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Zelinkaderes yong sp. nov. from Korea - the first recording of *Zelinkaderes* (Kinorhyncha: Cyclorhagida) in Asia

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Abstract

Background: A new kinorhynch species, *Zelinkaderes yong* sp. nov., is described from Korea.

Results: *Zelinkaderes yong* sp. nov. is described from coastal, sandy habitats in Korea by means of light and scanning electron microscopic techniques. The new species is characterized by the presence of cuspidate spines in lateroventral positions on segments 2 and 9, ventrolateral positions on segment 5, and lateral accessory positions on segment 8; flexible tiny acicular spines in lateroventral positions on segment 2, more regular-sized lateroventral acicular spines on segment 8, and middorsal spines on segments 4, 6, 8, 9, and 11. Females furthermore have acicular spines in middorsal and midlateral positions on segment 10, whereas males have crenulated spines on this segment. The absence of acicular spines in the lateral series of segment 9 makes it easy to distinguish the new species from all previously described congeners. The new species differs most from *Zelinkaderes submersus*, whereas it is morphologically closest to *Zelinkaderes klepali*. In regard to the spine patterns, the new species only differs from *Z. klepali* by its lack of lateroventral acicular spines on segment 9.

Conclusions: The finding of a new species of *Zelinkaderes* in East Asia extends the distributional range of the genus, which suggests that the genus basically could be present anywhere in the world and could be considered as cosmopolitan.

Keywords: Biodiversity; Meiofauna; Morphology; Taxonomy; Zelinkaderidae

Background

Kinorhynchs are small, worm-like, invertebrate animals that live among the marine meiobenthos. They have been known since 1851, but knowledge about their diversity is still incomplete (Dujardin 1851; Neuhaus 2013). The current number of 217 valid described species (based on description of adult specimens) is expected to increase substantially by intensified research efforts (Sørensen 2013). South Korea is one of the countries where kinorhynch diversity is relatively well known with more than ten new species discovered within the last 4 years (Sørensen et al. 2010a; Sørensen et al. 2010b, c; Lundbye et al. 2011; Sørensen et al. 2012; Sørensen et al. 2013).

The family Zelinkaderidae and genus *Zelinkaderes* were described in 1990 by R. P. Higgins (1990). Members of the genus are characterized by the presence of 16 indistinct placids on the neck that are basally fused with the first trunk segment. The first and second trunk segments consist of complete cuticular rings, whereas the third to tenth segments are composed of single plates with midventral articulations. Oral styles are bipartite; middorsal spines are present on segments 4, 6, and 8 to 11; cuspidate spines are found on several segments; and a midterminal spine is present. Currently, Zelinkaderidae accommodates two genera: *Triodontoderes* (see Sørensen and Rho 2009) with one species and *Zelinkaderes* (see Higgins 1990) with four previously described species. The first *Zelinkaderes* species to be discovered was actually described as *Cateria submersa* Gerlach 1969. This species was found in medium coarse sand near Helgoland in Northwest Germany (Gerlach 1969). However, this species was later redescribed by Higgins (1990) and assigned to the new genus, *Zelinkaderes*, under the name *Zelinkaderes submersus* (Gerlach 1969). In the same contribution, Higgins (1990) reported a second

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species of the genus, *Zelinkaderes floridensis* Higgins 1990, that was collected from localities with muddy sand, around 20 miles off Fort Pierce at the Atlantic Coast of Florida. Only 6 years later, Bauer-Nebelsick (1995) described a third species, *Zelinkaderes klepali* Bauer-Nebelsick, 1995, from coral sand at the Egyptian Red Sea coast. The fourth, and until now most recently discovered species, *Zelinkaderes brightae* Sørensen et al., 2007, was also described from Fort Pierce, Florida but from much cleaner calcareous sand than *Z. floridensis* and also closer to the coast. The type locality of *Z. brightae* is situated 6 miles off Fort Pierce (Sørensen et al. 2007), but subsequently, Herranz et al. (2013) have recorded the species at localities only 3 and 4 miles from the coast. Generally, the taxonomy of *Zelinkaderes* appears to be relatively uncomplicated, and the four known species can be distinguished by their lateral spine patterns and in particular by the position of their cuspidate spines.

In the present contribution, we describe the fifth species of *Zelinkaderes*. This species is the first intertidal species known from the genus, and it also represents the first Asian recording of the genus.

Methods

Specimens of *Zelinkaderes yong* sp. nov. were collected at two localities. The holotype and some paratypes were collected by scuba diving on 7 September 2001 from subtidal sand on 3- to 6-m depth at Guryongpo, near Pohang (Figure 1A) on the east coast of the Korean Peninsula (position: 36° 00′ 06″N, 129° 34′ 17″E). Additional paratypes were collected on 15 May 2010 from intertidal sand around Shinchang (Figure 1B) on the west coast of Jeju Island in South Korea (33° 20′ 42″N, 126° 10′ 12″E). At this second locality, the water retracts completely from the area at low tide. The substrate was fine sand with lots

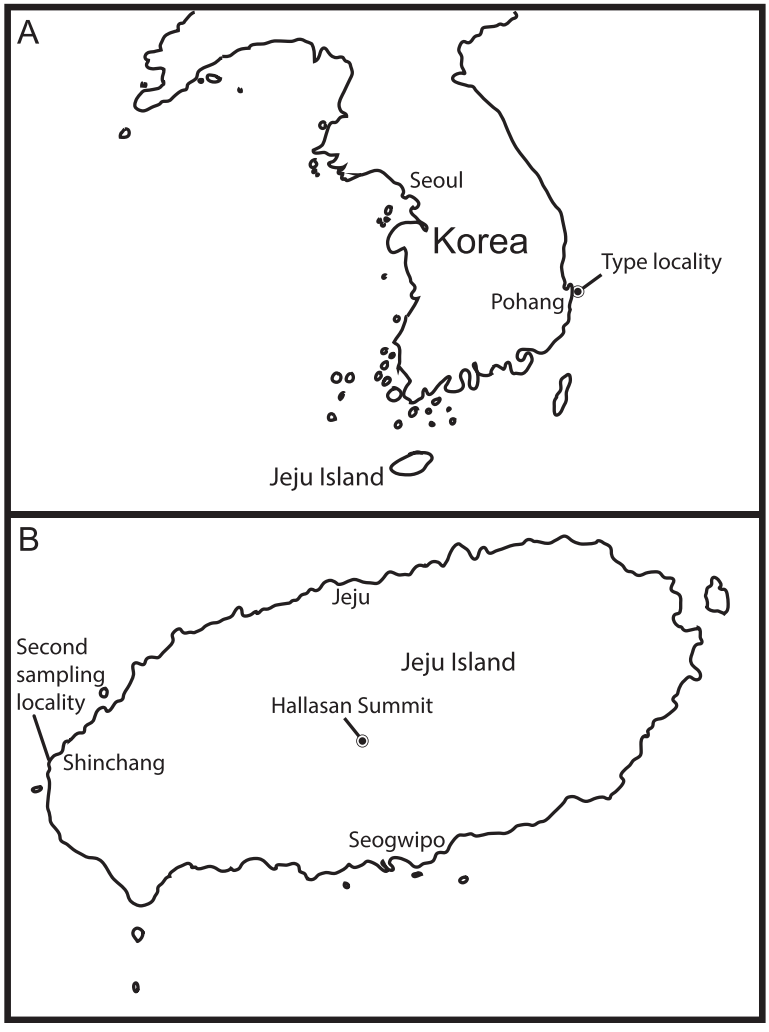


Figure 1 Maps showing the collection areas. A. Korean Peninsula showing Jeju Island and the type locality of *Zelinkaderes yong* sp. nov. at Guryongpo near Pohang. **B**. Jeju Island with the second sampling locality marked.

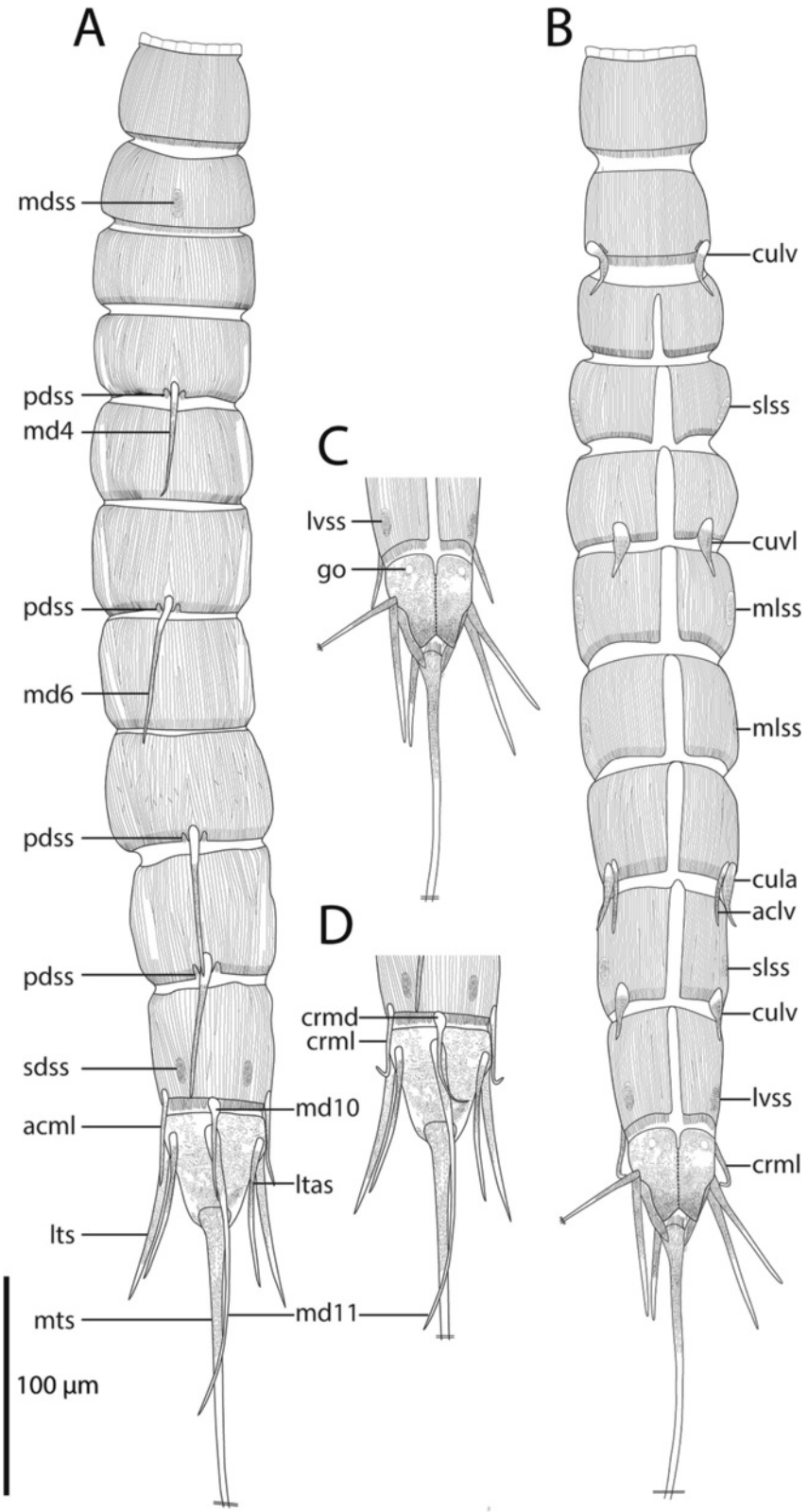


Figure 2 (See legend on next page.)

(See figure on previous page.)
Figure 2 Line art illustration of *Zelinkaderes yong* sp. nov. A. Female dorsal view. **B**. Male ventral view. **C**. Female posterior part ventral view. **D**. Male posterior part dorsal view. Drawings are based on SEM micrographs. Trunk length of the female specimen is approximately 500 μm, and trunk length of the male specimen is approximately 520 μm. Abbreviations: *aclv* acicular lateroventral spine, *acml* acicular midlateral spine, *crmd* crenulated middorsal spine, *crml* crenulated midlateral spine, *cula* cuspidate lateral accessory spine, *culv* cuspidate lateroventral spine, *cuvl* cuspidate ventrolateral spine, *go* gonopore, *ltas* lateral terminal accessory spine, *lts* lateral terminal spine, *lvss* lateroventral sensory spot, *md4-11* acicular middorsal spines on segments 4 to 11, *mdss* middorsal sensory spot, *mlss* midlateral sensory spot, *mts* midterminal spine, *pdss* paradorsal sensory spot, *sdss* subdorsal sensory spot, *slss* sublateral sensory spot.

of crustacean tubes (*Callianassa japonica* (Ortmann 1891)). Specimens at this locality were collected by digging a small pit into the sand and sieving the accumulating water with a net of 100-μm mesh size. The specimens occurred in so high numbers that no further extraction was required.

All collected specimens were fixed in 4% formalin buffered with sea water. For light microscopy, fixed specimens were transferred to distilled water, dehydrated through a graded series of glycerin, and mounted in Fluoromount G® on glass slides. They were examined using an Olympus BX51 microscope equipped with an Olympus DP20 camera and Normarski differential interference contrast optics. Measurements were made with Cell^D software version 2.7. (Olympus A/S, Ballerup, Denmark).

For scanning electron microscopy (SEM), specimens were dehydrated using a graded series of ethanol, transferred to acetone, and finally critical point dried. Dried specimens were mounted on aluminum stubs, sputter coated with a platinum/palladium mix, and examined with a JEOL JSM-6335 F field emission SEM (JEOL GmbH, Eching, Germany).

Type material is stored at the Natural History Museum of Denmark.

Results

Systematics

Order CYCLORHAGIDA (Zelinka, 1896) Higgins, 1964
Family ZELINKADERIDAE Higgins 1990
Genus ZELINKADERES Higgins 1990
Type species *Zelinkaderes yong* sp. nov.
Etymology: Like several other mud dragon species, this one is named after a dragon. The species name 'yong' refers to a dragon in Korean mythology.

Type material

Holotype: Adult male from Guryongpo, near Pohang on the East coast of the Korean Peninsula; 7th September 2001: 36° 00′ 06″N, 129° 34′ 17″E, in subtidal sand from 3- to 6-m depth, mounted in Fluoromount G®, deposited at the Natural History Museum of Denmark (NHMD) under accession number: ZMUC KIN-000818.

Paratypes: two adult females, three adult males, and one juvenile, collected at same time and locality as the holotype, mounted in Fluoromount G®, and deposited at the NHMD under accession numbers: ZMUC KIN-000819 to KIN-000824. Additional paratypes include seven adult females and two adult males, collected from an intertidal sand flat at Shinchang, Jeju Island, South Korea; 15th May 2010: 33° 20′ 42″N, 126° 10′ 12″E, mounted on an SEM stub and deposited at the NHMD under accession number: ZMUC KIN-000825.

Synonymy

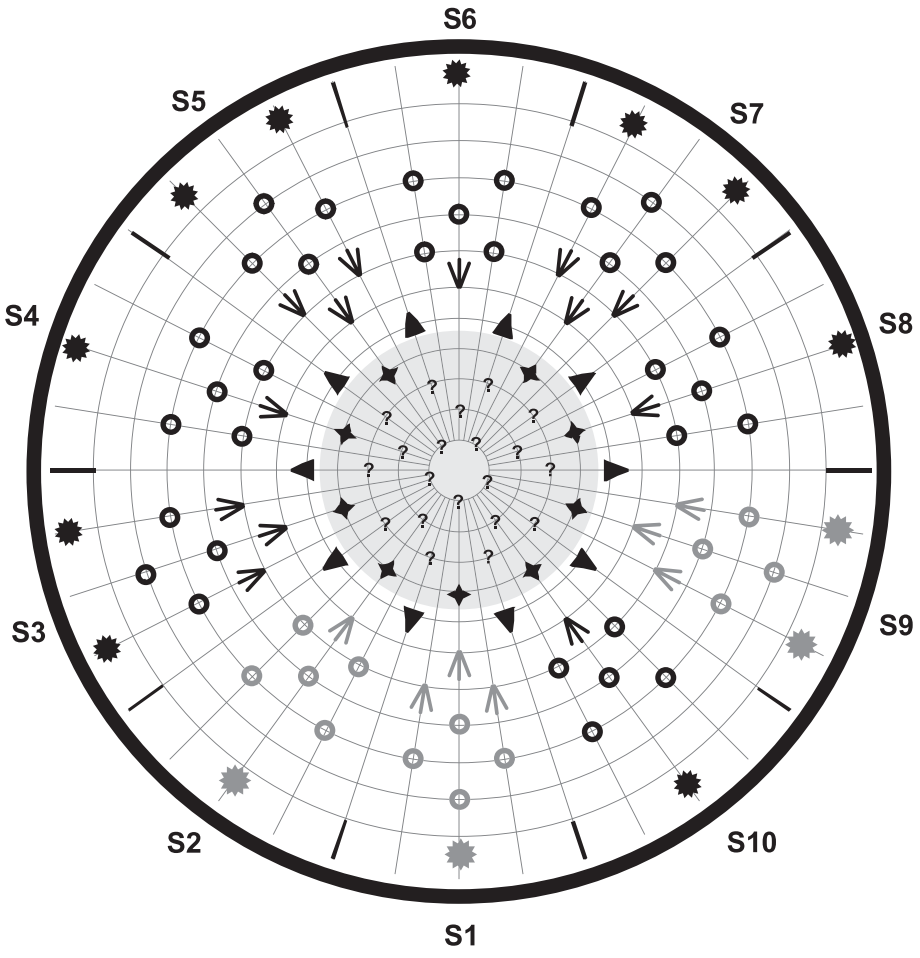
Zelinkaderes sp. in Park et al. 2006; *Zelinkaderes* sp. JKP-2005: 18S rRNA sequence (accession number AY746985) in GenBank (NCBI).

Diagnosis

Zelinkaderes yong sp. nov. has middorsal spines on segments 4, 6, and 8 to 11 (middorsal spine on segment 10 crenulated in males), lateroventral cuspidate spines on segments 2 and 9, lateral accessory cuspidate spines on segment 7, ventrolateral cuspidate spines on segment 5, lateroventral acicular spines on segment 8, and midlateral spines on segment 10, as regular acicular spines in females and crenulated spines in males. Lateral terminal spines, lateral terminal accessory spines, and midterminal spine are present on segment 11. Large sensory spots are present middorsally on segment 2, midlaterally on segments 2, 6, and 7, sublaterally on segments 4 and 9, subdorsally and lateroventrally on segment 10; smaller sensory spots are present in paradorsal positions around dorsal spines and in ventrolateral positions on segment 11. Trunk segments 1 to 10 have cuticular hairs arranged in a longitudinally striated pattern with distinct hairless patches midlaterally on segments 3 to 7 and 9. Segment 11 has cuticular hairs not arranged in any particular pattern.

Description

Adult specimens possess a head, neck, and 11 trunk segments (Figures 2A,B and 3). The trunk appears long, thin, and vermiform with a semicircular cross section and a slight thickening of the trunk in the middle (Figure 4A). Trunk segments 1 and 2 are composed of closed cuticular rings and segments 3 to 11 of a single plate with a midventral joint (Figure 2B). The midventral joint appears as a distinct cuticular surface marking



Scalid and style arrangement

Ring/Sector	1	2	3	4	5	6	7	8	9	10	Total
00 outer oral styles ✦	1	1	1	1	1	0	1	1	1	1	9
01 primary spinoscalids ▼	1	1	1	1	1	1	1	1	1	1	10
02 fringe ⋀	1	1	1	1	1	1	1	1	1	1	10
03 spinoscalids/fringe○ ⋀	2	2	2	2	2	2	2	2	2	2	20
04 spinoscalids ○	1	1	1	1	1	1	1	1	1	1	10
05 spinoscalids ○	2	2	2	2	2	2	2	2	2	2	20
06 splnoscallds ○	1	0	1	0	1	0	1	0	1	0	5
07 splnoscallds ○	0	0	0	0	0	0	0	0	0	0	0
08 trichoscalids ✹	1	1	2	1	2	1	2	1	2	1	14
Total scalids	8	7	9	7	9	7	9	7	9	7	79

Figure 3 Mouth cone and introvert diagram. Diagram of mouth cone (gray area) and introvert in *Zelinkaderes yong* sp. nov., showing the distribution of outer oral styles, scalids, and trichoscalids. The table shows scalid arrangement by sector. Not all introvert sectors could be examined, but assuming that the species displays the usual symmetry patterns, the scalid distributions for the non-examined sectors have been predicted. Scalid numbers and distributions based on predictions are marked with gray; numbers and distributions based on actual observations are marked with black.

on segments 3 to 10, whereas it is only an intracuticular line on segment 11. The anterior border of all segments is straight. An extremely weak pectinate fringe is present on the posterior edges of segments 1 to 10. The cuticle is patterned by longitudinal furrows populated with cuticular hairs (Figure 4B). The mid-terminal spine can be longer than the trunk of the animal. For a complete overview of measures and dimensions, see Table 1. The distribution of cuticular structures such as sensory spots and acicular and

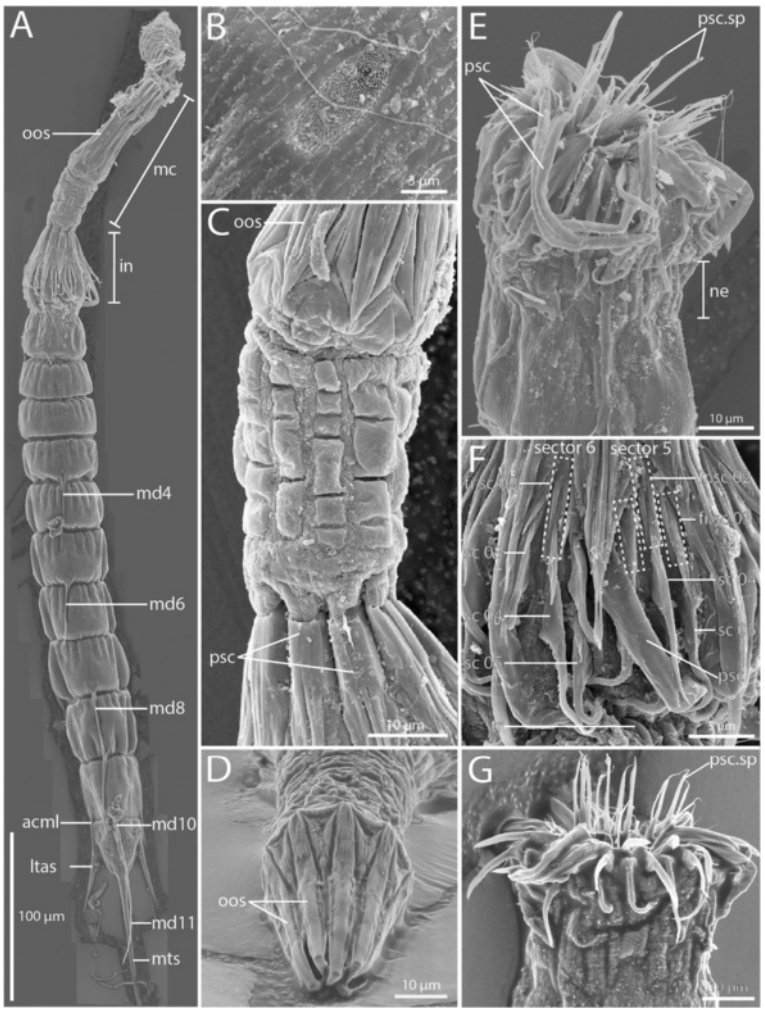


Figure 4 Overviews and details of head and trunk morphology. Scanning electron micrographs showing overviews and details of head and trunk morphology of *Zelinkaderes yong* sp. nov. paratypes (KIN-000825). **A**. Dorsal overview of female specimen. The midterminal (mt) spine is not shown entirely. **B**. Detail of the cuticle with the midlateral sensory spot on segment 6, showing the general structure of the cuticle as patterned by longitudinal furrows from where cuticular hairs emerge. **C**. Detail of the mouth cone showing the elongated proximal part of the mouth cone. **D**. Detail of the mouth cone in frontal view. **E**. Detail showing the spines at the bases of the primary spinoscalids that point in an anterior direction when the introvert is partly everted. **F**. The spines on the primary scalids as seen when the introvert is fully everted. **G**. Scalid spines pointing anteriorly as seen when the introvert is partly retracted. Abbreviations: *acml* acicular midlateral spine, *fr.sc* fringe replacing spinoscalid followed by ring number, *in* introvert, *ltas* lateral terminal accessory spine, *mc* mouth cone, *md4-11* acicular middorsal spines on segments 4 to 11, *mts* midterminal spine, *ne* neck region, *oos* outer oral styles, *psc* primary spinoscalids, *psc.sp* primary spinoscalid spines, *sc* spinoscalid followed by ring number, *tr* trichoscalid.

cuspidate spines is summarized in Table 2. Sensory spots belong to type 1.

Head

The head consists of a long retractable mouth cone and an introvert with five rings of scalids (Figures 3 and 4C-G). The exact position of the inner oral styles could not be examined, but their presence was observed in several specimens. The mouth cone is surrounded by nine anteriorly directed outer oral styles of equal size, composed of two units (Figure 4C,D). The outer oral styles alternate in length and are arranged in a way so that each style is located centrally and anterior to each introvert sector (Figure 4C), except sector 6 where the outer oral style is missing. The anterior parts of the styles point inwards (Figure 4D). The base of each style is characterized by a fringe of small anteriorly directed spines (Figure 4D). Triangular cuticular thickenings are present in between the bases of the oral styles (Figure 4D). The proximal part of the mouth cone, posterior to the outer oral styles, forms a long tube. The tube appears to have longitudinal areas with thickened

Table 1 Measurements from light microscopy of adult *Zelinkaderes yong* sp. nov. (in μm)

Character	*n*	Range	Mean	SD
TL	6	480 to 575	514.6	33.5
S1	6	38 to 55	48.0	6.7
S2	6	28 to 41	35.4	5.1
S3	6	32 to 44	36.2	4.6
S4	6	32 to 48	38.6	5.6
S5	6	38 to 49	41.9	4.2
S6	6	43 to 50	47.1	3.1
S7	6	44 to 57	49.2	4.5
S8	6	45 to 54	49.3	3.6
S9	6	47 to 58	53.2	4.4
S10	6	49 to 57	52.4	2.8
S11	6	30 to 45	37.2	5.1
MD 4 (ac)	6	16 to 30	23.2	5.4
MD 6 (ac)	6	22 to 42	33.1	7.9
MD 8 (ac)	6	31 to 45	41.0	5.2
MD 9 (ac)	6	35 to 47	41.5	4.8
MD 10 (ac)	6	35 to 53	42.6	7.1
MD 11 (ac)	6	84 to 114	95.4	11.8
LV 2 (cu)	12	10 to 20	16.4	2.6
VL 5 (cu)	12	15 to 22	20.7	2.1
LA 8 (cu)	11	21 to 30	25.1	2.7
LV 8 (ac)	12	32 to 41	36.3	3.3
LV 9 (cu)	12	20 to 27	24.5	2.0
ML 10 (ac)	4	31 to 33	31.8	0.8
ML 10 (cr)	7	28 to 44	35.5	6.0
LTS	11	58 to 76	65.6	6.2
LTAS	11	55 to 65	58.4	3.7
LTS/LTAS	10	1.0 to 1.3	1.1	0.1
MTS	4	410 to 561	489.9	81.4
MTS/TL	4	0.8 to 1.1	0.9	0.1

Abbreviations: *ac* acicular spine, *cr* crenulated spine, *cu* cuspidate spine, *LA* lateral accessory, *LTAS* lateral terminal accessory spine, *LTS* lateral terminal spine, *LV* lateroventral, *MD* middorsal, *ML* midlateral, *MTS* midterminal spine, *n* number of measured specimens, *S* segment lengths, *SD* standard deviation, *TL* trunk length, *VL* ventrolateral.

cuticle and a smooth surface, which alternate with thinner and probably more flexible cuticular areas.

The heads were everted in several paratypes mounted for SEM, but it was often difficult to examine the precise arrangement of scalids; hence, information cannot be provided for all introvert sectors. However, since the kinorhynch introvert usually follows certain symmetry patterns, and information only was missing for three sectors (sectors 1, 2, and 9), we have tried to predict the expected scalid arrangements in these sectors as well. It should be stressed though that the following description is based on incomplete data. The complete polar projection, showing mouth cone and introvert appendages, is shown in Figure 3. Structures in black are based on actual observations, whereas structures in gray are predictions.

The introvert shows spinoscalids in rings 01 and 03 to 06 and trichoscalids in ring 08, whereas ring 02 shows groups of short fringes instead of spinoscalids and ring 03 has both fringes and spinoscalids. The ten primary spinoscalids in ring 01 have three stiff spines on the base, oriented in a way that makes them stick out from the head opening once the introvert is everted (Figure 4E,G). The spines lay flat on the base of the spinoscalids once the introvert is fully everted (Figure 4F). Ring 02 has no scalids. Instead, a group of short fringes, resembling the fringes that often attach at the basal part of a spinoscalid, is present in each introvert sector (Figure 4F). Ring 03 shows both fully developed spinoscalids (two in each even-numbered sector) and the same kind of fringes as in the preceding ring (two in each odd-numbered sector) (Figure 4F). Ring 04 and the following two rings have only fully developed spinoscalids (Figure 3). Ten spinoscalids, one in each sector, are located in ring 04, whereas ring 05 has 20 spinoscalids, two in each sector, and ring 06 has a single spinoscalid in each odd-numbered sector only, giving a total of five spinoscalids in this ring.

A total of presumably 14 rather small and pointed trichoscalids are present near the neck region (Figures 3 and 4F). Placids are not clearly distinguishable on the neck (Figure 4G).

Trunk

Trunk segment 1 shows no prominent cuticular structures (Figures 4A and 5C). Anteriorly, it fuses directly with the head cuticle, and the neck region is only weakly defined as some cuticular thickenings that could be interpret as strongly reduced placids. The reduced placids show no sign of distal tripartition.

Segment 2 has one large middorsal and a pair of large midlateral sensory spots (Figures 2A, 4A, and 6A). A pair of cuspidate spines and a pair of very minute, flexible acicular spines (length ca. 5 μm from SEM), is located in lateroventral positions near the posterior end of the segment (Figures 2B, 5D, and 6A).

Segment 3 without spines or sensory spots, but hairless patches are present that correspond in size and location to the midlateral sensory spots on segment 2 (Figures 4A, 5E, and 6A).

Segment 4 has a middorsal spine that extends to the posterior edge of the following segment (Figure 7A). The spine is flanked by a pair of tiny, paradorsal sensory spots. Considerably larger sensory spots are present in sublateral positions (Figure 6B). Elongated hairless patches stretching

Table 2 Summary of nature and location of sensory spots and spines

Position segment	MD	PD	SD	ML	SL	LA	LV	VL
1								
2	ss			ss			cu, ac	
3								
4	ac	ss			ss			
5								cu
6	ac	ss		ss				
7				ss				
8	ac	ss				cu	ac	
9	ac	ss			ss		cu	
10	ac (f),cr (m)	?	ss	ac (f),cr (m)			ss	
11	ac, mts					ltas	lts	ss

Abbreviations: *LA* lateral accessory, *LV* lateroventral, *MD* middorsal, *ML* midlateral, *PD* paradorsal, *SD* subdorsal, *SL* sublateral, *VL* ventrolateral, *ac* acicular spine, *cu* cuspidate spine, *cr* crenulated spine, *(f)* female condition of sexual dimorphic character, *ltas* lateral terminal accessory spine, *lts* lateral terminal spine, *(m)* male condition of sexual dimorphic character, *mts* midterminal spine, *ss* sensory spot, *?* sensory spot expected but not observed.

over the anterior two thirds of the segment are located in mid- or laterodorsal positions (Figures 2A, 6B, and 7A).

Segment 5 has cuspidate spines in ventrolateral positions (Figure 6B). Hairless patches, similar to those on the preceding segment, are present (Figures 6B and 7A), but otherwise the segment has no conspicuous cuticular structures.

Segment 6 has middorsal spine, flanked by a pair of tiny, paradorsal sensory spots. The middorsal spine extends until the anterior part of segment 8 (Figure 7B). Large sensory spots are present in midlateral positions, elongate hairless patches are slightly dorsal to the sensory spots (Figure 6C). The widths of the hairless patches correspond to the width of the sensory spots but their areas extend almost along the entire segment (Figure 6C).

Segment 7 does not have any significant cuticular structures dorsally (Figure 4A). Large sensory spots are present midlaterally (Figure 6C), and hairless patches are similar in size and shape to those on segment 6, slightly dorsal to the sensory spots (Figure 6C).

Segment 8 has a middorsal spine, flanked by a pair of tiny, paradorsal sensory spots. The middorsal spine extends until the posterior edge of segment 9 (Figures 2A and 7C). Acicular spines are present in lateroventral positions and cuspidate spines in lateral accessory positions (Figures 2B, 6D, and 7D). A small, spiny protrusion is present on the cuticular edge of the insertion point of each cuspidate spine (Figure 6D). Lateral sensory spots are not present, whereas hairless patches appear as on the preceding segment.

Segment 9 has a middorsal spine, flanked by a pair of tiny, paradorsal sensory spots. The middorsal spine extends until the posterior edge of segment 10 (Figure 7E). Cuspidate spines are present in lateroventral positions near the posterior edge of the segment (Figure 2A). Large sensory spots are found sublaterally starting in the center of the segment and extending posteriorly, approximately one quarter of the segment (Figure 6D). Hairless patches are present midlaterally extending over 50% of the segment longitudinally (Figure 6D).

Segment 10 tapers slightly towards the posterior and has a middorsal spine that attaches close to the posterior margin of the segment (Figures 2A, 4A, and 7F). It was not possible to determine whether the spine is flanked by paradorsal sensory spots. Additional spines are present in midlateral positions (Figures 2A-B, 4A, 6E, and 7F). Middorsal and midlateral spines appear as regular acicular spines in females, whereas males have crenulated spines. Large sensory spots are present in subdorsal and lateroventral positions (Figures 2A-B and 6E).

Segment 11 tapers strongly towards the midterminal spine at its posterior end (Figures 2A-B, 4A, 5A-B, 6E, and 7G). Additional spines include a middorsal spine and a pair of lateral terminal and lateral terminal accessory spines (Figures 2A-B, 4A, 5B, and 6E). No paradorsal sensory spots are present around the middorsal or midterminal spines, but a pair of tiny sensory spots is present in ventrolateral positions, almost on the posterior edge of the tegumental plate. Female specimens have a pair of rounded gonopores on the ventral side of the segment (Figure 6E). Each gonopore is a round plate with an anterior slit-like opening and a conspicuous cuticular spike attached near the outer lateral edge of the plate (Figure 6E). The cuticular sculpturing of this segment is different from the other segments. Instead of hairs arranged in longitudinal rows, the cuticular hairs are distributed randomly on the surface (Figures 2A-B, 4A, 6E, and 7F).

Discussion

Notes on diagnostic features

Through its spine pattern, the new species can easily be distinguished from its four congeners. The single

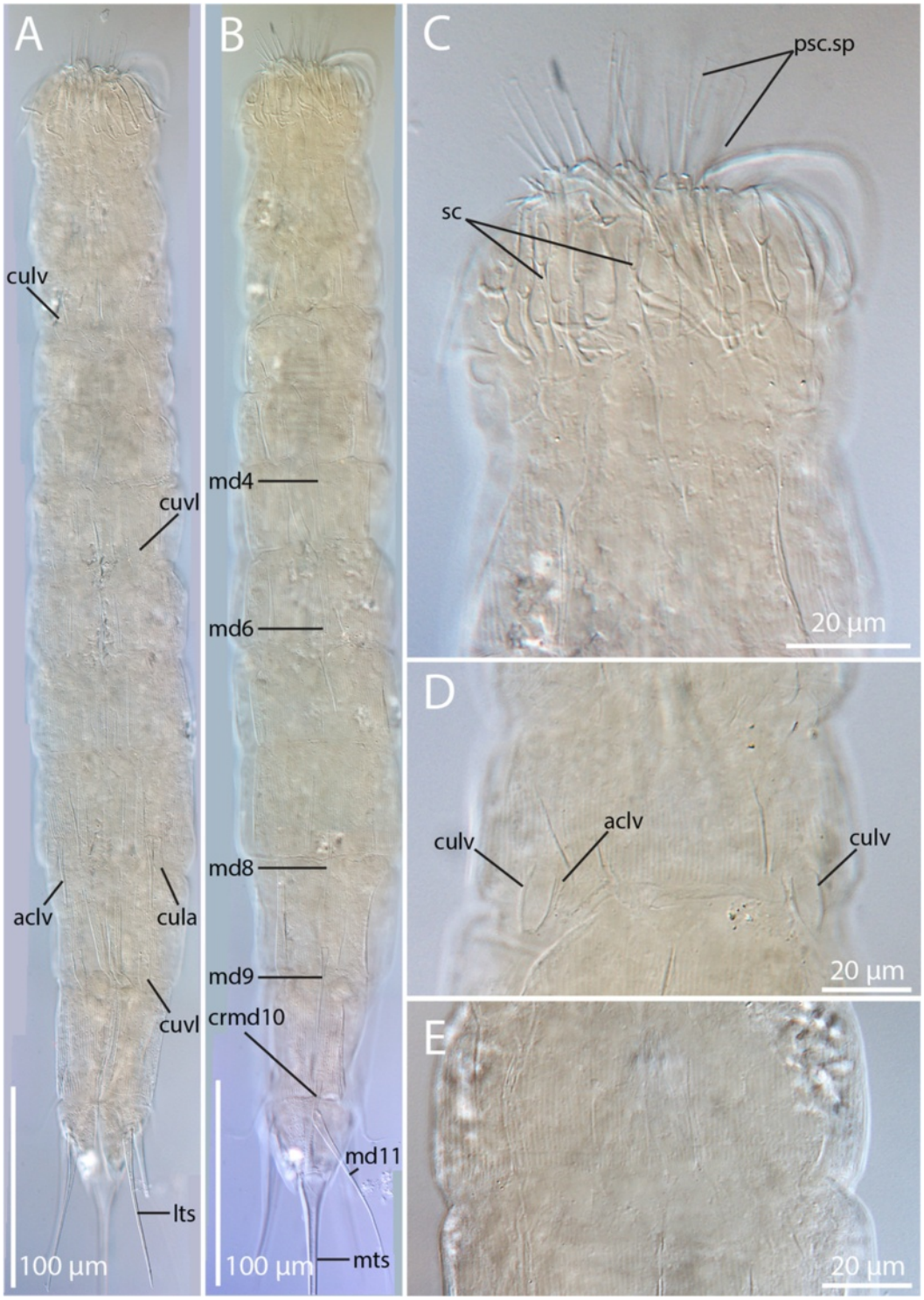


Figure 5 Overviews and details of trunk morphology. Light micrographs showing overviews and details of trunk morphology in *Zelinkaderes yong* sp. nov., holotypic male (KIN-000818). **A**. Ventral view of the entire specimen with incomplete midterminal spine. **B**. Dorsal view of the specimen shown in A. **C**. Partly everted introvert with scalids and scalid spines. **D**. Detail of the second trunk segment with cuspidate spines and the barely visible acicular spines. **E**. Ventral view of the third trunk segment showing the characteristic cuticular ornamentation with a longitudinal striation formed by the cuticular hairs and the pectinate fringe on the posterior border of the segment. Abbreviations: *aclv* acicular lateroventral spine, *crmd10* crenulated middorsal spine on segment 10, *cula* cuspidate lateral accessory spine, *culv* cuspidate lateroventral spine, *cuvl* cuspidate ventrolateral spine, *lts* lateral terminal spine, *md4-9 + 11* acicular middorsal spines on segments 4 to 9 and 11, *mts* midterminal spine, *psc.sp* primary spinoscalid spines, *sc* spinoscalid.

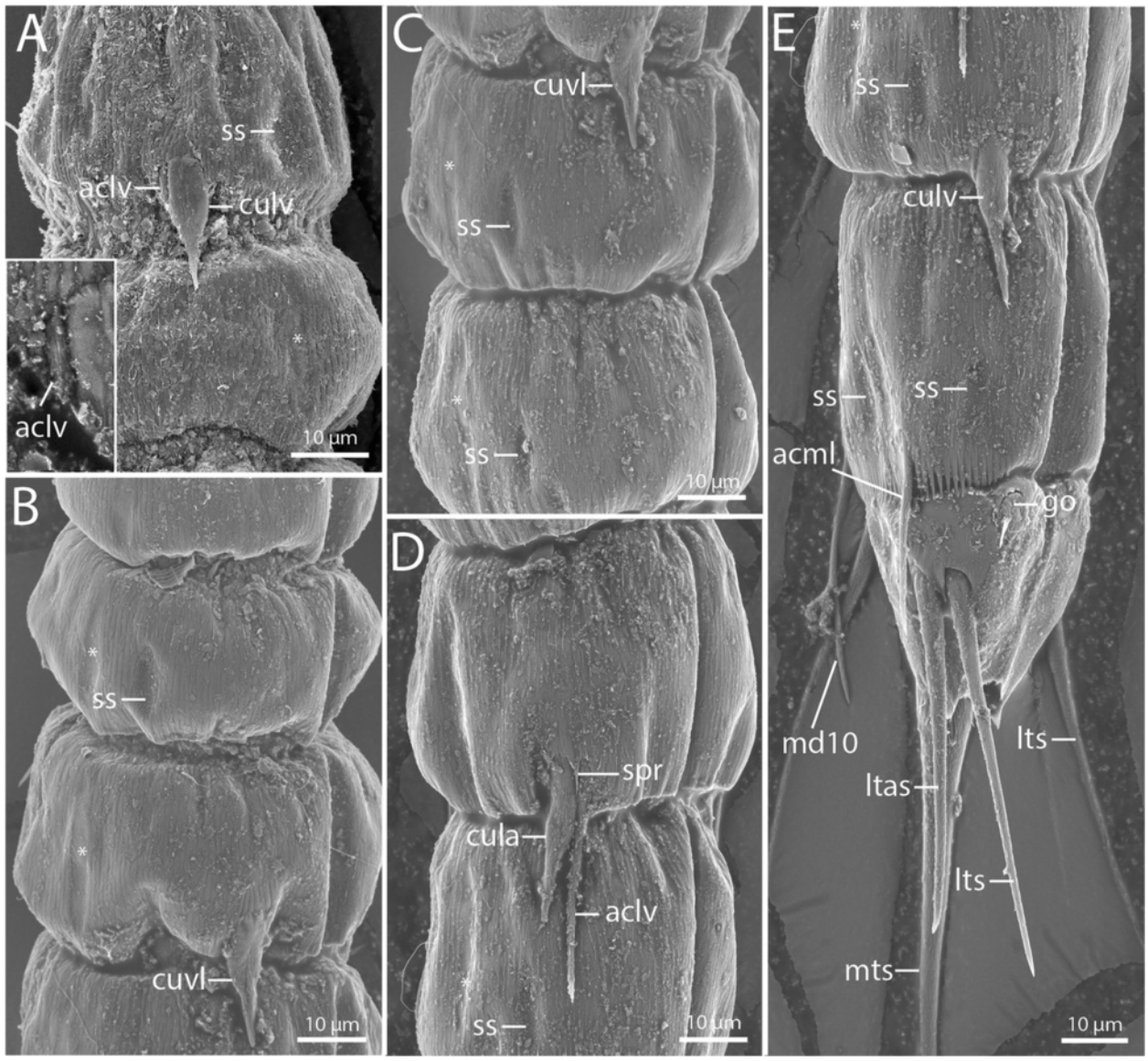


Figure 6 Details of female *Zelinkaderes yong* sp. nov. paratype (KIN-000825). A. Ventrolateral view on trunk segments 2 and 3 with lateroventral cuspidate spine and minute acicular spine. The inset shows a close-up of the minute acicular spine. **B**. Ventrolateral view of segments 4 and 5 with sublateral sensory spot on segment 4 and midlateral hairless patch (asterisk) as well as ventrolateral cuspidate spine on segment 5. **C**. Ventrolateral view of segments 6 and 7 with midlateral sensory spots and midlateral hairless patches (asterisk) on both segments. **D**. Ventrolateral view of segments 8 and 9, with lateral accessory cuspidate spine and lateroventral acicular spine on segment 8, and midlateral hairless patch (asterisk) and sublateral sensory spot on segment 9. **E**. Ventrolateral view of segments 9 to 11 of female specimen. Abbreviations: *aclv* acicular lateroventral spine, *acml* acicular midlateral spine, *cula* cuspidate lateral accessory spine, *culv* cuspidate lateroventral spine, *cuvl* cuspidate ventrolateral spine, *go* gonopore, *ltas* lateral terminal accessory spine, *lts* lateral terminal spine, *md10* acicular middorsal spine on segment 10, *mts* midterminal spine, *spr* spiny protrusion, *ss* sensory spot. Hairless patches are marked with asterisk '*'.

diagnostic trait that separates *Zelinkaderes yong* sp. nov. from other species of *Zelinkaderes* is its absence of lateroventral or lateral accessory acicular spines on segment 9. Such a spine is present in all four previously described species. Otherwise, it differs most from *Z. submersus* that shows cuspidate spines in the lateral series on all segments from segments 4 to 9 (Higgins 1990) and from *Z. brightae* that has ventrolateral cuspidate spines on segments 4 to 6 (Sørensen et al. 2007). In this part of the trunk (segments 4 to 6), *Z. yong* sp. nov. only possesses cuspidate spines on segment 5. *Z. floridensis* shows a closer resemblance to the new species, but besides the differences on segment 9, *Z. floridensis* is unique among its congeners by the absence of cuspidate spines on segment 2 (Higgins 1990). The cuspidate spines on segment 5 in *Z. floridensis* are furthermore located more laterally

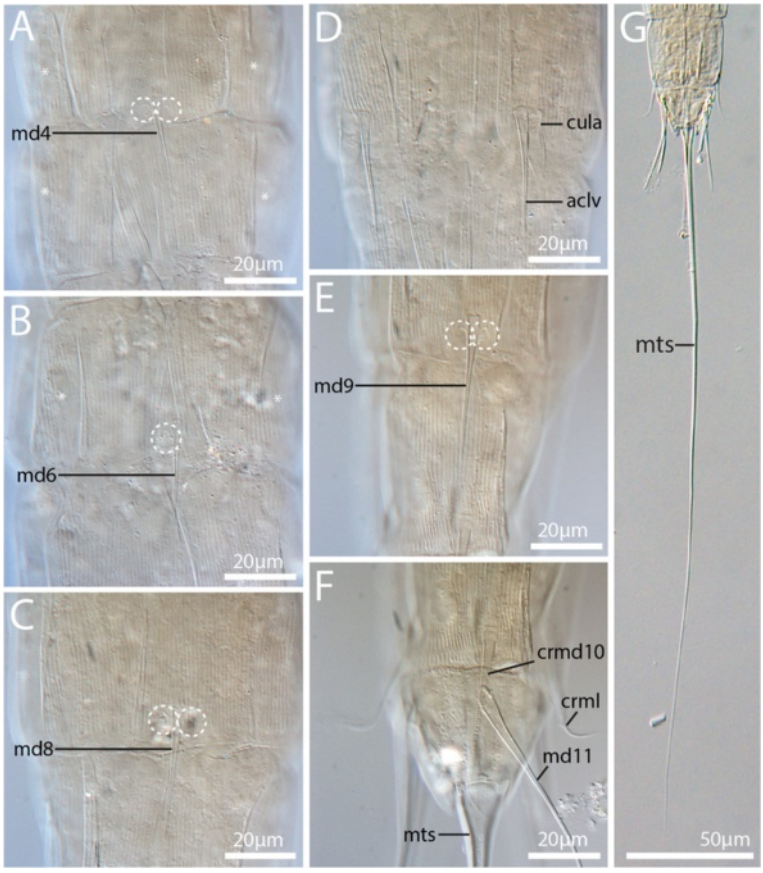


Figure 7 Light micrographs with details of *Zelinkaderes yong* sp. nov., holotypic male (KIN-000818). A. Dorsal view of segments 4 and 5 with weakly developed pectinate fringe and middorsal spine flanked by paradorsal sensory spots (dashed circles) on segment 4 as well as hairless patches on segments 4 and 5 (asterisk). **B**. Dorsal view of segment 6 with middorsal spine, hairless patches (asterisk), and paradorsal sensory spot (dashed circle). **C**. Dorsal view of segment 8 with middorsal spine flanked by paradorsal sensory spots (dashed circles). **D**. Ventral view of segment 8 with acicular and cuspidate spines. **E**. Dorsal view of segments 9 and 10 with middorsal spine of segment 9. Presence of paradorsal sensory spots (dashed circles) is only evident on segment 9. The hairless patches on segment 9 are out of focus and not indicated. **F**. Dorsal view of segments 10 and 11 with middorsal spine and lateral acicular spines on segment 10 and middorsal spine and base of the midterminal spine on segment 11. **G**. Posterior part of the specimen showing the long midterminal spine (mt) that can reach the same length as the trunk of the animal. Abbreviations: *aclv* acicular lateroventral spine, *crmd10* crenulated middorsal spine on segment 10, *crml* crenulated midlateral spine, *cula* cuspidate lateral accessory spine, *md4-9 + 11* acicular middorsal spines on segments 4 to 9 and 11, *mts* midterminal spine. Hairless patches are marked with asterisk '*'.

compared to the spines in *Zelinkaderes yong* sp. nov. The new species shows most resemblance with *Zelinkaderes klepali*. Except for the lateral accessory acicular spine on segment 9, present in *Z. klepali* and absent in *Z. yong* sp. nov., the spine patterns of the two species are identical. Also, the distribution of large sensory spots is identical for the two species. Bauer-Nebelsick (1995) reports the positions of some of them as dorsolateral, but according to the provided illustrations, these sensory spots are pretty much located in midlateral positions as in *Z. yong* sp. nov. The midlateral position of the sensory spots on segments 2, 6, and 7 in *Z. klepali* was also confirmed by personal examinations of the type specimens, carried out by the last author during a visit at the Natural History Museum of Vienna some years ago. Unfortunately, these examinations could not clarify whether small sensory spots are located near the attachment points of the middorsal spines, but at least Figure twenty three in Bauer-Nebelsick (1995) shows indications of paradorsal sensory spots around the middorsal spine of segment 4. Confirmation of the existence of additional paradorsal sensory spots would probably require SEM examinations, but the SEM specimens used in the description of *Z. klepali* are unfortunately no longer available (pers. comm. M. Bright). Based on studies of LM material, paradorsal sensory spots similar or identical to the spots of *Z. yong* are present on segments 4, 6, 8, and 9 of *Z. klepali* from the Red Sea (Neuhaus pers. comm.) One remarkable difference regarding sensory spots is the

apparent absence of type 3 sensory spots around the base of the midterminal spine in *Z. yong* sp. nov. Such sensory spots have been documented from both *Z. klepali* and *Z. brightae* (Bauer-Nebelsick 1995; Sørensen et al. 2007), and they even appear to be quite common in species of other genera with midterminal spine, e.g., *Triodontoderes*, *Antygomonas*, *Semnoderes*, *Sphenoderes*, *Tubulideres*, and *Wollunquaderes* (see Sørensen 2007; Sørensen et al. 2007, Sørensen et al. 2009, Sørensen et al. 2010c; Sørensen and Rho 2009, Sørensen and Thormar 2010).

Additional systematic and morphological remarks

Zelinkaderes yong sp. nov. fits well into the genus *Zelinkaderes*, with oral styles consisting of two units, segments 1 and 2 consisting of one closed cuticular ring, segments 3 to 11 with midventral articulation of the tergal plate, middorsal spines on segments 4, 6, and 8 to 11, cuspidate spines on segments 5 and 9, cuspidate spines and acicular spines on segment 8, and a conspicuous longitudinal striation pattern formed by rows of cuticular hairs on segments 1 to 10. However, it differs slightly in the composition of its neck region. When Sørensen and Rho (2009) described *Triodontoderes anulap* and assigned it to Zelinkaderidae, they also proposed an emended diagnosis for the family. In accordance with observations from *T. anulap*, *Z. brightae*, *Z. klepali*, and perhaps also *Z. floridensis*, Sørensen and Rho (2009) suggested that the presence of distally tripartite placids in the neck could be a common trait for all species of the family. However, this tripartition could not be confirmed for *Z. yong* sp. nov. because its placids are so inconspicuous that they can hardly be identified. We see this as a reduction that results from the extremely thin cuticle that is found in *Z. yong* sp. nov. Strongly reduced (or perhaps absence of) placids in species with thin cuticle are also known from other species, e.g., *Cateria* sp. (see Figure '5.1.9.' in Neuhaus 2013). Zelinkaderids might be either a highly derived taxon or, as suggested by Higgins 1990, a primitive form, closely resembling the common ancestor of the whole phylum.

The introvert in species of *Zelinkaderes* differs from most other kinorhynchs, due to its reduced number of spinoscalids. This reduction was already noticed in some of the earliest descriptions (see Higgins 1990; Bauer-Nebelsick 1995). In the description of *Z. brightae*, Sørensen et al. (2007) added more details to the *Zelinkaderes* introvert morphology by describing other structures, termed 'fringes' and 'spines', that apparently were replacing spinoscalids and suggested that these structures marked the positions of spinoscalids. We argue that the fringes and spines are reduced spinoscalids, but they might also represent anlagen of not fully developed spinoscalids. The scalid patterns observed in *Z. brightae* are very similar with those in *Z. yong* sp. nov. Actually, it appears that the section-wise arrangement of not only spinoscalids but also these peculiar fringes that could mark the position of reduced spinoscalids is identical in the two species. Furthermore, if we expect that Bauer-Nebelsick (1995) reported only the fully developed spinoscalids, leaving out the fringes, the introvert of *Z. klepali* would be identical with *Z. brightae* and *Z. yong* sp. nov. as well.

Conclusions

The finding of a new species of *Zelinkaderes* in East Asia extends the distributional range of the genus considerably. Species of the genus are now known from European, African, North American, and East Asian waters, which suggests that the genus basically could be present anywhere in the world and could be considered as cosmopolitan. The new species shows the closest resemblance with *Z. brightae*, but it would be too premature to suggest an actual sister-taxon relationship.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

AA investigated the specimens, made the figures, and drafted the manuscript. HSR and CYC discovered the new species, collected it at the type locality, and contributed to writing of the manuscript. MVS designed and coordinated the study and helped to draft the manuscript. All authors read and approved on the final manuscript.

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