

Four new species of *Pycnophyes* (Kinorhyncha: Homalorhagida) from Korea and the East China Sea

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SUMMARY: Four new species of *Pycnophyes* are described from Korean waters and the East China Sea. *Pycnophyes pardosi* n. sp. is distinguished from other congeners by the presence of a single paradorsal seta on segments 2-8 and a pair on segment 9, combined with the presence of longitudinal cuticular thickenings on the dorsal and ventral sides of segment 10. *Pycnophyes chalgap* n. sp. is easily distinguished by the shape of its midsternal plate with the rounded posterior margin, extending beyond and overlapping half of the following segment. *Pycnophyes cristatus* n. sp. is recognized by its lack of ventromedial setae on segments 3-6 combined with the presence of pointed middorsal processes that turn progressively longer towards the posterior segments from segment 6. The process on segment 10 is conspicuously long, extending beyond the posterior margin of segment 11. *Pycnophyes smaug* n. sp. is distinguished by its general scarcity of setae which, with the exception of those in lateroventral positions, only appear in laterodorsal positions on segments 2 and 9 and in ventromedial position on segment 9. The description of four additional species brings the total number of valid kinorhynch species around the Korean Peninsula up to 26.

Keywords: biodiversity, meiofauna, Pycnophyidae, morphology, taxonomy, Korean Peninsula.

RESUMEN: CUATRO NUEVAS ESPECIES DE *PYCNOPHYES* (KINORHYNCHA: HOMALORHAGIDA) DE COREA Y EL MAR DEL ESTE DE CHINA. — Se describen cuatro nuevas especies de aguas coreanas y del este del mar de China. *Pycnophyes pardosi* n. sp. se distingue de las demás especies por la presencia de una única seda paradorsal en los segmentos 2-8 y un par en el segmento 9, combinado con la presencia de engrosamientos cuticulares longitudinales en el lado dorsal y ventral del segmento 10. *Pycnophyes chalgap* n. sp. es fácilmente distinguible por la forma de su placa medioesternal con el margen posterior redondeado, sobrepasando y solapando la mitad anterior del siguiente segmento. *Pycnophyes cristatus* n. sp. es reconocible por la ausencia de sedas ventromediales en los segmentos 3-6 combinado con la presencia de salientes mediodorsales puntiagudos que a partir del segmento 6 se vuelven progresivamente más largos hacia los segmentos posteriores. El saliente del segmento 10 es llamativamente largo, extendiéndose más allá del margen posterior del segmento 11. *Pycnophyes smaug* n. sp. se distingue por su carencia general de sedas que, aparte de las lateroventrales, solo aparecen en posición laterodorsal en los segmentos 2 y 9, y en posición ventromedial en el segmento 9. La descripción de las cuatro especies aumenta hasta 26 el número total de especies válidas de kinorrincos entorno a la península coreana.

Palabras clave: biodiversidad, meiofauna, Pycnophyidae, morfología, taxonomía, península coreana.

INTRODUCTION

Since 2008 a collaborative team anchored in the Korean Institute of Ocean Science and Technology and

the Natural History Museum of Denmark has explored the taxonomy and biodiversity of East Asian kinorhynchs. Samples from various localities in the triangle between Malaysia, Micronesia and Korea have been

examined during the study, with the most intensive sampling in the area stretching from the Korean East Sea, through the Korea Strait to the central part of the East China Sea.

The study has already resulted in the description of 13 new species (Sørensen and Rho 2009, Sørensen *et al.* 2010a, 2010b, 2010c, 2012a, 2012b, in press, Lundbye *et al.* 2011) and more descriptions are currently under preparation. The taxonomic work has until now been done with a strong emphasis on cyclorhagid species, and the recently described species include 11 cyclorhagids and only a single homalorhagid, *Paracentrophyes anurus* Sørensen *et al.* 2010. However, the collecting campaigns also revealed several new species of homalorhagid *Pycnophyes* and some of them will be addressed and described in the present contribution. The genus is characterized by species with one tergal and three sternal plates on segment 1, one tergal and two sternal plates on segments 2-11 and a pair of lateral terminal spines on segment 11. Many species bear mid-dorsal processes or elevations along the trunk segments and males usually differ from females by the presence of a pair of ventral tubes on segment 2 and penile spines on segment 11 (Zelinka 1928, Higgins 1983).

So far, only four species of *Pycnophyes* have been recorded from the main study area, i.e. Korea and nearby localities. These include *P. furugelmi* Adrianov, 1999; *P. oshoroensis* Yamasaki *et al.*, 2012; *P. schornikovi* Adrianov, 1999 and *P. tubuliferus* Adrianov, 1989 from the Korean East Sea and Seto Inland Sea (see Adrianov and Malakhov 1999, Murakami *et al.* 2001, Yamasaki *et al.* 2012) and *P. tubuliferus* from Peter the Great Bay and the Korean west coast (Adrianov 1989, Adrianov and Malakhov 1999). Other recordings of homalorhagid kinorhynch from the area include only *Kinorhynchus yushini* Adrianov, 1989 and *Paracentrophyes anurus* (see Adrianov and Malakhov 1999, Sørensen *et al.* 2010a). One of the reasons for the limited attention paid to homalorhagid taxonomy is may be the difficulties that many researchers experience when trying to identify species of this group. The currently available identification keys are all based on characters that are often highly subjective, ambiguous or only discernible with one particular technique (i.e. only scanning electron microscopy or differential interference contrast).

The ongoing studies have clearly shown that the study area holds a diverse, and so far unrecovered cyclorhagid kinorhynch fauna, and the same pattern appears to exist for homalorhagids. Hence, with the present contribution we can double the number of *Pycnophyes* species known from the area, and contribute even further to the knowledge of kinorhynchs in this diverse region.

MATERIALS AND METHODS

Kinorhynchs were recorded from numerous localities (>35) in the East Sea, Korea Strait and East China

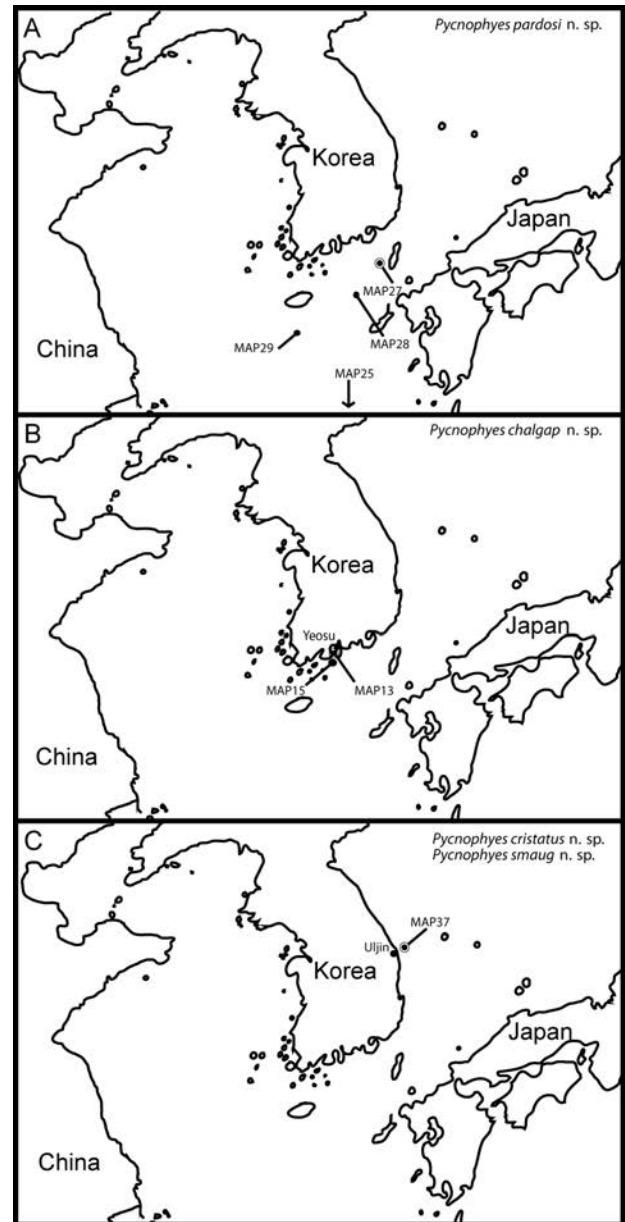


FIG. 1. – Maps showing collecting localities for *Pycnophyes pardosi* n. sp. (A), *Pycnophyes chalgap* n. sp. (B) and *Pycnophyes cristatus* n. sp. and *Pycnophyes smaug* n. sp. (C). Type localities are marked with a ring around the dot.

Sea during several collecting campaigns organized by the Korean Institute of Ocean Science and Technology between 2006 and 2012. Seven of the sampled stations yielded specimens for the present study (Fig. 1). Station names (MAP-followed by station number) follow the nomenclature used in other recent studies by the authors (see Sørensen *et al.* 2012a, 2012b, in press) to enable a more straightforward comparison of the faunal composition at the localities in past and future publications.

Samples were taken with a Smith-MacIntyre Grab or a box corer and were immediately fixed in formalin.

Subsequently, the meiofauna was extracted from the fixed samples using Ludox centrifugation and kinorhynchs were separated from other specimens under a stereomicroscope. Specimens for light microscopical (LM) studies were dehydrated through a graded glycerin series and mounted in Fluoromount G on glass slides. Specimens for LM were examined and photographed using Nomarski differential interference contrast (DIC) in an Olympus BX51 microscope equipped with an Olympus DP20 camera. Measurements were made with Cell[^]D software. Specimens for scanning electron microscopy (SEM) were dehydrated through a series of alcohol, and subsequently transferred to acetone through a graded alcohol/acetone series. When contained in 100% acetone, the specimens were critical point dried, mounted on aluminium stubs, sputter coated with a platinum/palladium mix and examined with a JEOL JSM-6335F Field Emission scanning electron microscope.

The terminology in the taxonomic account generally follows Neuhaus and Higgins (2002), Sørensen and Pardos (2008) and the most recent papers of the last author (Sørensen *et al.* 2012a, 2012b, in press). Terminology related to seta distribution for homalorhagids follows the standardization criteria established by Sánchez *et al.* (2011) and adopted by most authors (Sørensen *et al.* 2010a, Yamasaki *et al.* 2012, Sánchez *et al.* 2013), except for Neuhaus (2012). The terminology tied to the introvert has been modified slightly, so all scalids (except trichoscalids) are referred to as spinoscalids, and those in Ring 01 as primary spinoscalids. This modification is made to make the terminology used by different experts more uniform. It is based on a suggestion made by Neuhaus (Neuhaus 2012), and a consensus about the future use of this terminology was recently reached at the Third International Scalidophora Workshop.

All type material is deposited at the Natural History Museum of Denmark (NHMD), whereas non-types are stored in the personal collection of the last author, and will later become integrated in the NHMD collection.

RESULTS

Order HOMALORHAGIDA (Zelinka, 1896)
Family PYCNOPHYIDAE Zelinka, 1896
Genus *Pycnophyes* Zelinka, 1907

Pycnophyes pardosi n. sp.
(Figs 2-4)

Type material. Holotype, adult male, collected on 6 October 2008 in the Korea Strait, locality MAP27 (Fig. 1A): 34°16'25"N, 128°40'24"E, from mud with tiny shells at 96 m depth; mounted in Fluoromount G[®], deposited at the NHMD under accession number ZMUC KIN-638. Allotype, adult female, same collecting data as holotype, mounted in Fluoromount G[®], deposited at NHMD under accession number ZMUC KIN-639. Paratypes, three adult males; two collected on same date and locality as holotype, mounted in Fluoromount G[®], deposited at NHMD under accession numbers ZMUC KIN-603 and KIN-640; one collected on 6 August 2008

in the East China Sea, locality MAP25 (Fig. 1A) 28°32'41"N, 125°09'32"E, from deep sea mud at 104 m depth; mounted in Fluoromount G[®], deposited at NHMD under accession number ZMUC KIN-641. Five additional specimens, mounted for SEM, are stored in the last author's collection and will later be included in the NHMD general collection: three specimens were collected on the same date and at the same locality as the holotype (one male and two females), one male was collected on 6 October 2008 in the Korea Strait, locality MAP28: 33°44'31"N, 128°15'234"E, from mud with tiny shells at 126 m depth; and one female on the same date in the Korea Strait, locality MAP29 32°37'29"N, 126°42'14"E, from mud with tiny shells at 128 m depth.

Diagnosis. *Pycnophyes* without middorsal structures (middorsal processes or elevations) or intracuticular atria on any segment. Single paradorsal seta present on segments 2-8 and one pair of paradorsal setae on segment 9. The single paradorsal setae may appear on either the right or left side of the middorsal line. Tergal anterior margin of segment 1 denticulated and ornamented, and posterior margin broadly triangular. Ventral anterior margin of segment 1 bulging and ornamented. Dorsal and ventral sides on segment 10 with longitudinal cuticular thickenings, visible with DIC and SEM. Type 1 sensory spots on segments 1-10 and males with type 3 sensory spots on segment 11.

Etymology. This species is named in honor of Prof. Fernando Pardos (Spain), who is the PhD supervisor of the first author and a good friend and colleague of the last author.

Description. None of the specimens were suitable for introvert examinations, so data on number and arrangement of scalids and oral teeth are not available.

Neck with four dorsal and two ventral placids (Fig. 3E). Dorsal placids are rectangular and of similar size, whereas the ventral ones are much more elongate and narrow towards the lateral sides. All placids appear robust and hard, with a depression on their surface (Figs 3E, 4E). They articulate with the anterior edge of the first trunk segment. Cuticular folds appear between dorsal and ventral placids. Trichoscalid plates not present.

Trunk with 11 segments (Figs 2A-B, 3A-C, 4A-B); first segment with one tergal and three ventral plates (Figs 2A, 4A, E). Segments 2-11 with one tergal and two ventral sternal plates. All dimensions and measurements of the examined specimens are summarized in Table 1, and distribution of sensory spots and setae in Table 2. The segment width is nearly constant throughout the trunk. Maximum width is reached at segment 6 and the posterior segments taper slightly from this segment. Posterior margins of segments with thin pectinate fringe, and a free flap overlapping the anterior edge of the following segment. In addition, all segments with dorsoventral muscles, visible as muscular scars in subdorsal and ventromedial positions. Several subepidermal granules grouped throughout the lateral margins of all segments, only visible with DIC (Fig. 4F). Dorsal and ventral pectinate fringes becoming more developed towards the lateral margins.

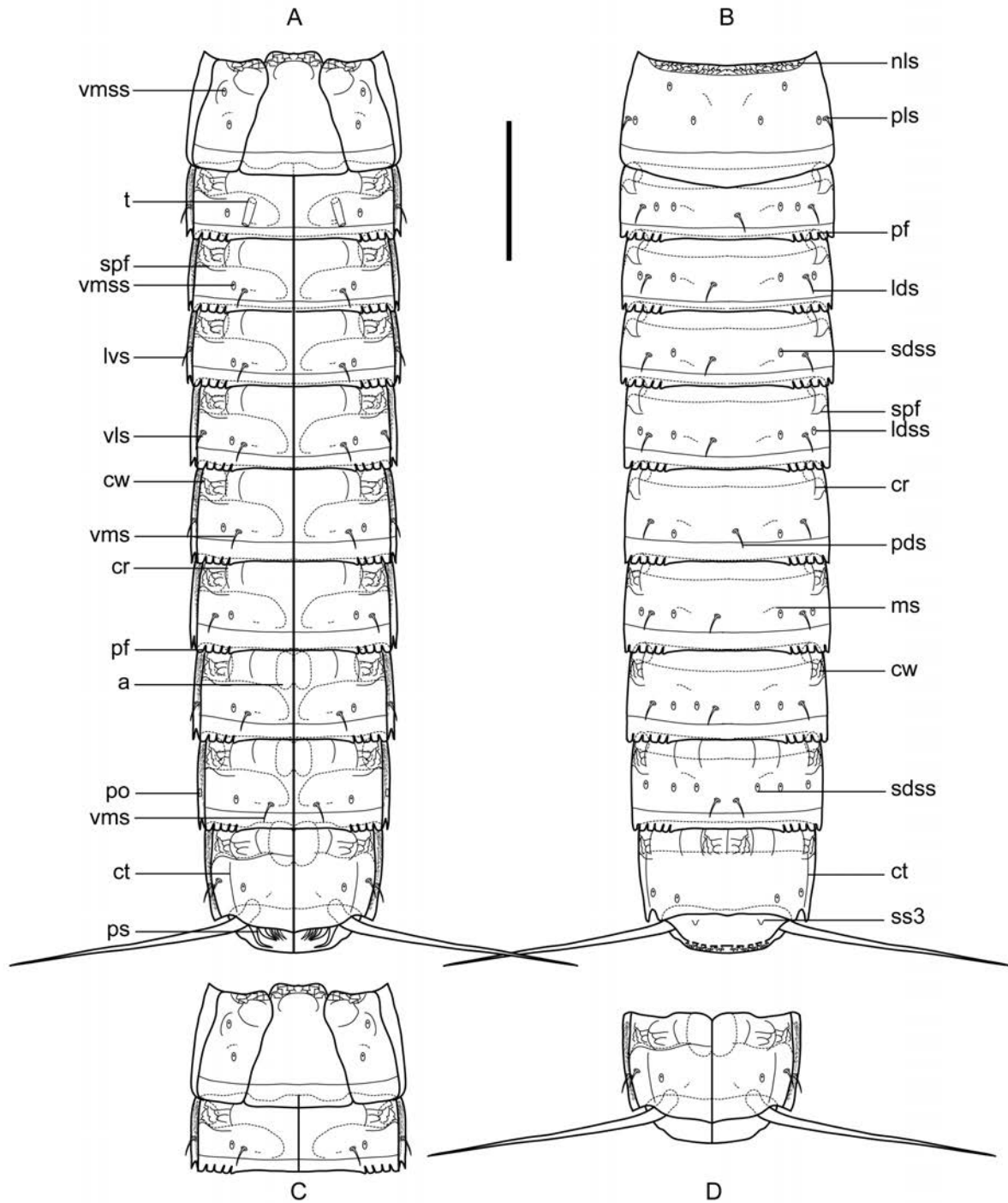


FIG. 2. – Line art illustrations of *Pyncophyes pardosi* n. sp. A, male, ventral view; B, male, dorsal view; C, female, segments 1-2, ventral view; D, female, segments 10-11, ventral view. Scale bar: 100 μ m; *a* apodeme, *cr* cuticular ridge, *ct* cuticular thickening, *cw* cuticular wrinkles, *lds* laterodorsal seta, *ldss* laterodorsal sensory spot, *lvs* lateroventral seta, *ms* muscular scar, *nls* net-like structure, *pds* paradorsal seta, *pf* pectinate fringe, *pls* paralateral seta, *po* protonephridial opening, *ps* penile spine, *sdss* subdorsal sensory spot, *spf* secondary pectinate fringe, *ss3* sensory spot type 3, *t* tube, *vls* ventrolateral seta, *vms* ventromedial seta, *vmss* ventromedial sensory spot.

One pair of ventromedial cuticular ridges on segment 2 and two pairs on segments 3-10 (Fig. 3A). Pachy-cycli of tergal and sternal plates as well as peg and socket joints well developed from segments 2 to 8, and less conspicuous on segment 9-10 (Fig. 4A-B). Ter-

gosternal junction on segments 2-10 covered by short cuticular hairs (Fig. 3K).

Segment 1: Anterolateral margins of tergal plate project into horn-like extensions. Tergal anterior margin of the segment strongly denticulated, followed by a

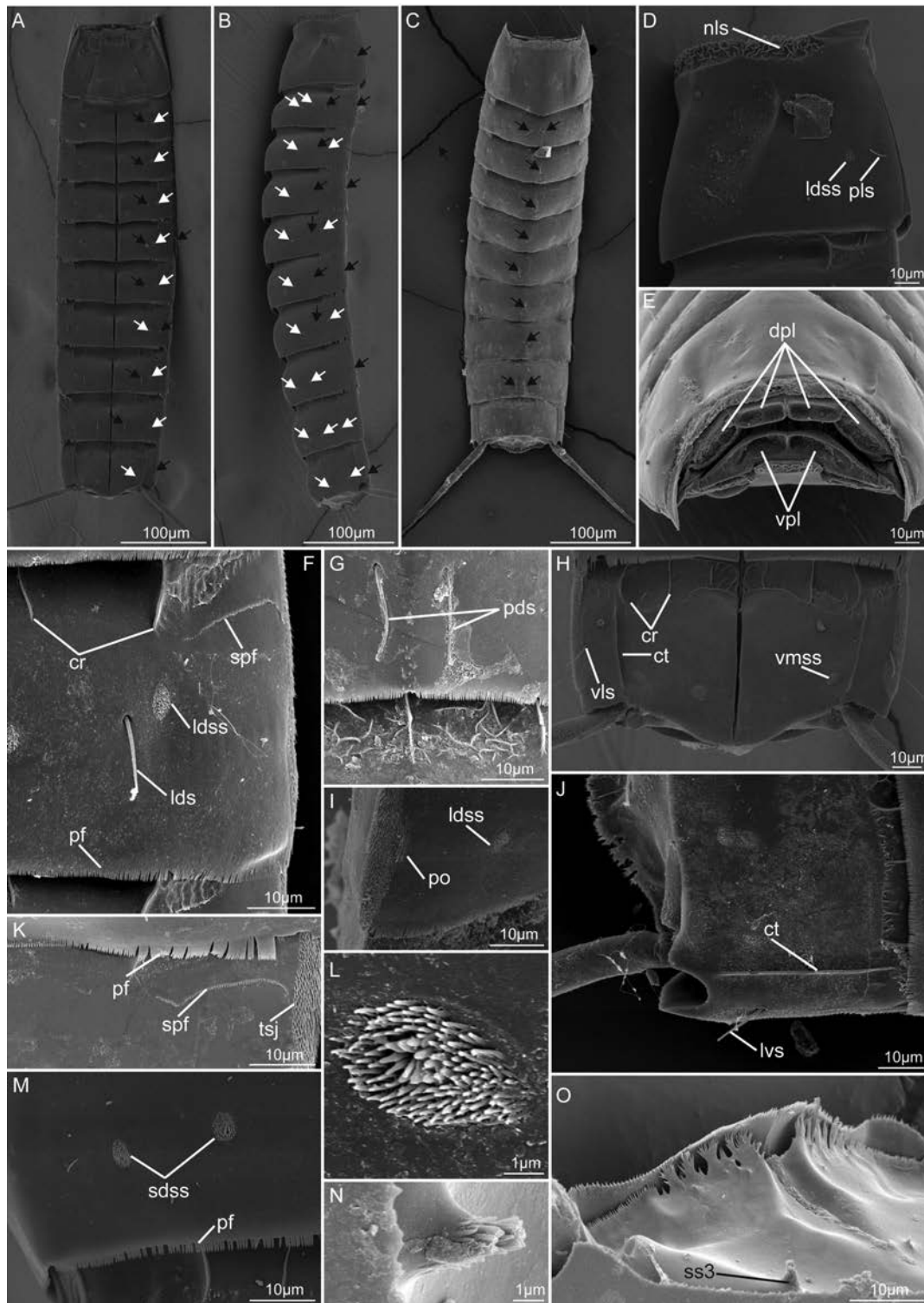


FIG. 3. – *Pycnophyes pardosi* n. sp. SEM photographs. A, female, ventral view; B, female, lateral view; C, male, dorsal view; D, female, lateral view of segment 1; E, male, anterior view of segment 1, dorsal and ventral placids; F, female, dorsal view of right half of segment 3; G, male, dorsal view of paradorsal regions of segment 9; H, female, ventral view of segment 10; I, female, dorsolateral view of segment 9; J, female, dorsal view of right half of segment 10; K, male, detail in anterior laterodorsal position on segment 3; L, female, subdorsal sensory spot of segment 4; M, female, dorsal view of left half of segment 8; N, male, sensory spot type 3 of segment 11; O, male, dorsal view of segment 11, showing the special shape of the posterior fringe; *cr* cuticular ridge, *ct* cuticular thickening, *dpl* dorsal placid, *lds* laterodorsal seta, *ldss* laterodorsal sensory spot, *lvs* lateroventral seta, *nls* net-like structure, *pds* paradorsal seta, *pf* pectinate fringe, *pls* paralateral seta, *po* protonephridial opening, *sdss* subdorsal sensory spot, *spf* secondary pectinate fringe, *ss3* sensory spot type 3, *tsj* tergosternal junction, *vls* ventrolateral seta, *vmss* ventromedial sensory spot, *vpl* ventral placid. Sensory spots are marked with white arrows and setae with black arrows A-C.

TABLE 1. – Measurements (μm) of adult *Pycnophyes pardosi* n. sp.; lts, lateral terminal spine; msw-6, maximum standard width of segment 6; n, number of measured specimens; SD, standard deviation; sw, standard width; s1-s11, segment lengths of trunk segments 1-11; TL, trunk length.

Character	n		Length allotype	Range	Average	SD
	♀	♂				
TL	1	4	676.7	604-667	633.3	29.8
sw10	1	4	121.3	117-131	125.9	5.8
sw/TL	1	4	0.18	0.19-0.20%	0.2%	0.004
msw-6	1	4	146.4	134-151	141.1	6.9
msw/TL	1	4	0.22	0.22-0.23%	0.22%	0.005
lts/TL	1	4	-	0.25-0.27%	0.26%	0.007
s1	1	4	99.4	79-100	89.0	7.8
s2	1	4	64.5	62-64	63.8	0.9
s3	1	4	62.5	61-62	62.8	2.0
s4	1	4	68.9	64-77	68.5	5.0
s5	1	4	66.9	65-77	69.0	5.5
s6	1	4	75.8	66-78	70.9	4.3
s7	1	4	73.9	67-78	71.5	4.2
s8	1	4	78.8	65-74	70.6	3.4
s9	1	4	81.7	65-80	71.8	6.5
s10	1	4	90.2	76-86	81.8	3.6
s11	-	-	-	-	-	-
lts11	-	2	-	152-174	164.2	16.8

characteristic cuticular ornamentation forming net-like structure (Fig. 3D). Posterior margin of dorsal plate slightly pointed middorsally, but without middorsal structure (middorsal process or elevation) or intracuticular atria (Fig. 3C). Tergal plate with one pair of muscular scars in the middle region, one pair of paralaral setae and three pairs of sensory spots, two pairs in subdorsal and one pair in laterodorsal positions, near the paralaral seta (Figs 2B, 3D). Sensory spots on this and all the following segments (except on segment 11) belong to type 1, are rounded to elongate and consist of several small cuticular papillae arranged around a collar of 8-10 wider papillae/petals with a cilium emerging through a central pore (similar to Fig. 3L). The sensory spots have one additional pore located outside the collar of papillae. Ventral side with two episternal plates and one trapezoidal midsternal plate, slightly longer than both episternal plates and hence overhanging the anterior edge of the segment (Fig. 4E). Episternal plates with a muscular scar in the middle region. Ventral anterior margin appears bulged and ornamented, followed by a contiguous depressed area. Each episternal plate with two ventromedial sensory spots. Pectinate fringe on both dorsal and ventral sides thin, but slightly more developed towards the lateral sides.

Segment 2: Tergal plate with a single paradorsal seta without associated middorsal structures (middorsal processes or elevations) or intracuticular atria (Fig. 2B). One specimen showed a pair of paradorsal setae (Fig. 3C), otherwise all other examined specimens showed only a single, unpaired seta in either left or right side paradorsal position. A pair of laterodorsal and lateroventral setae present. Two pairs of sensory spots, one subdorsal and one laterodorsal, present, the latter being close to the laterodorsal setae (Figs 3B, 4B). A pair of dorsoventral muscular scars appears on this and all the following segments until segment

TABLE 2. – Summary of location of setae and sensory spots in *Pycnophyes pardosi* n. sp. arranged by series. F, female condition of sexually dimorphic character; LD, laterodorsal; lts, lateral terminal spines; LV, lateroventral; m, male condition of sexually dimorphic character; ps, penile spines; PD, paradorsal; PL paralaral; SD, subdorsal; se, setae; * marks that the seta is unpaired; ss, sensory spots; ss3, sensory spot type 3; t, tubes; VL, ventrolateral; VM, ventromedial.

Segment	PD	SD	LD	PL	LV	VL	VM
1		ss,ss	ss	se			ss,ss
2	se*	ss	ss,se		se		ss,se(f),t(m)
3	se*	ss	ss,se				ss,se
4	se*	ss	se		se		ss,se
5	se*	ss	ss,se			se	ss,se
6	se*	ss	se		se		ss,se
7	se*	ss	ss,se				se,ss
8	se*	ss,ss	se		se		ss,se
9	se	ss,ss	ss				ss,se
10		ss	ss		se	se	ss
11		ss3(m)			lts	ps(2,m)	

10. Dorsal side with short secondary pectinate fringes in the anterior part of the segment, present from the tergo-sternal junction to the laterodorsal longitudinal ridge (Fig. 3K). Sternal plates with one pair of ventromedial sensory spots. Males always with a pair of large tubes located in the ventromedial position (Fig. 2A) and females with a pair of ventromedial setae (Fig. 2C). Ventral side with secondary pectinate fringe similar to that on the dorsal side, from the tergo-sternal junction to the first ventromedial cuticular ridge. Cuticular wrinkles located in the anteriormost parts of the sternal plates, from the tergo-sternal junction to the cuticular ridge, anterior to secondary pectinate fringe (Fig. 2A). Hairy tergo-sternal junctions, with numerous short cuticular hairs present (Fig. 3K). Pectinate fringe on both dorsal and ventral sides most developed near the lateral margins (Fig. 3K). Glandular cell outlets present anterolaterally on tergal and sternal plates, anterior to the secondary pectinate fringes. Pachycycli of tergal and sternal plates well developed, with a regular size of peg and socket joints.

Segment 3: Tergal plate with a single paradorsal seta but without middorsal structures (middorsal processes or elevations) or intracuticular atria, one pair of laterodorsal setae, and one pair of subdorsal and laterodorsal sensory spots (Figs 3B-C, 4B). Laterodorsal sensory spots more lateral than laterodorsal setae (Fig. 3F). Lateroventral setae not present. Sternal plates with one pair of ventromedial setae and slightly more lateral sensory spots (Fig. 3A). Tergo-sternal junctions, pachycycli, peg and socket joints, muscular scars, glandular cell outlets, cuticular wrinkles, pectinate fringe and secondary pectinate fringes as on the preceding segment.

Segment 4: Tergal plate with a single paradorsal seta but without middorsal structures (middorsal processes or elevations) or intracuticular atria (Figs 2B, 4B). Additional setae include one pair in laterodorsal and in lateroventral positions. Paired sensory spots present in subdorsal positions (Figs 3B-C, 4B). Sternal plates same as on segment 3 (Figs 3A), and segment otherwise similar to segment 2.

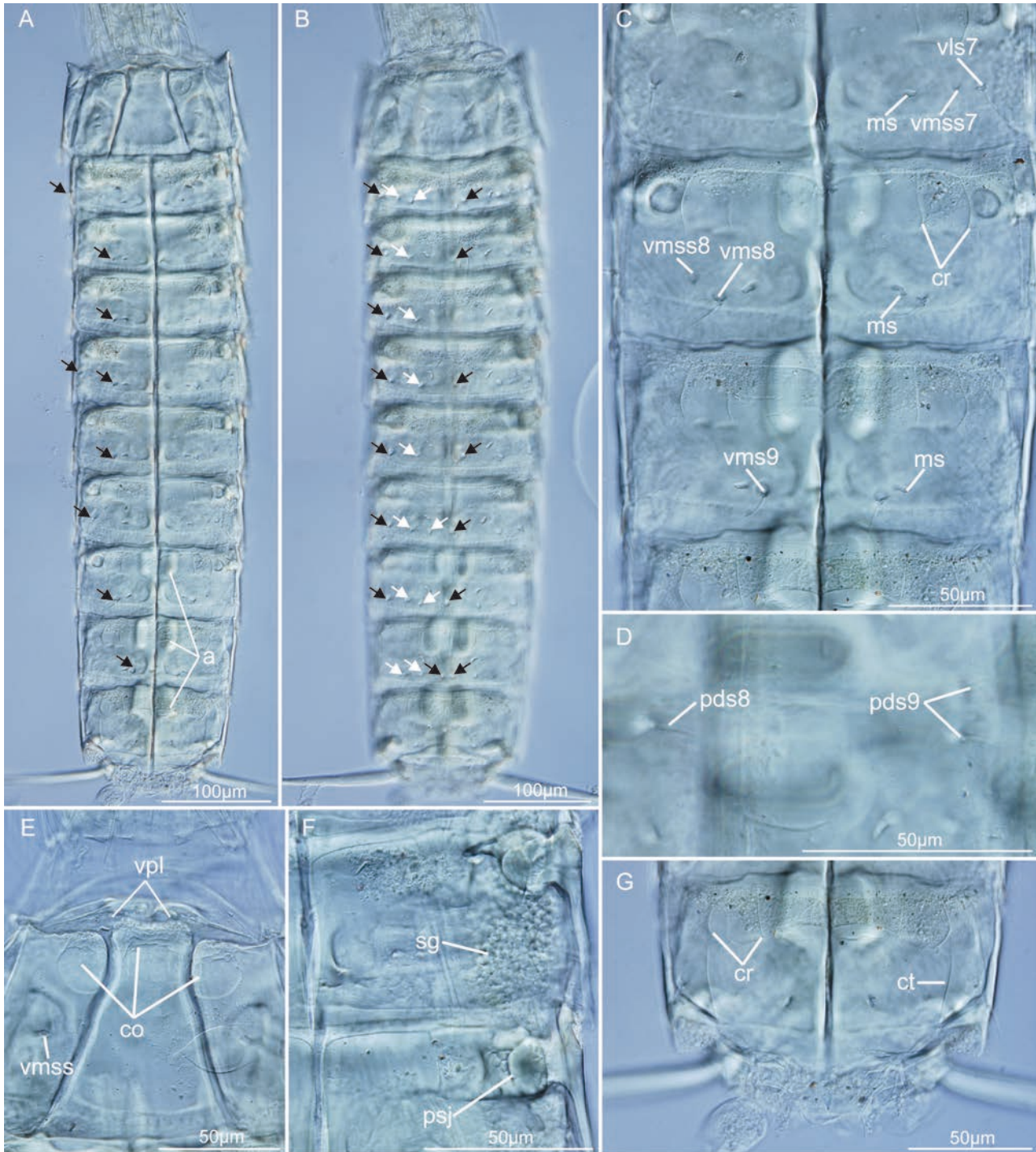


FIG. 4. – *Pycnophyes pardosi* n. sp. Differential interference contrast photographs of a male. A, ventral view; B, dorsal view; C, ventral view of segments 7-9; D, dorsal view of segments 8-9; E, ventral view of segment 1; F, ventral view of segments 3-4; G, ventral view of segment 10; *a* apodeme, *co* cuticular ornamentation, *cr* cuticular ridge, *ct* cuticular thickening, *ms* muscular scar, *pds* paradorsal seta, *psj* peg and socket joint, *sg* subcuticular gland, *vls* ventrolateral seta, *vms* ventromedial seta, *vmss* ventromedial sensory spot, *vpl* ventral placid. Sensory spots are marked with white arrows. Setae are marked with black arrows on A-B. Digits following labels refer to segment numbers.

Segment 5: Same as segment 3, but with a pair of ventrolateral setae (Figs 3A-B, 4A-B).

Segment 6: Same as segment 4 (Figs 3A-B, 4A-B).

Segment 7: Tergal plate similar to that on segment 3, but with cuticular wrinkles in the anteriormost region,

from the tergo-sternal junction to the cuticular ridge, anterior to the secondary pectinate fringe. Sternal plates with paired sensory spots and setae, but, unlike preceding segments, with the setae located more laterally (Figs 3A, 4A, C). Otherwise similar to preceding segments.

Segment 8: Tergal plate with a single paradorsal seta without associated middorsal structures (middorsal processes or elevations) or intracuticular atria (Figs 3C, 4D). Paired laterodorsal setae were observed in eight out of the ten specimens, whereas paired lateroventral setae were present in all. Two pairs of subdorsal sensory spots present (Figs 3M, 4B). Cuticular wrinkles as on segment 7. Sternal plates as those on segment 3 (Fig. 4C). Paired apodemes (or anteromesial thickenings of ventral pachycycli) near anterior margin of segment were observed in three males (Fig. 2A). Otherwise similar to preceding segments.

Segment 9: Tergal plate with one pair of paradorsal setae without middorsal structures (middorsal processes or elevations) or intracuticular atria (Figs 3C, G, 4D). Three pairs of sensory spots present, two in subdorsal and one in laterodorsal positions (Figs 3B, I, 4B). Cuticular wrinkles as on segment 7. Protonephridial opening in paralateral position, with the pore surrounded by a few short cuticular hairs; opening not sieve-like (Fig. 3I). Sternal plates with one pair of ventromedial sensory spots and setae, the latter located close to the limit of the paraventral position (Fig. 4C). Paired apodemes present near anterior margin of segment. Peg and socket joints inconspicuous. Otherwise similar to preceding segment.

Segment 10: Tergal plate with one pair of lateroventral setae and pairs of subdorsal and laterodorsal sensory spots near the posterior segment margin (Fig. 3B). Middorsal structure (middorsal process or elevation) or intracuticular atria absent. Cuticular wrinkles on the lateral margins as on segment 7, but also present in the subdorsal region (Fig. 2B). Lateral margins, furthermore, with longitudinal cuticular thickening visible with DIC and SEM (Fig. 3J). Sternal plates also with somewhat similar cuticular thickenings near their lateral margins (Figs 3H, 4G). Ventrolateral setae and ventromedial sensory spots present near the longitudinal hardening (Fig. 3H). A pair of apodemes present near the anterior margin. Peg and socket joints inconspicuous. Otherwise similar to preceding segments.

Segment 11: With paired lateral terminal spines (Figs 2A-B, D, 3C). Males with two pairs of penile spines and genital pores surrounded by a tuft of long hairs (Fig. 2A). Tergal plate with paired type 3 sensory spots, present in males only (Fig. 3N-O). Posterior segment margin with characteristic, irregularly fringed shape (see Fig. 3O).

Associated kinorhynch fauna. *Pycnophyes pardosi* n. sp. co-occurs with *Echinoderes tchefouensis* Lou, 1934 and other indetermined *Echinoderes* spp. at all four localities. Undetermined species of *Condyloderes* sp. were furthermore recorded from three localities, MAP25, 27 and 29. At localities MAP28 and 29 it also co-occurs with *E. microaperturus* Sørensen *et al.*, 2012 and *Meristoderes elleae* Sørensen *et al.*, in press, and at MAP25 with *Dracoderes abei* (see also Sørensen *et al.* 2012a, 2012b, in press).

Remarks. *Pycnophyes pardosi* n. sp. is easily distinguished from the only four species of the genus known from the region, *P. furugelmi*, *P. oshoroensis*, *P. schornikovi*, and *P. tubuliferus* (see Adrianov 1989, Adrianov and Malakhov 1999, Yamasaki *et al.* 2012), as none of them have paradorsal setae on all segments from 2 to 9.

Several other species, though, share the presence of paradorsal or middorsal setae on segments 2-9 with *Pycnophyes pardosi* n. sp. These include *P. australensis* Lemburg, 2002; *P. carinatus* Zelinka, 1928; *P. corrugatus* Higgins, 1983; *P. dentatus* Zelinka, 1928; *P. egyptensis* Higgins, 1966; *P. faveolus* Brown, 1999 (in Adrianov and Malakhov 1999); *P. flaveolatus* Zelinka, 1928; *P. kielensis* Zelinka, 1928; *P. newguiniensis* Adrianov, 1999; *P. parasanjuanensis* Adrianov and Higgins, 1996; *P. robustus* Zelinka, 1928 and *P. sanjuanensis* Higgins, 1961 (see Zelinka 1928, Higgins 1961, 1966, Brown 1985, Adrianov and Higgins 1996, Adrianov and Malakhov 1999, Lemburg 2002). However, whereas the presence of paradorsal setae is rather common, only six of these species have at least one segment with paired paradorsal setae. These species are *P. carinatus*, *P. faveolus*, *P. kielensis*, *P. newguiniensis*, *P. parasanjuanensis* and *P. robustus* (see Zelinka 1928, Brown 1985, Adrianov and Higgins 1996, Adrianov and Malakhov 1999). The new species can be distinguished from *P. carinatus*, *P. faveolus* and *P. newguiniensis* by its absence of middorsal or paradorsal setae on segment 1. Furthermore, *P. carinatus* has pairs of paradorsal setae on segment 1 (Zelinka 1928), *P. faveolus* on segments 3, 5 and 7-9 (Brown 1985), and *P. newguiniensis* on segments 2-9 (Adrianov and Malakhov 1999). The remaining three species also have pairs of paradorsal setae on other segments than those found in *Pycnophyes pardosi* n. sp. *Pycnophyes kielensis* has a single paradorsal seta on segment 8 only (Zelinka 1928), *P. parasanjuanensis* has a pair of paradorsal seta on segment 6 (males with another pair on segment 2) (Adrianov and Higgins 1996) and *P. robustus* on segments 3, 5, 7 and 9 (Zelinka 1928). Moreover, these six species do not have longitudinal cuticular thickenings on the dorsal and ventral sides on segment 10.

Since many old, but also some more recent, descriptions of species do not pay enough attention to the sensory spot distribution, it is not always helpful to use these for comparison of species. Of the species discussed above, only the description of *P. faveolus* provides accurate information on sensory spot distribution (Brown 1985).

The presence of cuticular ornamentation as a net-like structure on the dorsal anterior margin of segment 1, as present in the new species, is shared with *P. dentatus*, *P. lageria* Sánchez *et al.*, 2013; *P. faveolus*, *P. furugelmi*, *P. oshoroensis*, *P. parasanjuanensis* and *P. sanjuanensis* (see Zelinka 1928, Higgins 1961, Brown 1985, Adrianov and Higgins 1996, Adrianov and Malakhov 1999, Yamasaki *et al.* 2012, Sánchez

et al. 2013). Out of these, only *P. dentatus* and *P. lageria* also present cuticular ornamentation on the lateral margins of segment 10 (see Zelinka 1928, Sánchez *et al.* 2013). However, *Pycnophyes pardosi* n. sp. has a pair of longitudinal cuticular thickenings on segment 10, whereas *P. dentatus* (Zelinka 1928) has a higher number of longitudinal thickenings or vertical cuticular striations on this segment, and *P. lageria* has circular depressions on the same segment (Sánchez *et al.* 2013).

***Pycnophyes chalgap* n. sp.**
(Figs 5-8)

Type material: Holotype, adult male, collected on 26 May 2008, at the Korean south coast, near Yeosu, locality MAP13 (Fig. 1B) 34°42'17"N, 127°43'01"E, from mud at 4 m depth; mounted in Fluoromount G[®], deposited at the NHMD, under accession number ZMUC KIN-642. No females were available, hence no allotype is appointed. Paratypes, two adult males; one collected on same date and locality as holotype and one also on 26 May 2008 at a nearby locality, MAP15 (Fig. 1B) 34°34'43"N, 127°45'52"E, from mud with shell gravel at 13 m depth. Paratypes are mounted in Fluoromount G[®] and deposited at the NHMD under accession numbers ZMUC KIN-643 and KIN-644, respectively. Two additional male specimens mounted for SEM, one collected at locality MAP13 together with the holotype and one from MAP15, together with the paratype. Both specimens are stored in the last author's collection and will later be included in the NHMD general collection.

Diagnosis. *Pycnophyes* with the posterior margin of the midsternal plate rounded and longer than both episternal plates, extending beyond the anterior half of the following segment. Ventral anterior margin of segment 1 bulged and ornamented. Tergal anterior margin of segment 1 with fine denticulation and with a contiguous ornamented semicircular area. Middorsal bulge present on segments 2-4, whereas no middorsal processes or elevations are present on the remaining segments. Intracuticular atria visible with DIC on segments 2-9. Single paradorsal setae present on segments 2, 4, 6 and 8. Type 1 sensory spots present on segments 1-10, and type 3 sensory spots on segment 11 but in males only.

Etymology. The species name, *chalgap*, refers to a unit in the traditional Korean warrior armor that is used to protect the neck and throat. The name is inspired by the shape of the extended midsternal plate on segment 1.

Description. Mouth cone cylindrical and smooth, without any conspicuous cuticular features. Nine equally sized outer oral styles present, being thin, long, flexible and unarticulated, located one by each introvert sector except for the absence of an oral style in the middorsal sector 6 (Fig. 6).

The introvert has six rings of spinoscalids and one additional ring of trichoscalids (Figs 6, 7K). Ring 01 has ten primary spinoscalids consisting of two pieces: a short basal sheath and a long distal end. The basal piece of each primary spinoscalid is equipped with a row of

long fringes, longer in the middle region of the spinoscalid than on the lateral margins. Ring 02 is formed by ten spinoscalids, all consisting of a long end piece and a basal sheath. The basal sheath of each spinoscalid appears hairy at its proximal end and terminates into a short fringe. Ring 03 with 20 spinoscalids, two in each introvert sector, all resembling those of ring 02 (Fig. 6). Ring 04 is formed by only five spinoscalids, one in each odd numbered sector, and similar to those of the preceding rings but with a long fringe at the base. Ring 05 with 15 spinoscalids, one in each even numbered sector and two in odd numbered ones, and ring 06 with 13 spinoscalids, one in even numbered sectors and two in odd numbered ones except sector 6, where ring 06 spinoscalids are missing. Spinoscalids of rings 05 and 06 resemble those of ring 04. Ring 07 has 14 trichoscalids attached directly to the introvert, not through trichoscalid plates. All trichoscalids with a wide and hairy base and a narrower terminal tip.

Described by sector (Fig. 6), the spinoscalids are arranged in two groups, each one composed of a central scalid anterior to a pair scalids. The anterior and posterior scalid triplet is separated by ring 04, which has no scalids in even numbered sectors. Even sectors have six spinoscalids and one trichoscalid. The middorsal sector 6 has only the anterior scalid triplet and a single, central posterior scalid. Odd numbered sectors have seven spinoscalids and two trichoscalids, except sector 1 with only one trichoscalid. Scalids are arranged as a "double diamond" in each sector. See Figure 6 for a complete summary of oral styles and scalid and placid locations.

Neck with four dorsal and two ventral placids, all robust and hardly sclerotized. Dorsal placids are rectangular, whereas ventral placids have a more rounded appearance (Fig. 5A-B). All placids articulate with the first trunk segment and extend anteriorly along the thin and flexible cuticle of the introvert. Cuticular folds are present between the dorsal and ventral placids.

Trunk composed of 11 segments, with first segment composed of one tergal and three ventral plates (Figs 5A-B, 7A-B, D, 8A-C). Segments 2-11 with one tergal and two sternal plates. All dimensions and measures are summarized in Table 3, and distribution of sensory spots and setae in Table 4. The segment width is nearly constant throughout the trunk. Maximum sternal width is reached on segment 3 and the segments taper slightly from this segment. Most segment surfaces are covered by cuticular hairs and the tergo-sternal junctions on segments 2-10 appear hairy. Bulging middorsal region present on segments 2-4 (Figs 5B, 7B-C, 8D, G). Anteriormost region of both dorsal and ventral sides with a cuticular ornamentation on segments 2-10, more developed on segments 8-10. One pair of laterodorsal cuticular ridges on segments 2-6, ventromedial ones on segments 2-7 and two pairs on segments 8-10 (Fig. 5A-B). Subdorsal and ventromedial muscular scars present on each segment (Fig. 5A-B). One pair of apodemes near anterior margin on segments 5-10 (Fig. 8A).

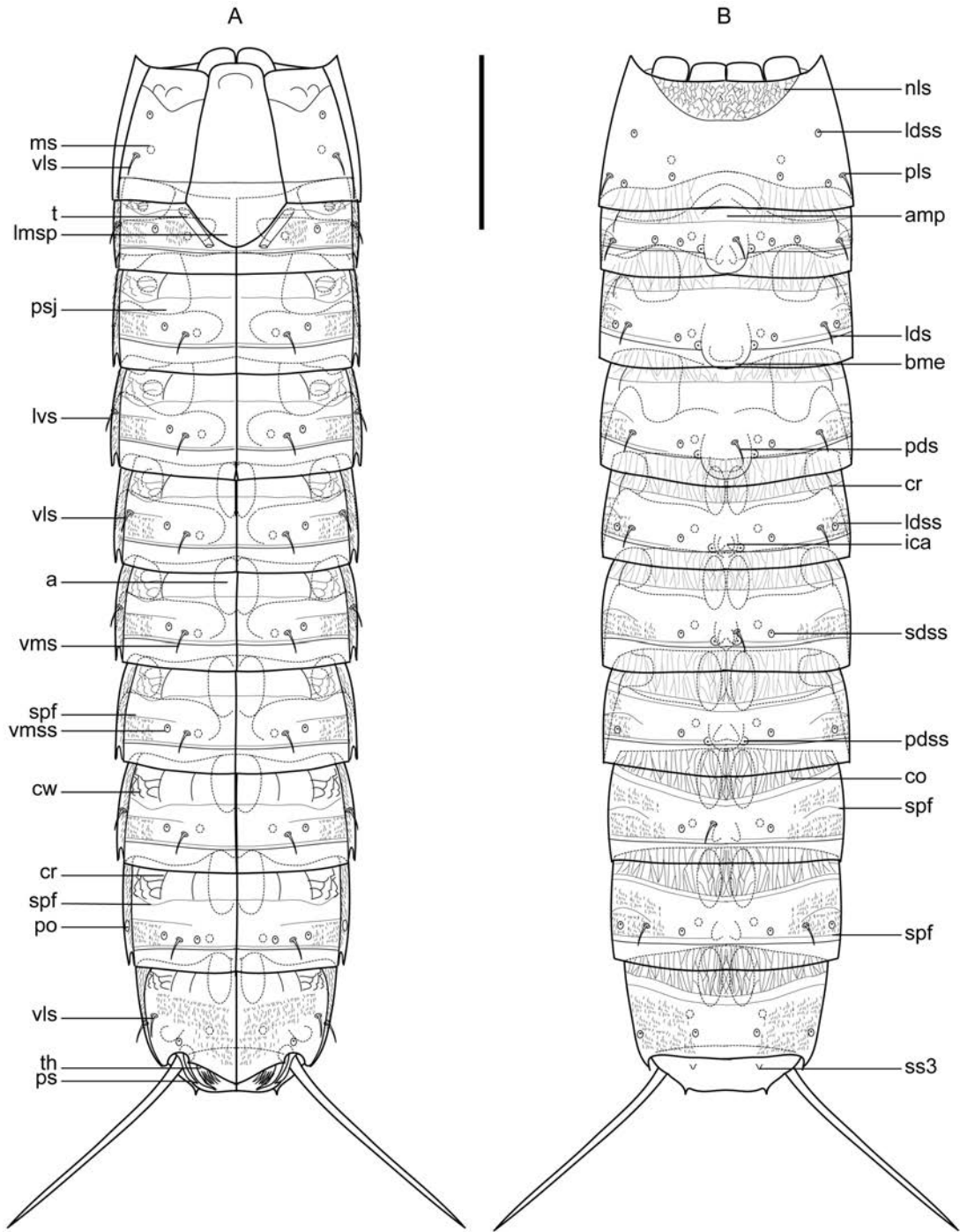
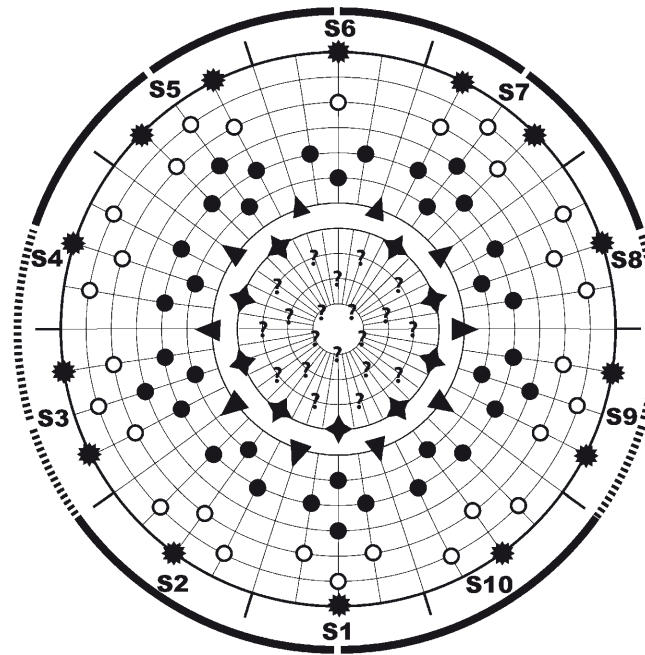


FIG. 5. – Line art illustrations of *Pycnophyes chalgap* n. sp. A, male, ventral view; B, male, dorsal view. Scale bar: 100 μ m; *a* apodeme, *amp* anterior middorsal projection, *bme* bulge middorsal elevation, *co* cuticular ornamentation, *cr* cuticular ridge, *cw* cuticular wrinkles, *ica* intracuticular atria of sensory spot, *lds* laterodorsal seta, *ldss* laterodorsal sensory spot, *lmsp* long midsternal plate, *lvs* lateroventral seta, *ms* muscular scar, *nls* net-like structure, *pds* paradorsal seta, *pdss* paradorsal sensory spot, *pls* paralateral seta, *po* protonephridial opening, *ps* penile spine, *psj* peg and socket joint, *sdss* subdorsal sensory spot, *spf* secondary pectinate fringe, *ss3* sensory spot type 3, *t* tube, *th* tuft of hairs, *vls* ventrolateral seta, *vms* ventromedial seta, *vmss* ventromedial sensory spot.

Pachycycli of tergal and sternal plates from segments 2-7 well developed, regular sized peg and socket joints present on segments 2 and 5-7 and more developed ones on segments 3-4. Pachycycli on the remaining segments not visible (Figs 5, 8A).

Segment 1: Anterolateral margins of tergal plate slightly projecting into horn-like extensions. Characteristic semicircular cuticular ornamentation appears as net-like structure on anterior fourth of tergal plate (Figs 5B, 8D). Middorsal structures (middorsal process



Scalid and style arrangement

Ring/Sector	1	2	3	4	5	6	7	8	9	10	Total
00 oos →	1	1	1	1	1	0	1	1	1	1	9
01 ▼	1	1	1	1	1	1	1	1	1	1	10
02 ●	1	1	1	1	1	1	1	1	1	1	10
03 ●	2	2	2	2	2	2	2	2	2	2	20
04 ●	1	0	1	0	1	0	1	0	1	0	5
05 ○	2	1	2	1	2	1	2	1	2	1	15
06 ○	1	2	1	2	1	0	1	2	1	2	13
07 tr ★	1	1	2	1	2	1	2	1	2	1	14
Total scalids	8	7	9	7	9	5	9	7	9	7	87

FIG. 6. – Diagram of mouth cone, introvert and placids in *Pycnophyes chalgap* n. sp. with the distribution and type of scalids by ring and sector. Dashed lines mark flexible cuticular lateral areas. “Double diamonds” are marked in the table with double lines; oos outer oral style, tr trichoscalid, s1-s10 sector number.

or middorsal elevation) or intracuticular atria not present. Tergal plate with one pair of subdorsal muscular scars in the middle region of the segment, one pair of paralateral setae and three pairs of sensory spots, one in subdorsal and two in laterodorsal positions, the latter near the paralateral seta (Figs 5B, 7B). Sensory spots on this and all following nine segments belong to type 1, being rounded to elongate and consisting of many small cuticular papillae surrounding a pore. Ventral side with two episternal plates and one midsternal plate. Midsternal plate with rounded, posterior extension that projects beyond the margin of the episternal plates and overlaps the anterior half of the following segment (Figs 7A, D, F, 8C). Muscular scar present in the middle region of the episternal plates. Anterior margin of ventral side bulged and ornamented, with a more posterior contiguous depressed area (Figs 7D, 8C). Each episternal plate with one ventrolateral seta and one ventromedial sensory spot (Figs 7D, 8A, C). Pectinate fringes serrated, only visible with SEM.

Segment 2: Tergal plate with a single paradorsal seta, one pair of laterodorsal and lateroventral setae and

one pair of paradorsal sensory spots associated with intracuticular atria (Figs 5B, 8B). This pair of sensory spots appears closer to the middle region of the segment than to the posterior margin. Two additional pairs of sensory spots present in subdorsal positions (Fig. 8B). Blunt anterior middorsal projection present. Middorsal region from this segment to segment 4 appears very high or bulging, hump-like (Figs 7B, 8D). Three secondary pectinate fringes present parallel to the anterior margin of the segment (Fig. 5B). The anteriormost fringe stretches over the tergal plate, whereas the second one extends from the lateral margins to the laterodorsal setae, where it is V-shaped and covers the insertion of the seta (similar to Fig. 7E). The posteriormost fringe extends from the lateral margins to the subdorsal position. Short cuticular hairs, not arranged in any particular pattern, are present between these secondary fringes, from the lateral margins to the laterodorsal position. One pair of subdorsal muscular scars appears on this and all following segments (except on segment 11). Sternal plates with a pair of ventromedial sensory spots (Figs 5A, 7A, F). Males with a pair of large, ven-

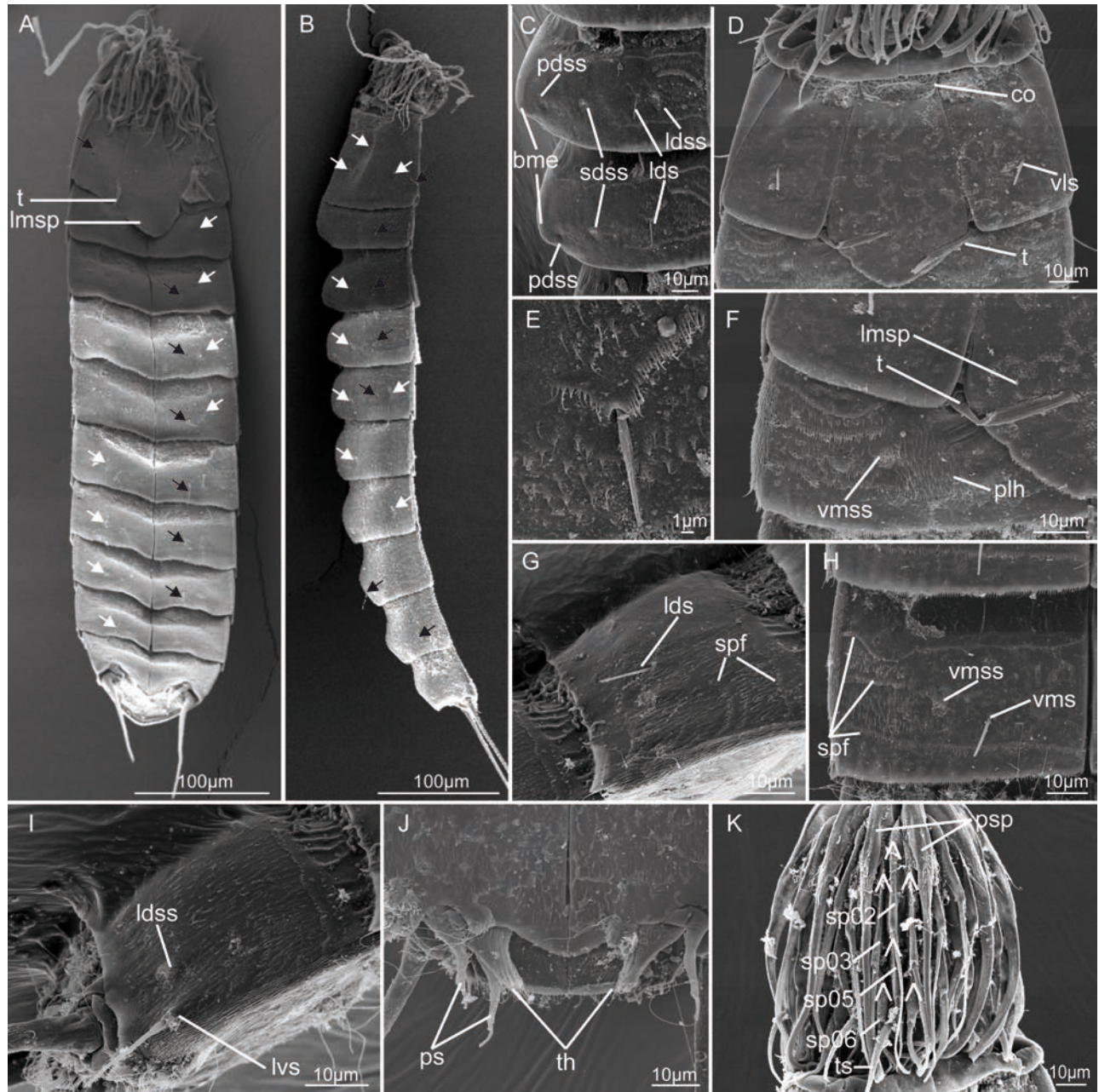


FIG. 7. – *Pyncophyes chalgap* n. sp. SEM photographs of male. A, ventral view; B, lateral view; C, dorsolateral view of segments 3-4; D, ventral view of segment 1; E, laterodorsal seta on segment 4; F, ventral view of segments 1-2; G, lateral view of segment 9; H, right sternal plate of segment 7; I, lateral view of segment 9; J, ventral view of segments 10-11; K, introvert sectors 1-2; *bme* bulge middorsal elevation, *co* cuticular ornamentation, *lds* laterodorsal seta, *ldss* laterodorsal sensory spot, *lmsp* long midsternal plate, *lvs* lateroventral seta, *pdss* paradorsal sensory spot, *plh* patch of long hairs, *ps* penile spine, *psp* primary spinoscalid, *sdss* subdorsal sensory spot, *sp* spinoscalid, *spf* secondary pectinate fringe, *t* tube, *th* tuft of hairs, *ts* trichoscalid, *vls* ventrolateral seta, *vms* ventromedial seta, *vmss* ventromedial sensory spot. Sensory spots are marked with white arrows and setae with black arrows on A-B. Digits following labels on K refer to the introvert ring numbers. Lambda symbols (Λ) mark attachment points of scalids.

tromedial tubes (Fig. 7F). Tergosternal junctions hairy. Three secondary pectinate fringes on the ventral side: two in the anterior region of the sternal plates from the tergosternal junctions to the ventromedial cuticular ridges, and the anteriormost stretching across the complete surface of the sternal plates (Fig. 5A). Patch of longer hairs located in ventromedial position and additional patches of short cuticular hairs present in

the ventrolateral region between the secondary fringes (Fig. 7F). Pectinate fringes slightly less developed in the dorsal and ventrolateral areas than in ventromedial and paraventral ones. Glandular cell outlets present on tergal and sternal plates, between anterolateral margin of the segment and the anteriormost secondary pectinate fringes. One pair of ventromedial muscular scars appears on this and all following segments. Pachycycli

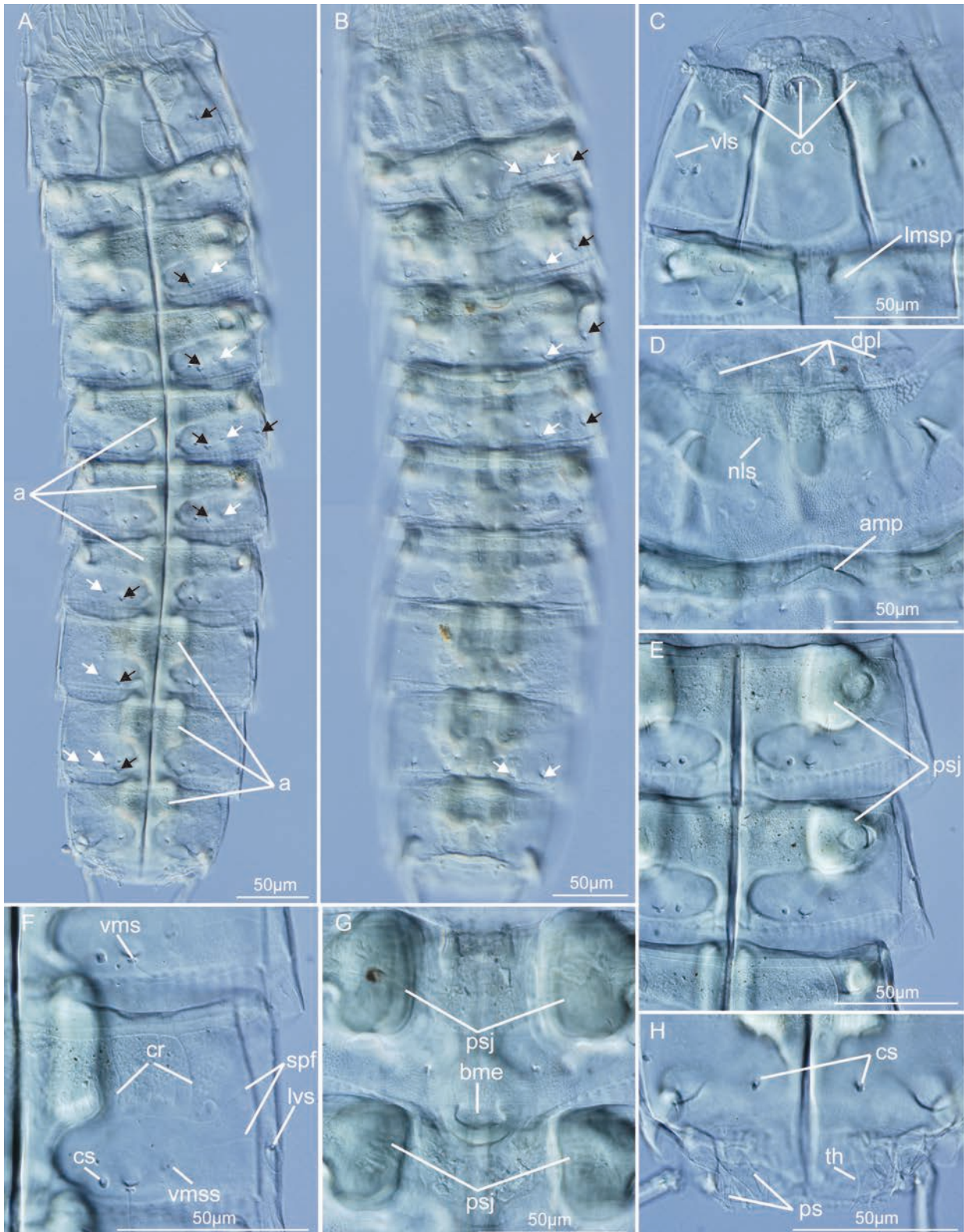


FIG. 8. – *Pycnophyes chalgap* n. sp. Differential interference contrast photographs of male. A, ventral view; B, dorsal view; C, central view segments 1-2; D, dorsal view of segments 3-4; E, ventral view of segments 3-4; F, right sternal plate of segment 8; G, dorsal view of segments 3-4; H, ventral view of segments 10-11; *a* apodeme, *amp* anterior middorsal projection, *bme* bulge middorsal elevation, *co* cuticular ornamentation, *cr* cuticular ridge, *cs* cuticular scar, *dpl* dorsal placid, *lmsp* long midsternal plate, *lvs* lateroventral seta, *nls* net-like structure, *ps* penile spine, *psj* peg and socket joint, *spf* secondary pectinate fringe, *th* tuft of hairs, *vls* ventrolateral seta, *vms* ventromedial seta, *vmss* ventromedial sensory spot. Sensory spots are marked with white arrows and setae with black arrows on A-B.

TABLE 3. – Measurements (μm) of adult *Pycnophyes chalgap* n. sp.; esp, episternal plate; lts, lateral terminal spine; msp, midsternal plate; msw-3, maximum standard width of segment 3; n, number of measured specimens; SD, standard deviation; sw, standard width; s1-s11, segment lengths of trunk segments 1-11; TL, trunk length.

Character	n ♂	Range ♂	Average ♂	SD ♂
TL	3	573-619	596.4	23.1
sw10	3	100-114	105.7	7.7
sw/TL	3	0.17-0.18%	0.18%	0.009
msw-3	3	129-151	138.1	11.8
msw/TL	3	0.22-0.24%	0.23%	0.01
lts/TL	1	0.27%	0.27%	-
esp/msp	3	0.73-0.75%	0.75%	0.02
msp	3	100-105	102.6	2.6
esp	3	76-77	76.7	0.5
s2	3	32-46	39.7	7.5
s3	3	64-70	66.4	3.4
s4	3	66-70	67.8	1.7
s5	3	61-73	65.8	6.3
s6	3	62-68	65.8	3.0
s7	3	62-67	64.9	2.9
s8	3	68-74	70.1	3.3
s9	3	65-70	67.3	2.9
s10	3	70-77	72.9	3.9
s11	3	-	-	-
lts11	1	165	165	-

of tergal and sternal plates well developed, with normal sized the peg and socket joints (Fig. 8A).

Segment 3: Tergal plate with hump-like middorsal region (Fig. 7B-C). One pair of paradorsal sensory spots associated with intracuticular atria. Paradorsal sensory spots located as on segment 2. Two additional pairs of sensory spots present in subdorsal and laterodorsal positions. One pair of laterodorsal setae located mesially to the laterodorsal sensory spots (Fig. 7C). Sternal plates with one pair of ventromedial setae and sensory spots, the latter located more laterally (Figs 7A, 8A). With ventrolateral cuticular hair patches. Dorsal and ventral sides with cuticular wrinkles on the anteriormost area on this and all following segments (except segment 11). Pachycycli and peg and socket joints much more developed than on preceding segment (Fig. 8A, E, G). Tergosternal junctions, glandular cell outlets, pectinate fringe and secondary fringes similar to those on preceding segment.

Segment 4: Tergal plate similar to that on segment 3 but without laterodorsal sensory spots, and with a single paradorsal seta and a pair of lateroventral setae (Figs 5B, 7B, 8B). Sternal plates, pachycycli, peg and socket joints, and other structures similar to those on segment 3 (Fig. 8A, E, G).

Segment 5: Tergal and sternal plate similar to those on segment 3, but without the middorsal bulge and with a pair of ventrolateral setae (Figs 7A-B, 8A-B). Pachycycli and peg and socket joints similar to those on segment 2. One pair of apodemes present near anterior margin of the segment (Figs 5A, 8A). Otherwise similar to preceding segments.

Segment 6: Tergal plate with a single paradorsal seta and one pair of paradorsal sensory spots associated with intracuticular atria (Figs 5B, 7B). Pairs of

TABLE 4. – Summary of location of setae and sensory spots in *Pycnophyes chalgap* n. sp. arranged by series. LD, laterodorsal; lts, lateral terminal spines; LV, lateroventral; m, character trait assumed to be male condition of sexually dimorphic character; ps, penile spines; PD, paradorsal; PL, paralateral; SD, subdorsal; se, setae; * marks that the seta is unpaired; ss, sensory spots; ss3, sensory spot type 3; t, tubes; VL, ventrolateral; VM, ventromedial.

Segment	PD	SD	LD	PL	LV	VL	VM
1		ss	ss,ss	se		se	ss
2	se*,ss	ss,ss	se		se		ss,t(m)
3	ss	ss	ss,se				ss,se
4	se*,ss	ss	se		se		ss,se
5	ss	ss	ss,se			se	ss,se
6	se*,ss	ss			se		ss,se
7	ss	ss	ss				ss,se
8	se*	ss			se		ss,se
9		ss	se,ss				ss,se,ss
10		ss	ss		se	se	ss
11		ss3(m)			lts	ps(2,m)	

subdorsal sensory spots and lateroventral setae present. Sternal plates similar to those on segment 3 with one pair of apodemes near anterior margin of the segment. Pachycycli and peg and socket joints similar to those on segment 2. Otherwise similar to preceding segments.

Segment 7: Tergal and sternal plates similar to those on segment 3 (Fig. 7H), except for the absence of laterodorsal setae and the middorsal bulge. One pair of apodemes present near anterior margin of segment. Pachycycli and peg and socket joints similar to those on segment 2. Otherwise similar on preceding segments.

Segment 8: Tergal plate similar to that on segment 6, but with the single paradorsal seta located on the opposite side and an apparent lack of paradorsal sensory spots (Fig. 5B). Lateroventral setae not present. One specimen with paired laterodorsal setae was observed. Sternal plates similar to those on segment 3, but with an additional pair of ventromedial cuticular ridges and some additional hairs that may appear in the ventromedial position (Fig. 8F). Dorsal and ventral sides with the cuticular ornamentation in the anteriormost area of the segment more developed than on preceding segments. Pachycycli and peg and socket joints are not visible (Fig. 8A, F). Otherwise similar to preceding segments.

Segment 9: Tergal plate similar to that on segment 5, except for the apparent lack of paradorsal sensory spots (Fig. 7G). Protonephridial opening paralaterally, not sieve-like, surrounded by several short hairs. Sternal plates similar to those on segment 8, but with an additional pair of ventromedial sensory spots (Fig. 8A). Cuticular ornamentation on dorsal and ventral sides as on segment 8. Pachycycli and peg and socket joints not visible. Otherwise similar to preceding segments.

Segment 10: Tergal plate with one pair of lateroventral setae and one pair of subdorsal and laterodorsal sensory spots (Fig. 7I). Middorsal structure (middorsal process or elevation) or intracuticular atria absent. Sternal plates with one pair of ventrolateral setae and one pair of ventromedial sensory spots close to the posterior margin of the segment. Cuticular hairs present throughout the surface of the segment (Fig. 7I-J). Cu-

ticular ornamentation on both dorsal and ventral sides as on segment 8. Pachycycli and peg and socket joints not visible. Otherwise similar to preceding segments.

Segment 11: With one pair of lateral terminal spines (Figs 5A-B, 7A-B). Tergal plate with two pairs of type 3 sensory spots in subdorsal positions (Fig. 5B). Cuticular hairs present throughout the surface of the segment. Males with two pairs of penile spines and two genital pores surrounded by a tuft of long hairs and one pair of cuticular extensions appearing somewhat horn-like (Figs 5A, 7J, 8H).

Associated kinorhynch fauna. *Pycnophyes chalgap* n. sp. lives in coastal waters at relatively shallow depths. Other species recorded from MAP13, the locality situated at 4 m depth, include *Kinorhynchus yushini* and *Meristoderes herranzae* Sørensen *et al.*, in press, whereas co-occurring species on the slightly deeper MAP15 locality include *Dracoderes abei*, *Echinoderes rex* Lundbye *et al.* 2011, *E. tchefouensis* and *K. yushini* (see Sørensen *et al.* 2012a, in press).

Remarks. *Pycnophyes chalgap* n. sp. is easily distinguished from the known species by the shape of its midsternal plate with the posterior margin being rounded and longer than both episternal plates, overlapping the anterior half of the following segment. This new species can also be recognized by its tergal anterior margin of segment 1 with a semicircular cuticular ornamentation as a net-like structure, apodemes on segments 5-10, peg and socket joints being more developed on segments 3-4 than on other segments, middorsal bulge on segments 2-4 and the presence of single paradorsal setae on segments 2, 4, 6 and 8. Only two other *Pycnophyes* species have paradorsal or middorsal setae on these particular segments: *P. rugosus* Zelinka, 1928 and *P. tubuliferus* (females on segment 2, 4, 6 and 8 and males on 6 and 8, see Adrianov 1989, Murakami *et al.* 2001). However, the first of these has a different distribution of lateroventral setae (segments 2-8 and 10) and number of apodemes (segments 9 and 10) (Zelinka 1928). The latter, *P. tubuliferus*, is one of three *Pycnophyes* species described from the area. *Pycnophyes chalgap* n. sp. and *P. tubuliferus* share several characters inclusive ventromedial sensory spot distribution, and distribution of setae in the lateroventral, ventrolateral and ventromedial positions (Adrianov 1989, Murakami *et al.* 2001). However, the two species can be differentiated by many other cuticular structures, including the long midsternal plate and other structures located on the dorsal side, such as the distribution of laterodorsal sensory spots and setae. *P. tubuliferus* has laterodorsal sensory spots on segments 3-9, whereas *Pycnophyes chalgap* n. sp. lacks them on segments 4, 6 and 8. *Pycnophyes chalgap* n. sp. has no laterodorsal setae on segment 6 while *P. tubuliferus* bears these (in fact the population of the Pacific coast of Japan has an additional pair of laterodorsal setae on this segment and in segments 2 and 4, see Murakami *et al.* 2001).

Regarding the presence of cuticular ornamentation as a net-like structure on the dorsal anterior margin of segment 1, it also appears in *P. dentatus*, *P. lageria*, *P. faveolus*, *P. furugelmi*, *P. oshoroensis*, *P. parasanjuanensis* and *P. sanjuanensis*. However none of them present the cuticular ornamentation with a semicircular profile: *P. lageria* has a profile that resembles candle wax drop (Sánchez *et al.* 2013), and *P. dentatus*, *P. faveolus*, *P. furugelmi*, *P. oshoroensis*, *P. parasanjuanensis* and *P. sanjuanensis* have a rectangular profile (see Zelinka 1928, Higgins 1961, Brown 1985, Adrianov and Higgins 1996, Adrianov and Malakhov 1999, Yamasaki *et al.* 2012).

***Pycnophyes cristatus* n. sp.**
(Figs 9-11)

Type material. Holotype, adult male, collected on 11 November 2011 in the East Sea, off Uljin, locality MAP37 (Fig. 1C) 37°01'26"N, 129°30'55"E, from mud at 160 m depth; mounted in Fluoromount G®, deposited at the NHMD, under accession number ZMUC KIN-645. No females were available, hence no allotype is appointed. Paratype, adult male mounted for SEM, collected on the same date and at the same locality as the holotype, deposited at the NHMD, under accession number ZMUC KIN-646.

Diagnosis. *Pycnophyes* with middorsal processes on segments 1-10 and intracuticular atria on segments 1-9, but without any adjacent paradorsal seta. Middorsal processes of equal lengths until segment 6, turning progressively longer from this segment and towards the posterior ones. Middorsal process on segment 10 conspicuously long, extending beyond posterior margin of segment 11. Laterodorsal and ventromedial setae present only on segments 7-9.

Etymology. The species name, *cristatus*, is feminine, derived from Latin *crista*, crest, and refers to the conspicuous middorsal processes on segments 1-10.

Description. Mouth cone (Fig. 10I) and scaldic arrangements by rings and sectors are apparently identical to the pattern described for *Pycnophyes chalgap* n. sp. (see Fig. 6). Only sector 6 could not be examined, so data from this sector are unavailable. The general scaldic morphology also resembles that of *P. chalgap* sp. nov., except for the spinoscalids of rings 02 to 06 in *P. cristatus* n. sp., which possess a conspicuous long fringe near their attachment points (Fig. 10K).

Neck with four dorsal and two ventral placids (Figs 9A-B, 11C-D). All placids appear robust and hardly sclerotized, with concave surfaces. Dorsal placids rectangular, but with the medial ones slightly wider and with a notch in their middle regions (Fig. 11C). Ventral placids rectangular, extending from the lateral margin of the episternal plate to the midventral line (Fig. 11D). All placids join the anterior edge of the first trunk segment and extend anteriorly along the thin and flexible cuticle of the introvert.

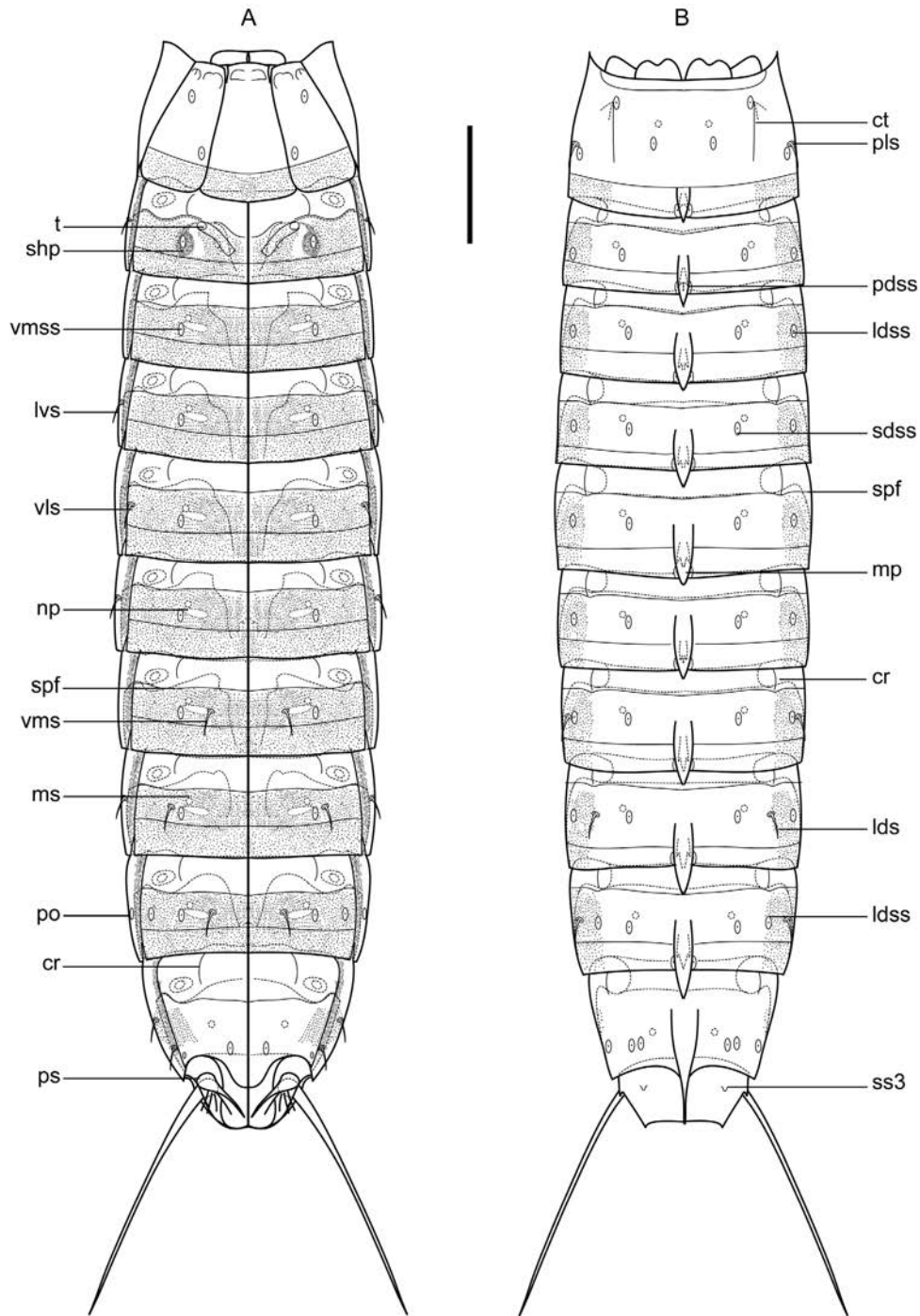


FIG. 9. – Line art illustrations of *Pycnophyes cristatus* n. sp. A, male, ventral view; B, male, dorsal view. Scale bar: 100 μ m; *cr* cuticular ridge, *ct* cuticular thickening, *lds* laterodorsal seta, *ldss* laterodorsal sensory spot, *lvs* lateroventral seta, *mp* middorsal process, *ms* muscular scar, *np* naked patch, *pdss* paradorsal sensory spot, *pls* paralateral seta, *po* protonephridial opening, *ps* penile spine, *sdss* subdorsal sensory spot, *shp* short hair patch, *spf* secondary pectinate fringe, *ss3* sensory spot type 3, *t* tube, *vls* ventrolateral seta, *vms* ventromedial seta, *vmss* ventromedial sensory spot.

Trunk with 11 segments (Figs 9A-B, 10A, 11A-B), with first segment composed of one tergal and three ventral plates (Fig. 11D). Segments 2-11 with one tergal and two ventral sternal plates. Dimensions and measurements of the examined specimens are summarized in Table 5 and distribution of sensory spots and

setae in Table 6. The segment width is nearly constant throughout the trunk, but reaches its maximum sternal width at segment 6 and tapers slightly from this segment. Segments 1 to 10 with middorsal processes, which always extend beyond the posterior margin of the segment (Figs 9B, 11B). These middorsal pro-

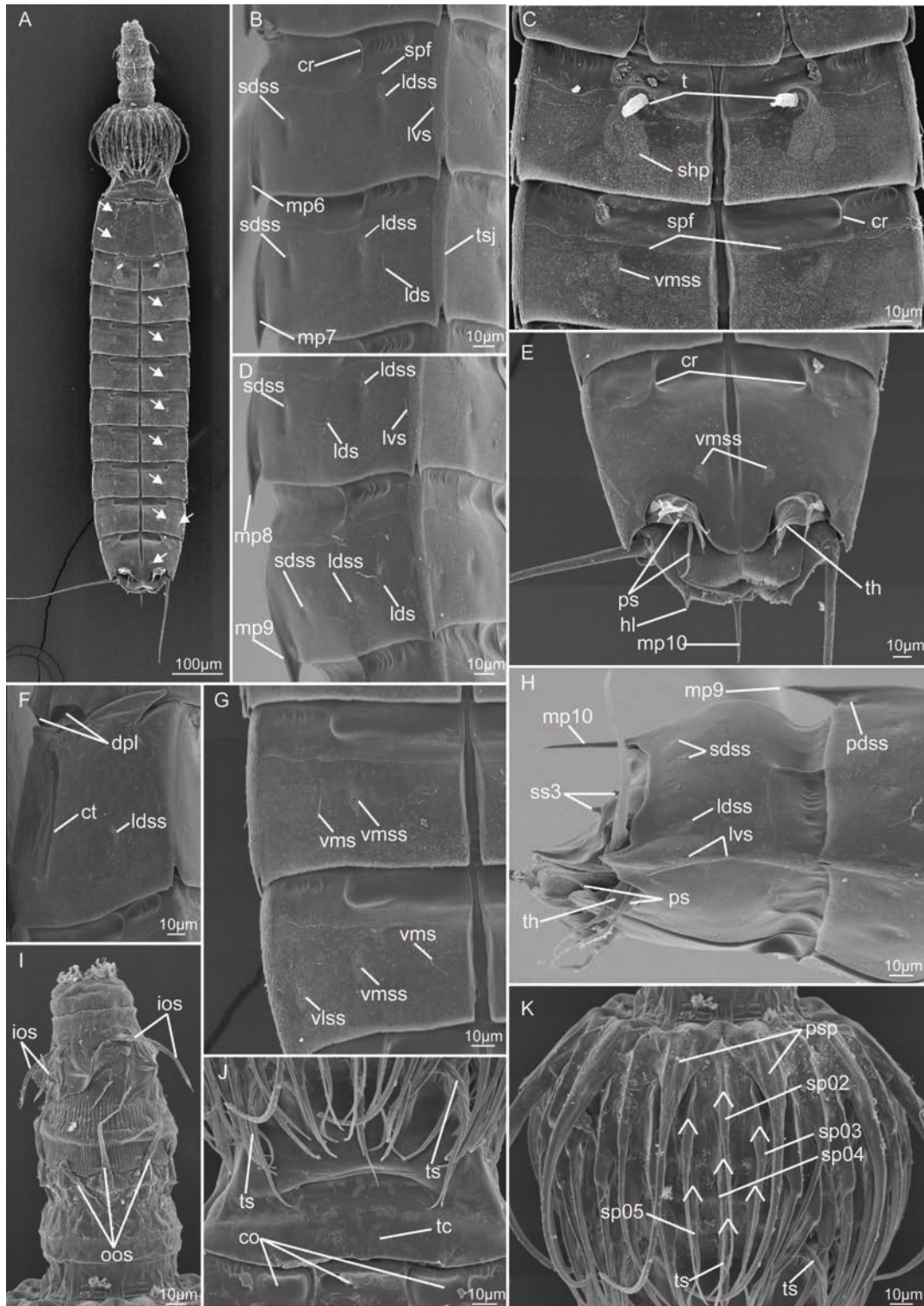


FIG. 10. – *Pycnophyes cristatus* n. sp. SEM photographs of male. A, ventral view; B, lateral view of segments 6-7; C, ventral view of segments 2-3; D, lateral view of segments 8-9; E, ventral view of segments 10-11; F, lateral view of segment 1; G, ventral view of segments 8-9; H, lateral view of segments 9-11; I, mouth cone; J, ventral view of segment 1 and the thin cuticle of the introvert; K, male, introvert sector 1; *co* cuticular ornamentation, *cr* cuticular ridge, *ct* cuticular thickening, *dpl* dorsal placid, *hl* horn-like extension, *ios* inner oral style, *lds* laterodorsal seta, *ldss* laterodorsal sensory spot, *lvs* lateroventral seta, *mp* middorsal process, *oos* outer oral style, *pdss* paradorsal sensory spot, *ps* penile spine, *psp* primary spinoscalid, *sdss* subdorsal sensory spot, *shp* short hairs patch, *sp* spinoscalid, *spf* secondary pectinate fringe, *ss3* sensory spine 3, *t* tube, *tc* thin cuticle of the introvert, *th* tuft of hairs, *ts* trichoscalid, *tsj* tergosternal junction, *vls* ventrolateral sensory spot, *vms* ventromedial seta, *vmss* ventromedial sensory spot. Sensory spots are marked with white arrows on A. Digits following labels refer to segment numbers except on K where they refer to the introvert ring numbers. Lambda symbols (Λ) mark attachment points of scalids.

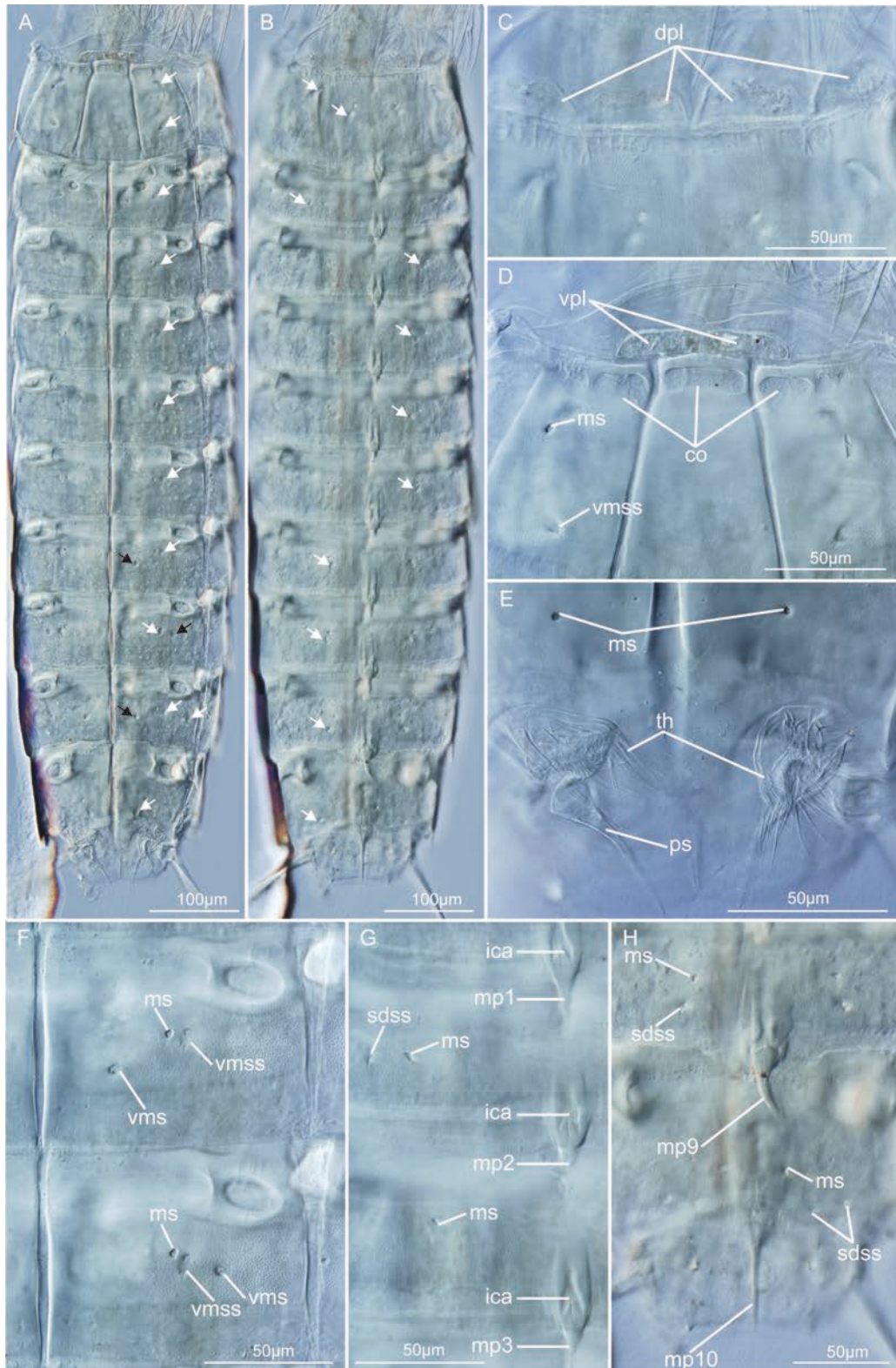


FIG. 11. – *Pyncophyes cristatus* n. sp. Differential interference contrast photographs of male. A, ventral view; B, dorsal view; C, dorsal view of neck and segment 1; D, ventral view of neck and segment 1; E, ventral view of segments 10-11; F, left sternal plates of segments 7-8; G, dorsal view of left half of segments 1-3; H, dorsal view of segments 9-11; *co* cuticular ornamentation, *dpl* dorsal placid, *ica* intracuticular atria of sensory spots, *mp* middorsal process, *ms* muscular scar, *ps* penile spine, *sdss* subdorsal sensory spot, *th* tuft of hairs, *vms* ventromedial seta, *vmss* ventromedial sensory spot, *vpl* ventral placid. Sensory spots are marked with white arrows. Setae are marked with black arrows. Digits following labels refer to segment numbers.

TABLE 5. – Measurements (μm) of male holotype of *Pycnophyes cristatus* n. sp.; lts, lateral terminal spine; mps9-mps10, middorsal process length of segments 9-10; msw-6, maximum standard width of segment 6; sw, standard width; s1-s11, segment lengths of trunk segments 1-11; TL, trunk length.

Character	Length
TL	923
sw10	172
sw/TL	0.13%
msw-6	203
msw/TL	0.22%
lts/TL	0.24%
mps9/s9	0.34%
mps10/s10	0.40%
s1	117
s2	80
s3	81
s4	86
s5	86
s6	90
s7	91
s8	92
s9	91
s10	125
s11	44
lts11	220
mps9	31.6
mps10	49.7

cesses have a similar length until segment 6 and turn progressively longer from this point and towards the posterior segments, reaching the maximum size on segment 10 (Figs 10E, H, 11H). In addition, all segments with a pair of dorsoventral muscular scars and two pairs of cuticular ridges, one laterodorsal and one ventromedial (Fig. 9A-B). Apodemes not present. Peg and socket joints and pachycycli well developed and of similar sizes on segments 2-10 (Figs 9, 11A). Hairy tergo-sternal junctions with several long hairs present on segments 2-10.

Segment 1: Anterolateral margins of tergal plate project into horn-like extensions. Tergal anterior edge of the segment smooth, followed by a narrow area of cuticular ornamentation. Longitudinal cuticular thickenings present in subdorsal area, posterior to sensory spots (Fig. 10F). Posterior margin of dorsal plate with a middorsal process that surpasses the posterior margin of the segment, and one pair of paradorsal sensory spots associated with the intracuticular atria (Fig. 11G). Furthermore, tergal plate with one pair of muscular scars in the middle region of the segment, one pair of paralateral setae and three additional pairs of sensory spots, two in subdorsal and one in laterodorsal position (Figs 9B, 10F). Sensory spots on this and all following segments are rounded to elongate and belong to type 1 (except on segment 11). Ventral side with two episternal plates and one trapezoidal midsternal plate. Ventral anterior margin ornamented, followed by a contiguous concave area (Figs 10J, 11D). Each episternal plates with a muscular scar near its anterior margin and with two ventromedial sensory spots, one located on the anterior third of the plate and one on the posterior third (Fig. 10A). Short cuticular hairs present only on the

TABLE 6. – Summary of location of setae and sensory spots in *Pycnophyes cristatus* n. sp. arranged by series. F, female condition of sexually dimorphic character; LD, laterodorsal; lts, lateral terminal spines; LV, lateroventral; m, male condition of sexually dimorphic character; ps, penile spines; PD, paradorsal; PL, paralateral; SD, subdorsal; se, setae; ss, sensory spots; ss3, sensory spot type 3; t, tubes; VL, ventrolateral; VM, ventromedial.

Segment	PD	SD	LD	PL	LV	VL	VM
1	ss	ss,ss	ss	se			ss,ss
2	ss	ss	ss		se		ss,t(m)
3	ss	ss	ss				ss
4	ss	ss	ss		se		ss
5	ss	ss	ss			se	ss
6	ss	ss	ss		se		ss
7	ss	ss	ss,se				se,ss
8	ss	ss	se,ss		se		ss,se
9	ss	ss	ss,se			ss	se,ss
10		ss,ss	ss		se,se	ss	ss
11		ss3(m)			lts	ps(2,m)	

posterior part, on both dorsal and ventral side. Pectinate fringes on dorsal and ventral sides inconspicuous, only visible with SEM.

Segment 2: Tergal plate with middorsal process, one pair of paradorsal sensory spots and associated intracuticular atria similar to those on segment 1 (Fig. 11G). Paired setae present in lateroventral positions, and sensory spots in subdorsal and laterodorsal positions. A pair of subdorsal muscular scars appears anterior to the subdorsal sensory spots on this and all following segments (Fig. 11G). One pair of laterodorsal cuticular ridges present. Sternal plates with one pair of ventromedial sensory spots and a pair of large ventromedial tubes located anterior to the sensory spots (Figs 10C, 11A). Cuticular ridges present in ventromedial positions. Short cuticular hairs present posterior to secondary pectinate fringe. Other kind of shorter cuticular hairs appear only on the sternal plates, forming a patch around the ventromedial sensory spots and the tubes. A mesial ventromedial smooth patch is located adjacent to this (Fig. 10C). Hairy tergo-sternal junctions with several long hairs present. Pectinate fringe on both dorsal and ventral sides similar to that on preceding segment. Secondary pectinate fringe on dorsal and ventral sides located in the anterior region of the segment, parallel to the anterior edge and surrounding the whole surface of the segment. Glandular cell outlets located anterolaterally on tergal and sternal plates, anterior to the secondary pectinate fringes. Pachycycli well developed, and peg and socket joints of normal size (Fig. 11A).

Segment 3: Tergal plate similar to that of segment 2, except for the absence of lateroventral setae (Fig. 11G). Sternal plates with one pair of ventromedial sensory spots. Cuticular hairs on sternal plates similar to those on the previous segment but without patches of shorter cuticular hairs. Paired smooth patches more elongate than those on segment 2. Other structures similar to those on preceding segment (Fig. 10C).

Segment 4: Tergal and sternal plates similar to those on segment 3, but with one pair of lateroventral setae.

Segment 5: Tergal and sternal plates similar to those

on segment 3, but with one pair of ventrolateral setae.

Segment 6: Tergal and sternal plates same as on segment 4 (Fig. 10B).

Segment 7: Tergal plate similar to that on segment 3, but with the middorsal process slightly more developed and with one pair of laterodorsal setae located lateral to the laterodorsal sensory spots (Fig. 10B). Sternal plates similar to those of segment 3, but also a pair of ventromedial setae, located close to the paraventral area (Fig. 11A, F). Otherwise similar to preceding segments.

Segment 8: Tergal plate similar to that of segment 4, but with the middorsal process more developed and with a pair of laterodorsal setae located mesial to the laterodorsal sensory spots (Fig. 10D). Sternal plates similar to those of segment 7, but with the ventromedial setae located more lateral than the sensory spots (Figs 10G, 11A, F). Otherwise similar to preceding segments.

Segment 9: Tergal plate with middorsal process more developed than on preceding segments (Figs 10H, 11H). Paradorsal sensory spots and their associated intracuticular atria similar to those on preceding segments. One pair of laterodorsal setae present in same position as the laterodorsal sensory spots on segment 8. Two pairs of sensory spots, one subdorsal and one laterodorsal, the latter in the same position as the laterodorsal setae on segment 8 (Fig. 10D). Protonephridial opening paraterally, not sieve-like, surrounded by several short hairs. Sternal plates with a pair of ventromedial setae close to the paraventral position margin, and two pairs of sensory spots, one ventromedial in the same position as on previous segment, and one in ventrolateral position (Fig. 10G). Otherwise similar to preceding segments.

Segment 10: Tergal plate with middorsal process much more developed than on the previous segment, extending to or beyond terminal end of trunk. Paradorsal sensory spots and intracuticular atria not present (Figs 10H, 11B, H). Two pairs of lateroventral setae present. Three pairs of sensory spots located near the posterior margin of the segment, two in subdorsal and one in laterodorsal position (Figs 10H, 11H). Sternal plates with one pair of ventromedial and ventrolateral sensory spots, the latter being conspicuously smaller than the first one (Fig. 10E). Posterior margins of sternal plates with deep notches over the male genital pores (Figs 10E, 11E). Otherwise similar to preceding segments.

Segment 11: Middorsal process absent. With a pair of lateral terminal spines (Fig. 9A-B), and males with two pairs of penile spines and one pair of genital pores surrounded by a tuft of long hairs (Figs 10E, H, 11E). Tergal plate with two pairs of subdorsal type 3 sensory spots and one pair of horn-like cuticular extensions (Fig. 10E, H). Cuticular hairs and pectinate fringe similar to those on preceding segments.

Associated kinorhynch fauna. *Pycnophyes cristatus* n. sp. was found at locality MAP37 – a locality from a

set of samples that are still under examination. Various still unidentified species of *Echinoderes* are present in the sample, together with a new of species of *Dracoderes* that is currently under description (pers. comm. M V. Sørensen).

Remarks. *Pycnophyes cristatus* n. sp. can be distinguished from most other species of *Pycnophyes* by the presence of its middorsal processes, which increase progressively in length from segment 7. Especially the middorsal process of segment 10 is very conspicuous and extends well beyond the posterior margin of the segment. Six other species bear middorsal processes that increase in length towards the posterior segments. These include *P. carinatus*, *P. arctous* Adrianov, 1999; *P. chilensis* Lang, 1953; *P. chukchiensis* Higgins, 1991; *P. furugelmi* and *P. odhneri* Lang, 1949 (see Zelinka 1928, Lang 1949, 1953, Higgins 1991, Adrianov and Malakhov 1999). However, only three of these species possess a middorsal process of segment 10 extending well beyond the posterior margin of the segment: *P. arctous*, *P. chukchiensis* and *P. furugelmi*. *P. chukchiensis* and *P. furugelmi* both possess ventromedial setae on segments 3-6 (Higgins 1991, Adrianov and Malakhov 1999), whereas *Pycnophyes cristatus* n. sp. has no ventromedial setae on these segments. Moreover, these species differ from *P. cristatus* n. sp. by their distribution of sensory spots and laterodorsal and lateroventral setae: *P. chukchiensis* has ventromedial sensory spots only, specifically on segments 1-10, laterodorsal setae on segments 2-9, and lateroventral ones on segments 2-10 (Higgins 1991); and *P. furugelmi* has ventromedial sensory spots only, specifically on segments 3-8, laterodorsal setae on segments 4-8 in males and the females with ventromedial sensory spots on segments 3-6 and 9, and laterodorsal setae on segments 2, 3, 4, 6, 8 (Adrianov and Malakhov 1999). Though *P. arctous* lacks ventromedial setae on segments 3-6, like the new species, it has no ventromedial setae on segments 7-9, as found in *Pycnophyes cristatus* n. sp. (see Adrianov and Malakhov 1999). Furthermore, *P. arctous* differs from *Pycnophyes cristatus* n. sp. by its appearance of middorsal processes of segments 1-7, which are nearly obtuse, whereas all the middorsal processes of *Pycnophyes cristatus* n. sp. are pointed.

Pycnophyes smaug sp. nov.
(Figs 12-15)

Type material. Holotype, adult female, collected on 11 November 2011 in the East Sea, off Uljin, locality MAP37 (Fig. 1C) 37°01'26"N, 129°30'55"E, from mud at 160 m depth; mounted in Fluoromount G®, deposited at the NHMD, under accession number ZMUC KIN-647. Allotype, adult male, collected on same date and at the same locality as the holotype, mounted in Fluoromount G®, deposited at NHMD under accession number ZMUC KIN-648. Four additional specimens, one male and three females, collected on the same date and at the same locality as the holotype, mounted for SEM, are stored in the last author's collection and will later be included in the NHMD general collection.

Diagnosis. *Pycnophyes* with middorsal elevations and intracuticular atria on segments 1-9, but without paradorsal setae flanking the middorsal elevations. Ventral anterior margin of segment 1 bulged and ornamented. Tergal anterior margin of segment 1 denticulated and ornamented. Trunk segments generally with few setae, present only as laterodorsal setae on segments 2 and 9, lateroventral setae on segments 2, 4, 6, 8 and 10, ventrolateral setae on segment 5 and ventromedial setae on segment 9 (females also on segment 2). Type 2 sensory spots on segments 1-10.

Etymology. Like other recently described kinorhynchs, the species is named after a dragon. The species name *smaug*, refers to the dragon Smaug, the greatest and most powerful in the later part of the Third Age in the books of J.R.R. Tolkien.

Description. Introvert and mouth cone: mouth cone (Fig. 14N) and spinoscalid arrangements by rings and sectors (Figs 13, 14O) are identical to the pattern described for *Pycnophyes chalgap* n. sp., except for sector 6, which shows the same scalid pattern as other even numbered sectors (unlike *Pycnophyes chalgap* n. sp., which has a small number of spinoscalids in this sector). The general spinoscalid morphology also resembles that in *Pycnophyes cristatus* n. sp. See Figure 13 for a complete summary of oral style and scalid and placid locations.

Neck with four dorsal and two ventral placids, appearing robust and hardly sclerotized, with concave surfaces. The two medial dorsal placids are wider, with a rectangular profile and a notch in their middle regions, whereas the two lateral ones are narrower with a square profile without a notch (Figs 12B, 15C). Ventral placids rectangular, extending from the lateral margin of the episternal plate to the midventral line (Fig. 12A). All placids articulate with the first trunk segment and extent anteriorly along the thin and flexible cuticle of the introvert.

Trunk composed of 11 segments (Figs 12A-B, 14A-C, 15A-B), with first segment composed of one tergal and three sternal plates (Fig. 14L). Segments 2-11 with one tergal and two sternal plates. All dimensions and measurements of the examined specimens are summarized in Table 7 and distribution of sensory spots and setae in Table 8. The segment width is almost constant throughout the trunk, but maximum sternal width is reached at segment 6, and the segments turn slightly narrower from this point. Segments 1-9 with paradorsal intracuticular atria and middorsal elevations that never extend beyond the posterior margin of the segment (Fig. 14A). Segments 3-9 with at least two pairs of small oblique dorsoventral muscular scars. One pair of laterodorsal cuticular ridges is present on segments 2-10 and two pairs of subdorsal ones on segments 8-10. One pair of ventromedial cuticular ridges present on segments 2-8 and two pairs on segments 9-10 (Fig. 12A-B). Pachycycli of similar size, and well developed

from segments 2-10. Peg and socket joints well developed on segments 2-8 and less developed on segments 9 and 10. Hairy tergo-sternal junction on segments 2-10 with three kinds of short hairs (e.g. Fig. 14F).

Segment 1: Anterolateral margins of tergal plate project into horn-like extensions. Tergal anterior margin finely denticulated and with a narrow reticulated area. Posterior margin of dorsal plate with a middorsal elevation (never surpassing the posterior margin of the segment), flanked by a pair of paradorsal sensory spots with associated intracuticular atria only visible with DIC (Fig. 15G). Tergal plate with three additional pairs of sensory spots, one in subdorsal and two in laterodorsal positions (Figs 12B, 14A-B, 15C). Sensory spots on this and all the following segments belong to type 2 (except on segment 11), being rounded to elongate and consisting of two pores surrounded by several small cuticular papillae (e.g. Fig. 14G). One pore is located centrally in the sensory area and the other, more elevated one, in the anterior region. Small oblique muscular scars present in subdorsal position. Ventral side with two episternal plates and one trapezoidal midsternal plate; posterior margin of midsternal plate with a small, pointed midventral process (Figs 12A, 14L). Ventral anterior margin with a depressed area. Each episternal plate with one ventromedial sensory spot near the anterior margins (Fig. 15A) and with a muscular scar in the middle region. Tergo-sternal junction inconspicuous. Pectinate fringes on both dorsal and ventral sides inconspicuous, only visible with DIC.

Segment 2: Tergal plate with middorsal elevation; associated paradorsal sensory spots and intracuticular atria similar to those on segment 1 (Figs 14D, 15G). A pair of laterodorsal and lateroventral setae present. Four additional pairs of sensory spots present as one subdorsal, two laterodorsal and one lateroventral pair, the latter being smaller than the other ones (Fig. 14D and similar to Fig. 14E). Laterodorsal pair located most mesially is more rounded and smaller than the other laterodorsal and subdorsal pairs. The laterodorsal pair of sensory spots located most laterally appears at the same position as the laterodorsal cuticular ridges (Fig. 14D). One pair of oblique subdorsal muscular scars present. Patch of scale-like cuticular hairs from the tergo-sternal junctions to the position of the laterodorsal cuticular ridges. Sternal plates with one pair of ventromedial sensory spots (Fig. 15A), located in the same position as the ventromedial cuticular ridges. Males with pair of big tubes located in the ventromedial position (Fig. 12C); females with a pair of ventromedial setae (Figs 12A, 15A). One pair of ventromedial muscular scars. Patch of scale-like cuticular hairs present along the sternal plates from their lateral margins to the position of the cuticular ridges (similar to Fig. 14H). Hairy tergo-sternal junctions divided into three portions, each one with different kinds of cuticular hairs (Fig. 14F): the anteriormost with several short and thin hairs only joined to the trunk by the base; the next portion with wider cuticular hairs joined by their whole length with

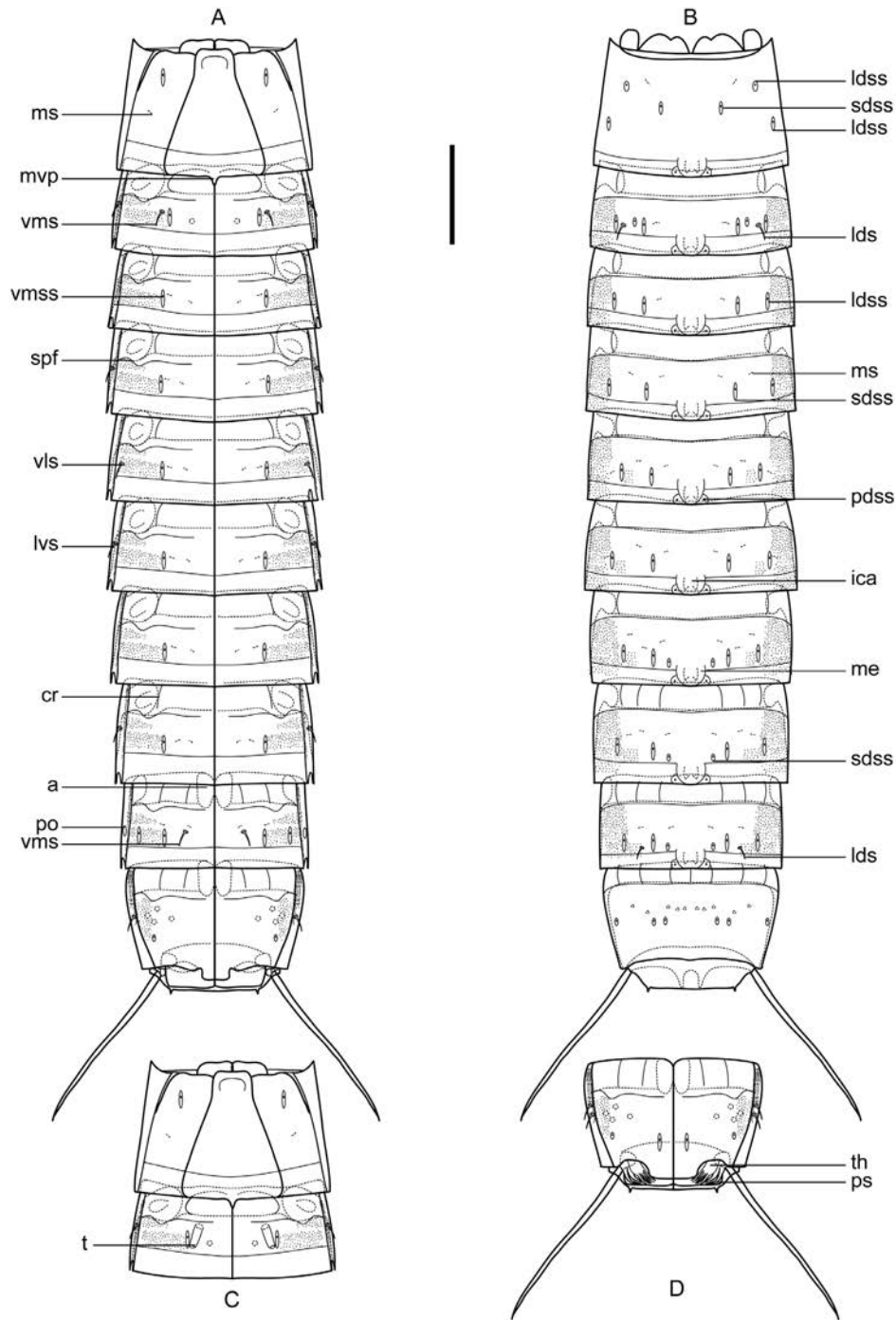
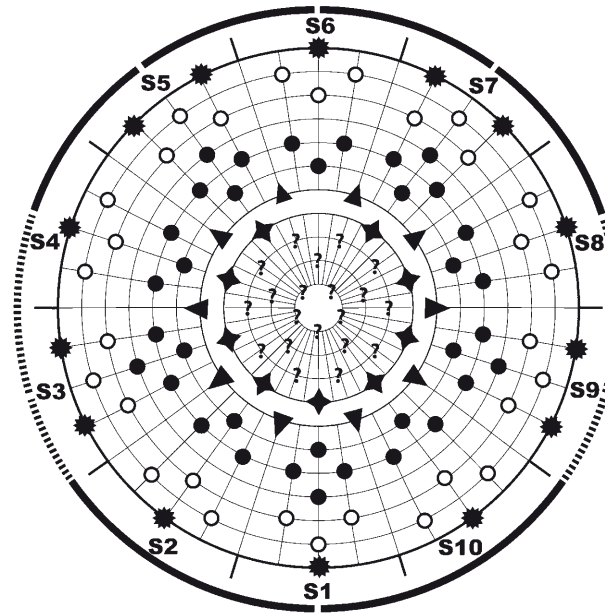


FIG. 12. – Line art illustrations of *Pycnophyes smaug* n. sp. A, female, ventral view; B, female, dorsal view; C, male, segments 1-2, ventral view; D, male, segments 10-11, ventral view. Scale bar: 100 μ m; *a* apodeme, *cr* cuticular ridge, *ica* intracuticular atria of sensory spot, *lds* laterodorsal seta, *ldss* laterodorsal sensory spot, *lvs* lateroventral seta, *me* middorsal elevation, *ms* muscular scar, *mvp* midventral process, *pdss* paradorsal sensory spot, *po* protonephridial opening, *ps* penile spine, *sdss* subdorsal sensory spot, *spf* secondary pectinate fringe, *t* tube, *th* tuft of hairs, *vls* ventrolateral seta, *vms* ventromedial seta, *vmss* ventromedial sensory spot.

the surface and only with the free tips; and the posteriormost portion with longer and wider cuticular hairs joined along the surface by their whole length, without the free tips. Secondary pectinate fringe on dorsal and ventral sides located in the anterior region of the segment, parallel to the anterior edge and surrounding the

whole segment, except in the paraventral region. Glandular cell outlets present on tergal and sternal plates on this and all following segments, located anterolaterally, anterior to the secondary pectinate fringes (Fig. 14D). Pachycycli well developed, with a normal size of the peg and socket joints.



Scalid and style arrangement

Ring/Sector	1	2	3	4	5	6	7	8	9	10	Total
00 oos +	1	1	1	1	1	0	1	1	1	1	9
01 ▼	1	1	1	1	1	1	1	1	1	1	10
02 •	1	1	1	1	1	1	1	1	1	1	10
03 •	2	2	2	2	2	2	2	2	2	2	20
04 •	1	0	1	0	1	0	1	0	1	0	5
05 ○	2	1	2	1	2	1	2	1	2	1	15
06 ○	1	2	1	2	1	2	1	2	1	2	15
07 tr •	1	1	2	1	2	1	2	1	2	1	14
Total scalids	8	7	9	7	9	7	9	7	9	7	89

FIG. 13. – Diagram of mouth cone, introvert and placids in *Pycnophyes smaug* n. sp. with the distribution and type of scalids by ring and sector. Dashed lines mark flexible cuticular lateral areas. “Double diamonds” are marked in the table with double lines. oos outer oral style, tr trichoscalid, s1–s10 sector number.

Segment 3: Tergal plate with middorsal elevation; associated paradorsal sensory spots and intracuticular atria similar to those on preceding segments (Fig. 15G). Three pairs of sensory spots present in subdorsal, laterodorsal and lateroventral positions (Fig. 14D). The first two are large and elongated, whereas the lateroventral ones are smaller and wider. Two pairs of oblique muscular scars present in subdorsal and laterodorsal positions (Fig. 15G). Sternal plates with one pair of ventromedial sensory spots in the same position as on preceding segment (Figs 14C, 15F). Two pairs of ventromedial muscular scars (Fig. 15F). Tergosternal junctions, glandular cell outlets, pachycycli, peg and socket joints, pectinate fringe and secondary pectinate fringe as on preceding segment.

Segment 4: Tergal and sternal plates similar to those on segment 3 but with a pair of lateroventral setae (Figs 14E, G, 15F).

Segment 5: Tergal and sternal plate similar to those on segment 3, but with a pair of ventrolateral setae. The patches of scale-like cuticular hairs on the tergal plate extend towards the subdorsal position. A couple of scale-like cuticular hairs appear mesially on the sternal plates. Otherwise similar to preceding segment.

Segment 6: Tergal and sternal plates similar to those on segment 4. Segment otherwise as preceding segment.

Segment 7: Tergal and sternal plates similar to those on segment 3, but with an additional pair of subdorsal sensory spots present, close to the middorsal elevation (Fig. 14B). The additional sensory spots are rounded, opposed to the other elongated ones. One pair of apodemes present near anterior margin of segment, only visible in males. Patches of cuticular hairs on both dorsal and ventral side similar to those on segment 5. Otherwise similar to preceding segment.

Segment 8: Tergal plate similar to segment 7 but with a pair of lateroventral setae and two additional pairs of cuticular ridges in subdorsal positions. Sternal plates same as on segment 3 (Fig. 14H, M). One pair of apodemes present near anterior margin of segment, only visible in males. Patches of cuticular hairs on both dorsal and ventral side similar to those on segment 5. Otherwise similar to preceding segment.

Segment 9: Tergal plate similar to segment 8, except for the setae that appear in laterodorsal and not lateroventral positions (Fig. 14B). Protonephridial opening, not sieve-like, present in paralaral position

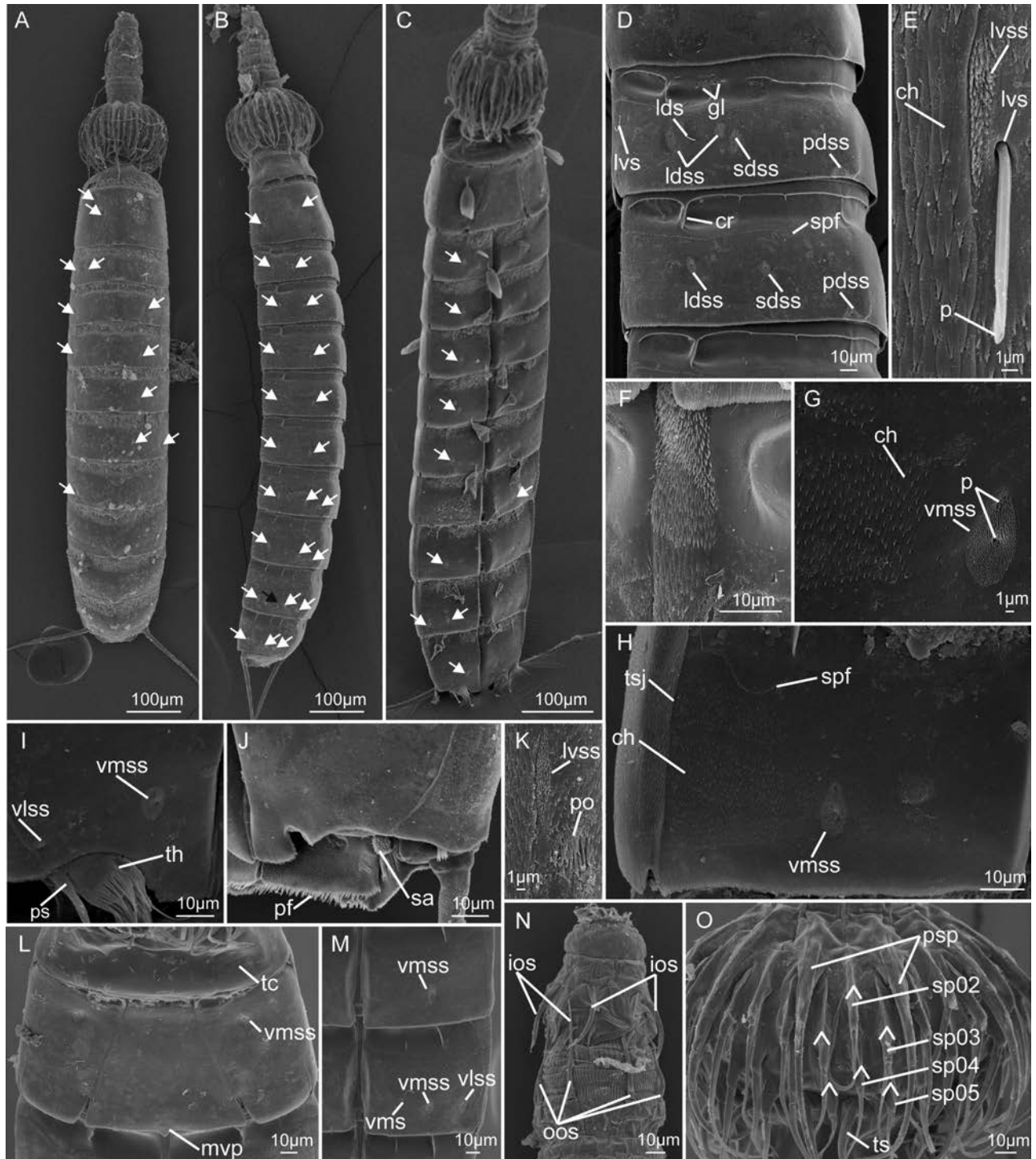


FIG. 14. – *Pycnophyes smaug* n. sp. SEM photographs. A, female, dorsal view; B, female, lateral view; C, male, ventral view; D, female, lateral view of segments 2-3; E, female, tergosternal area of segment 4; F, female, segment 2, tergosternal junction with three kinds of hairs; G, male, ventromedial position of segment 4; H, male, right sternal plate of segment 8; I, male, left sternal plate of segment 10; J, female, left sternal plate of segments 10-11; K, female, lateral view of segment 9, protonephridial opening; L, female, ventral view of segment 1 and the thin cuticle of the introvert; M, female, left sternal plates of segments 8-9; N, female, mouth cone; O, female, introvert sector 8; *ch* cuticular hairs, *cr* cuticular ridge, *gl* glandular cell outlets, *ios* inner oral style, *lds* laterodorsal seta, *ldss* laterodorsal sensory spot, *lvs* lateroventral seta, *lvss* lateroventral sensory spot, *mvp* midventral process, *oos* outer oral style, *p* pore, *pdss* paradorsal sensory spot, *pf* pectinate fringe, *po* protonephridial opening, *ps* penile spine, *psp* primary spinoscalid, *sa* sensory area, *sdss* subdorsal sensory spot, *sp* spinoscalid, *spf* secondary pectinate fringe, *tc* thin cuticle of the introvert, *th* tuft of hairs, *ts* trichoscalid, *tsj* tergosternal junction, *vlss* ventrolateral sensory spot, *vms* ventromedial seta, *vmss* ventromedial sensory spot. Sensory spots are marked with white arrows and setae with black arrows on A-C. Digits following labels on O refer to the introvert ring numbers. Lambda symbols (A) mark attachment points of scalids.

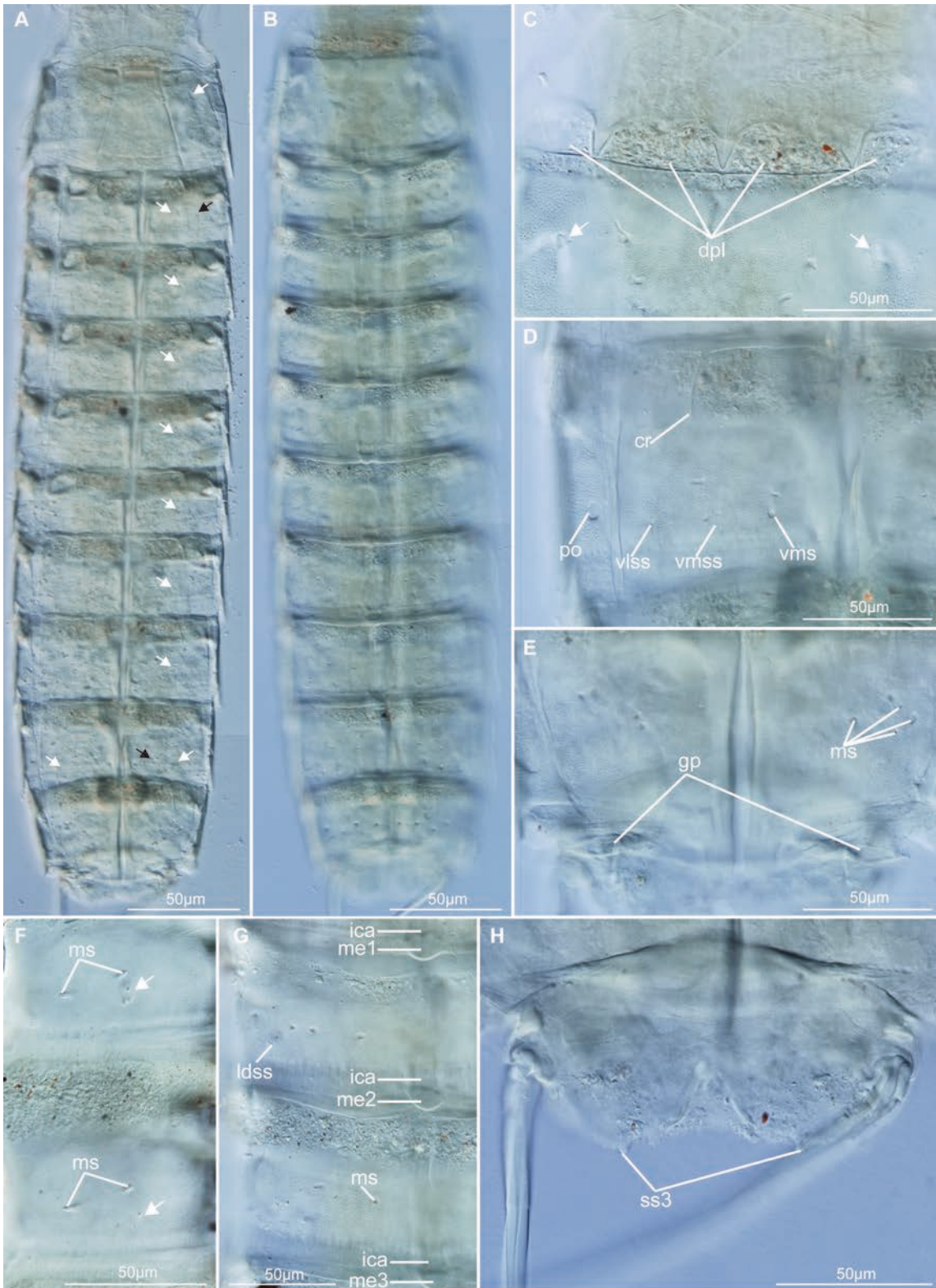


FIG. 15. – *Pycnophyes smaug* n. sp. Differential interference contrast photographs. A, female, ventral view; B, female, dorsal view; C, female, dorsal view of neck and segment 1; D, female, left sternal plates of segment 9; E, female, ventral view of segment 10; F, male, right sternal plates of segments 3-4; G, female, dorsal view of left half of segments 1-3; H, female, dorsal view of segment 11; *cr* cuticular ridge, *dpl* dorsal placid, *gp* gonopore, *ica* intracuticular atria of sensory spots, *ldss* laterodorsal sensory spot, *me* middorsal elevation, *ms* muscular scar, *po* protonephridial opening, *ss3* sensory spot type 3, *vlss* ventrolateral sensory spot, *vms* ventromedial seta, *vms* ventromedial sensory spot. Sensory spots are marked with white arrows. Setae are marked with black arrows. Digits following labels refer to segment numbers.

TABLE 7. – Measurements of female holotype and male allotype of *Pycnophyes smaug* n. sp.; lts, lateral terminal spine; msw-6, maximum standard width of segment 6; sw, standard width; s1-s11, segment lengths of trunk segments 1-11; TL, trunk length.

Character	Length	
	holotype ♀	allotype ♂
TL	960	897
sw10	169	179
sw/TL	0.18%	0.20%
msw-6	200	201
msw/TL	0.21%	0.22%
lts/TL	0.18%	0.22%
s1	127	126
s2	88	86
s3	93	90
s4	89	92
s5	89	95
s6	96	101
s7	96	104
s8	97	104
s9	101	106
s10	124	135
s11	70	55
lts11	170	201

(Fig. 15D); pore surrounded by few short hairs (Fig. 14K). Sternal plates similar to those on previous segments but with one additional pair of ventromedial cuticular ridges, ventromedial setae and ventrolateral sensory spots (Figs 14M, 15D). One pair of apodemes present near anterior margin of segment, visible in both sexes (Fig. 12A). Patches of cuticular hairs on both dorsal and ventral side similar to those on segment 5. Peg and socket joints inconspicuous. Otherwise similar to preceding segment.

Segment 10: Middorsal structure (middorsal process or elevation) or intracuticular atria absent. Tergal plate with two pairs of lateroventral setae in males, and only one pair in females. Three pairs of sensory spots present, two in subdorsal and one in laterodorsal positions (Fig. 14B). Two pairs of cuticular ridges present in subdorsal position, and one in laterodorsal. Males with one pair of ventromedial and ventrolateral sensory spots, the latter smaller than the other; and posterior margins of sternal plates with deep notches over the genital pores (Figs 12D, 14I). Females only with one pair of small ventrolateral sensory spots. Posterior sternal segment margin in females straighter than in males, with small but deep notches near the paraventral positions (Fig. 14J). Both sexes with two pairs of ventromedial cuticular ridges. Hairy tergo-sternal joints are not present along the whole lateral margins. One pair of apodemes present near anterior margin (Fig. 12A-D). Peg and socket joints very indistinct. Patches of cuticular hairs on both dorsal and ventral side, similar to those on segment 4. Several small and rounded muscular scars appear on the dorsal and ventral sides (Fig. 15B, E). Otherwise similar to preceding segment.

Segment 11: With a pair of lateral terminal spines (Fig. 12A-B). Tergal plate with one pair of small, horn-like cuticular extensions. Males with two pairs of penile spines and a pair of genital pores surrounded by a tuft

TABLE 8. – Summary of location of setae and sensory spots in *Pycnophyes smaug* n. sp. arranged by series. f, female condition of sexually dimorphic character; LD, laterodorsal; lts, lateral terminal spines; LV, lateroventral; m, male condition of sexually dimorphic character; ps, penile spines; PD, paradorsal; SD, subdorsal; se, setae; ss, sensory spots; ss3, sensory spot type 3; t, tubes; VL, ventrolateral; VM, ventromedial.

Segment	PD	SD	LD	LV	VL	VM
1	ss	ss	ss,ss			ss
2	ss	ss	ss,se,ss	se,ss		ss,se(f),t(m)
3	ss	ss	ss	ss		ss
4	ss	ss	ss	se,ss		ss
5	ss	ss	ss	ss	se	ss
6	ss	ss	ss	se,ss		ss
7	ss	ss,ss	ss	ss		ss
8	ss	ss,ss	ss	se,ss		ss
9	ss	ss,ss	se,ss	ss	ss	ss,se
10		ss,ss	ss	se,se(m)	ss	ss(m)
11		ss3(m)		lts	ps(2,m)	

of long hairs (Figs 12D, 14I). Females with one pair of type 3 sensory spots (Fig. 15H) and a spherical sensory area located in the ventral part of the tergal plate, so these structures are visible in ventral view (Fig. 14J).

Associated kinorhynch fauna. See under description of *Pycnophyes cristatus* n. sp.

Remarks. *Pycnophyes smaug* n. sp. has, apart from its lateroventral setae, only setae in laterodorsal positions on segments 2 and 9, and in ventromedial position on segment 9. Several other species share the absence of middorsal or paradorsal setae on all segments, but only seven of them have such a scarcity of setae on the whole dorsal side as found in *Pycnophyes smaug* n. sp. These include *P. argentinensis* Martorelli and Higgins, 2004; *P. arctous*, *P. canadensis* Higgins and Karczynski, 1989; *P. chilensis*, *P. maximus* Reimer, 1963; *P. odhneri* and *P. ponticus* (Reinhard, 1881) (see Reinhard 1881, Lang 1949, 1953, Reimer 1963, Higgins and Karczynski 1989, Adrianov and Malakhov 1999, Martorelli and Higgins 2004).

However, *P. chilensis* and *P. maximus* do not have any kind of setae at all (see Lang 1953, Reimer 1963), *P. canadensis* has subdorsal setae on segment 1 (see Higgins and Karczynski 1989), whereas the remaining species only show setae in lateroventral position on the tergal plates: *P. arctous* on segment 2 (in females only), *P. argentinensis* on segment 6, *P. odhneri* on segments 2, 4, 6, 8 and 10, and *P. ponticus* on segments 2-10 (see Reinhard 1881, Lang 1949, Adrianov and Malakhov 1999, Martorelli and Higgins 2004) and hence not in laterodorsal position of segments 2 and 9 as found in *Pycnophyes smaug* n. sp. Moreover, *P. odhneri* differs from *Pycnophyes smaug* n. sp. in the presence of ventromedial setae on all segments (Lang 1949), whereas *Pycnophyes smaug* n. sp. has ventromedial setae on segment 9 only. *P. ponticus* has ventromedial setae on a single segment only, and it appears on segment 4 (Reinhard 1881), and not segment 9 as in *Pycnophyes smaug* n. sp.

Pycnophyes smaug n. sp. can also be distinguished from the above species by other characters. The new species has a midventral process on the posterior margin of midsternal plate, whereas none of the seven species discussed has this structure. Furthermore, *P. arctous*, *P. chilensis* and *P. odhneri* have long mid-dorsal processes, which clearly extend beyond the posterior margin of segments 9-10 in the former species (Adrianov and Malakhov 1999) and of segment 9 in the other two species (Lang 1949, 1953). Information on sensory spot distribution is unfortunately not available for any of the species discussed here.

DISCUSSION

The description of four new species brings the total number of valid kinorhynch species around the Korean Peninsula up to 26. Since additional new species are currently under description (M. V. Sørensen, pers. comm.), the Korean kinorhynch fauna now can be considered among the most well-examined in the world. Only the Iberian Peninsula has been subject to similar intensive studies, and from this region we also know close to 30 species (Sánchez *et al.* 2012). Similar studies of other, comparable regions would be interesting to determine whether Spain and Korea hold a particularly high kinorhynch diversity, or whether the high species numbers are due to the great sampling effort made in the area, which means that similar high diversities in other places could be expected at these latitudes.

With eight known *Pycnophyes* species (*P. furugelmi*, *P. oshoroensis*, *P. schornikovi* and *P. tubuliferus*, plus the four described herein), in the Korean-Western Japanese region, the genus's diversity is beginning to reach levels known from other comparable regions. For instance, a total of nine *Pycnophyes* species are now known from the waters around the Iberian Peninsula in Europe (Sánchez *et al.* 2012). The two regions are comparable in size, situated in subtropical regions and relatively well-sampled, so this may give us a hint about the diversity we can expect to find in such areas. For comparison, 6 species are known from the slightly colder temperate Scandinavian inland waters, including the Baltic Sea and Kattegat (Higgins 1983), and only two from the arctic West Greenland, though especially the Disko Island and Disko Bay area has been sampled very intensively by Higgins and Kristensen (1988), and through numerous student field courses since the mid-1980s. On the other hand, 12 species are known from the warmer Mediterranean Sea. This could be a weak indication showing that diversity of the genus increases from the colder Polar Regions towards the equator. Our knowledge on global kinorhynch distribution in general is of course far too limited to draw this conclusion yet, but the limited amount of data that is currently available points in this direction. Comparable studies from tropical regions are not yet available because the few studies that have been carried out closer to the equator focus on much smaller areas, but it would be desirable

to study whether diversity, as expected, is higher in such areas.

With the addition of the four new species described in the present contribution, and two additional ones described recently (Sánchez *et al.* 2013) the number of valid *Pycnophyes* species based on descriptions of adult specimens will reach 53, and hence strengthen the genus' position as the second most diverse after *Echinoderes*. We still need to understand why these two particular genera stand out as the most successful in terms of speciation, but at least the present study has confirmed that *Pycnophyes* is among the most diverse.

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