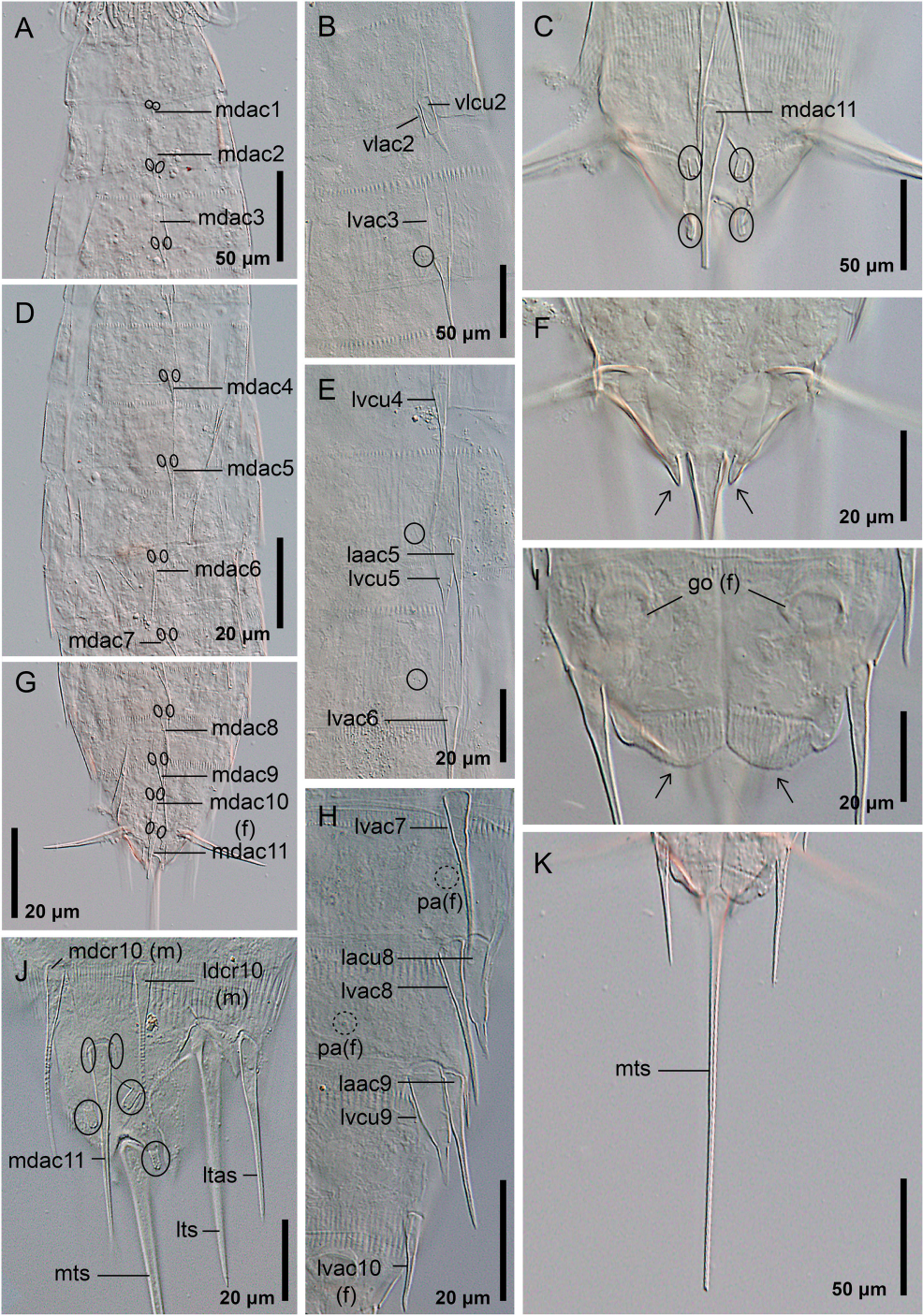
Ring -03: ? helioscalids
Ring -02: ? inner oral styles
Ring -01: 10 inner oral styles
Ring 00: 9 outer oral styles
Ring 01: 10 primary spinoscalids
Ring 02: 15 scalids
Ring 03: 15 scalids
Ring 04: 15 scalids
Ring 05: 15 scalids
Ring 06: /
Trichoscalid row: 14 trichoscalids

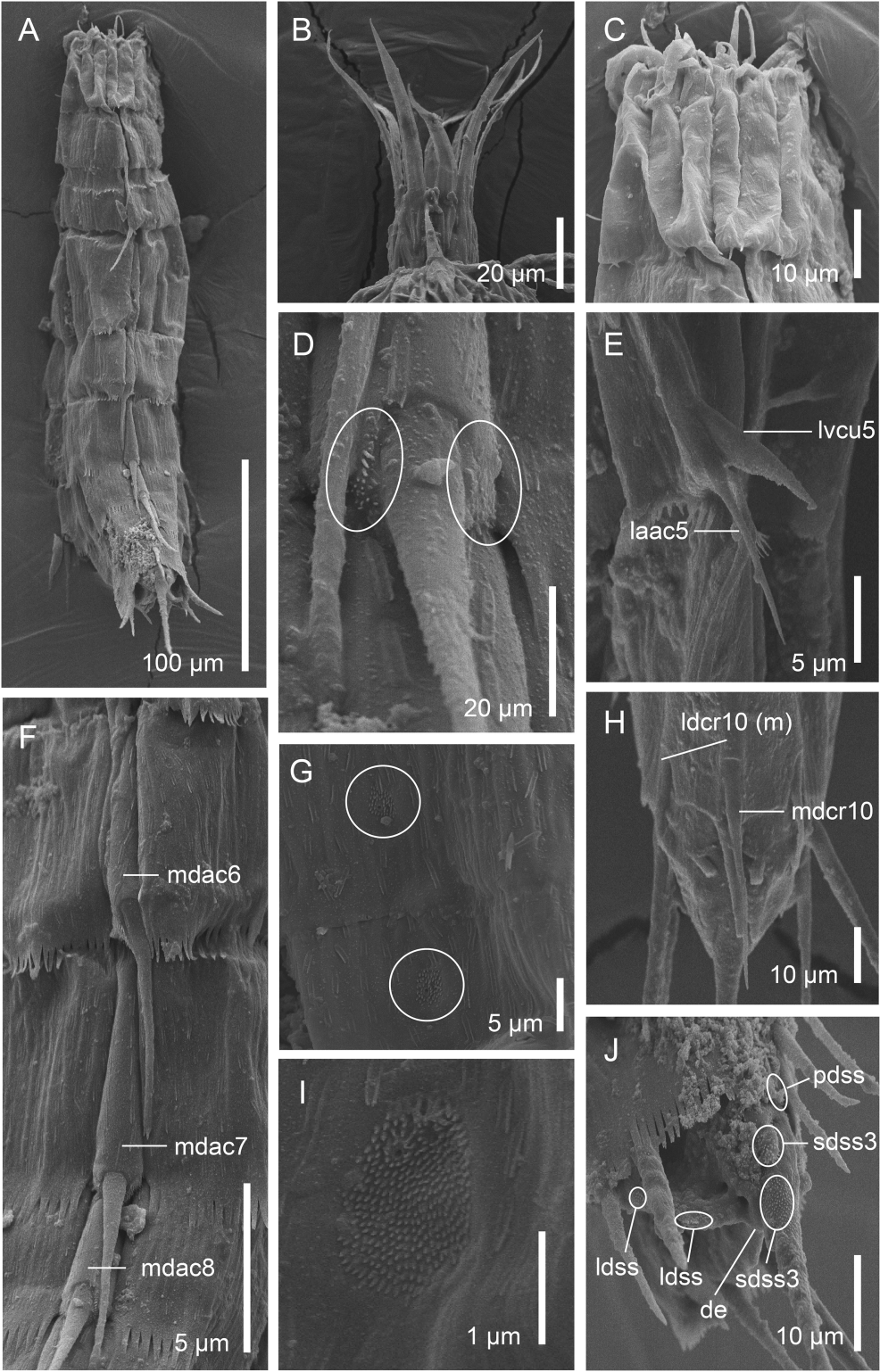
By sector:

Odd sectors: 6 scalids

Even sectors: 6 scalids


A
100 µm
B
100 µm
C
oos
(r00)
ios
(r-01)
20 µm
D
sp
tct
oos
(r00)
20 µm
E
psc
(r01)
bs
dp
ts
20 µm
F
psc
(r01)
bs
20 µm
G
sc
(r02)
sc
(r03)
sc
(r04)
sc
(r05)
10 µm
H
sc
(r02)
sc
(r03)
sc
(r04)
sc
(r05)
10 µm
I
S8
ppf
spf
S9
ppf
spf
S10
20 µm
J
100 µm
K
100 µm
L
g
go (f)
50 µm


A
mdac1
mdac2
mdac3
50 µm
B
vlcu2
vlac2
lvac3
50 µm
C
mdac11
50 µm
D
mdac4
mdac5
mdac6
mdac7
20 µm
E
lvcu4
laac5
lvcu5
lvac6
20 µm
F
20 µm
G
mdac8
mdac9
mdac10
(f)
mdac11
20 µm
H
lvac7
pa(f)
lacu8
lvac8
pa(f)
laac9
lvcu9
lvac10
(f)
20 µm
I
go (f)
20 µm
J
mdcr10 (m)
ldcr10
(m)
mdac11
ltas
lts
mts
20 µm
K
mts
50 µm


A
100 µm
B
20 µm
C
10 µm
D
20 µm
E
lvcu5
laac5
5 µm
F
mdac6
mdac7
mdac8
5 µm
G
5 µm
H
ldcr10 (m)
mdcr10
10 µm
I
1 µm
J
pdss
sdss3
ldss
ldss
sdss3
de
10 µm