



A review of the genus *Litinium* Cobb, 1920 (Nematoda: Enoplida: Oxystominidae) with descriptions of four new species from two contrasting habitats

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Abstract

Four new species of the genus *Litinium* are described from mangroves and from deep sea. The genus *Litinium* now includes ten valid species. An emended generic diagnosis and a pictorial guide for species identification are given. *Litinium quangi* sp. n. and *L. curticauda* sp. n., both found in mangroves of South Vietnam, are morphologically similar and differ from other congeneric species in body size, having short anterior setae, ovoid amphideal fovea and a short rounded tail. *Litinium quangi* differs from *L. curticauda* in the number of midventral preanal supplementary setae (one in *L. quangi* and two in *L. curticauda*) and relative tail length (c' 1.12–1.63 in *L. quangi* and 0.83–0.94 in *L. curticauda*). *Litinium abyssorum* sp. n. and *L. profundorum* sp. n., both collected from the Angola Basin, South-East Atlantic Ocean, at depth 5400 m, are also morphologically similar and differ from other species of the genus by having a smaller body and relatively large amphideal fovea with deep invagination of the anterior edge. *Litinium abyssorum* differs from *L. profundorum* in the number of midventral preanal setae (two in *L. abyssorum*, one in *L. profundorum*), relative tail length (c' 3.61 in *L. abyssorum* and 1.17 in *L. profundorum*) and *L. abyssorum* has unequal spicules.

Key words: Angola Basin, deep-sea nematodes, DIVA I project, marine biodiversity, taxonomy, Vietnam mangroves, morphology, pictorial key

Introduction

Litinium Cobb, 1920 is a small and distinct genus of the family Oxystominidae. Like other oxystominid taxa, species of *Litinium* species dwell in marine or at least brackish bottom sediments worldwide, from mangroves to deep sea. Species of *Litinium* are generally rare and constitute a small part of marine nematode assemblages wherever found (Gerlach 1958a; Tietjen 1971; Soetaert *et al.* 1995; Mokievsky *et al.* 2011). Most *Litinium* species were described on the base of single or few specimens, often of one sex. However, the species of *Litinium* are mainly well-defined and present few problems in their discrimination from one another. Most earlier records of *Litinium* species were from shallows of tropical and temperate zones of the Atlantic Ocean and the tropical zone of the Indo-West Pacific. More recently, deep-sea species were recorded, which did not appear to share any common features distinguishing them from shallow-water species (see data in this paper). The first taxonomic review of the genus was performed by Quang Ngo Xuan *et al.* (2008), and the most recent account was presented by Smol *et al.* (2014).

Here we describe four new species: two similar species from mangroves in South Vietnam and two species, also similar, from the South-East Atlantic deep sea. An updated list of species, emended generic diagnoses and pictorial key for species identification are also presented.

Material and methods

Samples containing species *Litinium quangi* **sp. n.** and *L. curticauda* **sp. n.** were collected in the Can Gio National Reserve, South Vietnam (intertidal zone of a mudflat) by Nguyen Dinh Tu and Nguyen Vu Thanh in April 2011. The samples were taken using a tube of 3.5 cm diameter and then fixed in hot (60°C) 10% formaldehyde. Nematodes were extracted by flotation with Ludox and then slowly evaporated to anhydrous glycerin after Seinhorst (1959), and mounted on permanent glycerin slides with paraffin rings.

Deep sea sediment samples containing species *Litinium abyssorum* **sp. n.** and *L. profundorum* **sp. n.** were taken at the station 346 in the Angola Basin, south-east Atlantic Ocean, during the DIVA-I campaign of the research vessel Meteor M48/1 in July, 2000. The sediment was sampled using a Barnett's multicorer. Each core had a diameter of 9.6 cm and consisted of the upper 5 cm of sediment. The sediment was preserved in 5% formaldehyde solution on board. In the laboratory the fixed samples were washed through a 40 µm mesh sieve with tap water. Meiofauna and organic particles were separated from the remaining sand particles by centrifugation with a colloidal silica polymer (Levasil) as flotation medium and kaolin to cover heavier particles. Nematodes were extracted and processed to glycerin by means of slow evaporation (Seinhorst 1959) and mounted on permanent glycerin slides with paraffin-beewax rings.

The nematodes were examined, depicted, measured and drawn with a Leica DM 5000 light microscope equipped with Nomarski optics.

Abbreviations:

a—body length divided by maximum body diameter;
am.l.—length of the amphideal fovea, in µm;
am.w.—width of the amphideal fovea, in µm;
b—body length divided by pharyngeal length;
c—body length divided by tail length;
c'—tail length, expressed in anal diameters;
calc (calculated)—morphometric value calculated from drawings of published species descriptions;
c.s.—length of cephalic setae, in µm;
diam.am.—body diameter at the level of amphids, in µm;
diam.ani—anal body diameter, in µm;
diam.ca.—body diameter at the level of cardia, in µm;
diam.c.s.—body diameter at the level of cephalic setae, in µm;
diam.midb.—midbody diameter, in µm;
diam.n.r.—body diameter at the level of nerve ring, in µm;
dis.am.—distance from the cephalic apex to the anterior rim of the amphideal fovea, in µm;
dis.c.s.—distance from the cephalic apex to the circle of the cephalic setae, in µm;
dis.v.pore—distance from the cephalic apex to the ventral pore, in µm;
i.l.s.—length of inner labial setae, in µm
L—body length, in µm;
o.l.s.—length of outer labial setae, in µm;
spic.—spicule's length, range from chord to arc, or if exact way of measure not indicated by an author;
spic.arc—spicule's length along the arch, in µm;
V—distance of vulva from anterior end as percentage of body length, in %

Taxonomy

Oxystominidae Chitwood, 1935

Litinium Cobb, 1920, emended diagnosis

(= *Alaimonemella* Allgén, 1935, syn. Lorenzen, 1981: 304)

Oxystominidae, Oxystomininae. Circles of six inner and six outer labial setae situated close together on the anterior end, subapically, with a circle of four cephalic setae posterior to the circles of inner and outer labial setae. Amphideal fovea situated between the circles of the outer labial and cephalic setae. Amphideal fovea varies in shape between species and may differ in males and females of the same species: may be ovoid with an anterior round aperture, horseshoe-like or crescent contoured or more complex. An only posterior antidromously reflexed ovary present; vulva shifted anteriorly. Tail never clavate, more or less short, cylindrical or occasionally conical, with rounded tip; terminal caudal capsule absent or weakly developed.

Type species: *Litinium aequale* Cobb, 1920.

Ten valid species, from marine and brackish sediments.

Remark. Within Oxystominidae, *Litinium* is morphologically closest to *Thalassoalaimus* de Man, 1893, and differentiation of the two genera may be difficult. *Thalassoalaimus* is particularly characterized by having a conical tail with a terminal structural elaboration, with distinctly thickened inner cuticle of the tail tip forming a so called tail capsule. However, the tail capsule in some species may be poorly developed (e.g. *Th. lissus* Gagarin, 2009) or almost absent (*Th. tardus* de Man, 1893). On the other hand, the newly described *Litinium profundorum* sp. n. also has a weak thickening of the inner cuticle layer of the tail tip (but the latter is rounded rather than conical). Differentiation of *Litinium* and *Thalassoalaimus* should be clarified in a further study of *Thalassoalaimus* species.

Annotated species list

Litinium abyssorum sp. n. Present paper.

Litinium aequale Cobb, 1920. Cobb, 1920: 234, fig. 8; female, Florida, ocean beach, sand. Gerlach, 1958b: 349, fig. 1 a–b; one male, Nosy Be (island near the northeast coast of Madagascar), sand, broken shells. Soetaert *et al.*, 1995, Table 3; mentioned as collected along the transect from 160 to 1220 m off Corsica, Mediterranean Sea.

Litinium bananum Gerlach, 1956. Gerlach, 1956: 87, Taf. 27, Fig. a–e; one male and one female, Kiel Bay of the west Baltic Sea. Tietjen, 1971, Table 5; no description, the species is recorded along transects off North Carolina (Atlantic coast of North America) from 400 to 2500 m deep. Soetaert *et al.*, 1995, Table 3; recorded along a transect from 160 to 1220 m off Corsica, Mediterranean Sea.

Litinium curticauda sp.n. Present paper.

Litinium obtusilobus Bussau, 1993. Bussau, 1993: 513–616, Abb. 221, 222; two females, South-East Pacific Ocean, nodule-bearing area of the Peru Basin, 3754 m deep. Holotype and paratype female specimens differ considerably from one another in body length and some morphometrics (L 1600 μ m and 680 μ m, index *c* 40.0 and 21.9, respectively), and hence conspecificity of the two specimens may be questionable.

Litinium parmatum Wieser, 1954. Wieser, 1954: 184, Abb. 7 a–c; one female, Mediterranean Sea, Tyrrhenian Sea, Sorrento Peninsula, littoral.

Litinium profundorum sp. n. Present paper.

Litinium quangi sp. n. Present paper.

Litinium simplex (Allgén, 1935) Lorenzen, 1981 sp. inq. Allgén, 1935: 149–150, Fig. 75 a–b; one female, Oresund. The species was described by Allgén (1935) as a type and only species of the newly established genus *Alaimonemella* Allgén, 1935. The only other record of this species is made by Gerlach (1958a) in the Kiel Bay, one station, with no mention on number of specimens and with no comments.

Litinium subterraneum Tchesunov, Mokievsky & Nguyen Vu Thanh, 2010. Tchesunov *et al.*, 2010: 168–171, figs 8, 9; table 5; two males and five females, Central Vietnam, mangrove biotope. Mokievsky *et al.* (2011) found

the species to be relatively abundant (0.3–7.4% of all the nematode individuals) and more or less homogeneously distributed vertically in the column 0–4 cm of poorly sorted medium-grained sand from a mangrove site of the Nha Trang Bay, Central Vietnam.

***Litinium volutum* Gerlach, 1962.** Gerlach, 1962: 93, Taf. 3, Fig. i–k; one male, Maldives Islands, subterranean water (salinity not indicated) above sea level.

Remarks on the species composition of the genus *Litinium*. Lorenzen (1981) considered the species *Alaimonemella simplex* Allgén, 1935, the type and only species of the genus *Alaimonemella* Allgén, 1935, as probably identical to *Litinium bananum* Gerlach, 1956. Hence he considered the name *Alaimonemella* to be a junior synonym of *Litinium*. Allgén (1935) placed the genus *Alaimonemella* in the family Siphonolaimidae, but it was later synonymised with *Tubolaimella* Allgén, 1934 within Linhomoeidae by de Coninck (1965), and more recently placed within Trefusiidae by Gerlach & Riemann (1974). The species *A. simplex* is however based on a single poorly described female (Allgén, 1935) with some doubtful characters such as only two lateral and four submedian anterior setae, round amphid (this may be an amphideal aperture) and paired ovaries. Lorenzen (1981) regarded this species as *species inquirenda*.

Quang *et al.* (2008) described two different males designated as *Litinium* sp. 1 and *Litinium* sp. 2. Both males were indicated as holotypes but scientific names were not given. Both species were collected in Can Gio mangroves, South Vietnam, *i.e.* in the same area as specimens of two new species described below. One of those two new species, *i.e.* *L. curticauda* sp. n., corresponds well to *Litinium* sp. 2; but the second new species, *L. quangi* sp. n., is not *Litinium* sp. 1.

***Litinium quangi* Tchesunov, Nguyen Dinh Tu & Nguyen Vu Thanh sp. n.**

Figs 1, 2, Table 1

Material. Holotype male, three paratype males, allotype female and paratype female. All the specimens are deposited in the Vietnam National Museum of Nature (18 Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam) with slide numbers VNMN.0011 (holotype male, paratype male 3 and allotype female), VNMN.0012 (paratype male 1 and paratype female 1) and VNMN.0013 (paratype male 2).

Locality. South Vietnam coast, Dong Nai River Delta, Can Gio National Reserve, 10°32'176"N and 106°45'919"E, 0.5 m deep. Sediment consisted of silt and clay (80.5%) and sand (19.5%). NaCl content 13.5‰.

Description. Body very long and slender, filiform. Cuticle thick, smooth over entire body. Head slightly separated off by a very slight narrowing at the level of the cephalic setae. Cuticle anterior to the amphideal fovea 1–1.3 μ m thick, posterior to the amphideal fovea 1.6–2 μ m, posterior to the cardia 2–3.4 μ m, tail terminal cuticle 3.9–4.2 μ m.

Six inner labial and six outer labial sensilla equal in length and shape. Both circles united in a joint crown of twelve short setae where outer labial setae situated just posterior to inner labial setae. Four equally short cephalic setae situated separately just posterior to the amphideal foveas in area of postcephalic narrowing.

Amphideal fovea large, longitudinally ovoid, with distinct cuticularised horseshoe-shaped fringe; aperture round, with very fine rim, located at anterior end of fovea.

A few short ventral, subventral and lateral papillae and tiny setae situated posterior to the amphideal fovea, anterior to the excretory pore, at 62–67 μ m from anterior end. A very minute midventral seta about 1 μ m long present 10–12 μ m anterior to the ventral pore.

No metanemes found.

Mouth opening tiny. Buccal cavity not developed as such and its walls not differentiated from the cuticular lining of the pharynx. Pharynx evenly muscular and slender throughout its length but widening gradually to the posterior end. Cardia widely conical and surrounded by intestinal tissue. Midgut lumen is partially filled with mass of fine granular material.

Ventral pore at about half distance from anterior end to the nerve ring, and posterior to the midventral seta. Only anterior portion of ventral gland duct discernible.

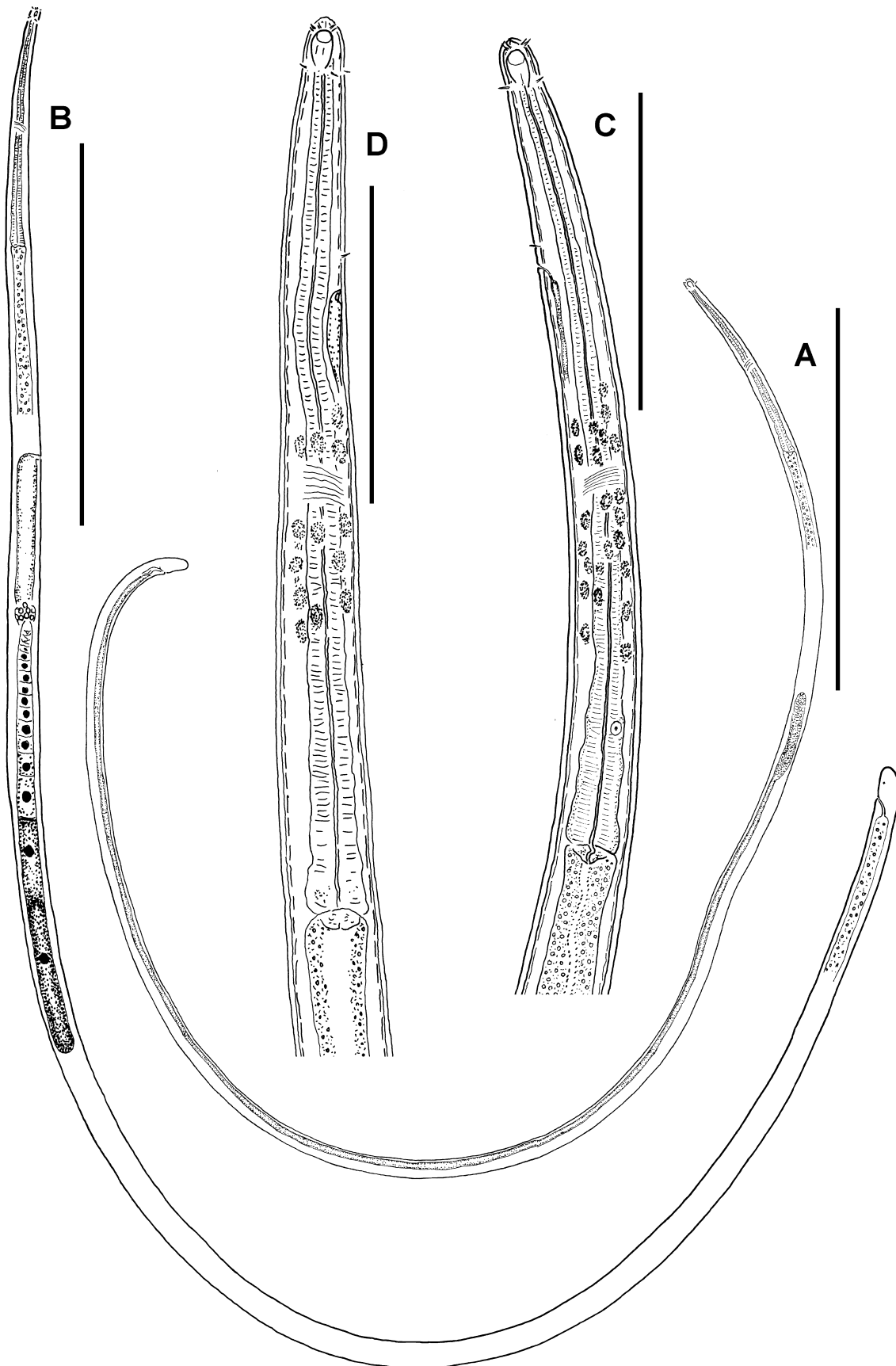


FIGURE 1. *Litinium quangi* sp. n., entire and anterior body. **A:** holotype male, entire; **B:** allotype female, entire; **C:** holotype male, anterior body; **D:** allotype female, anterior body. Scale bars: A, B 500 μ m; C, D 100 μ m.

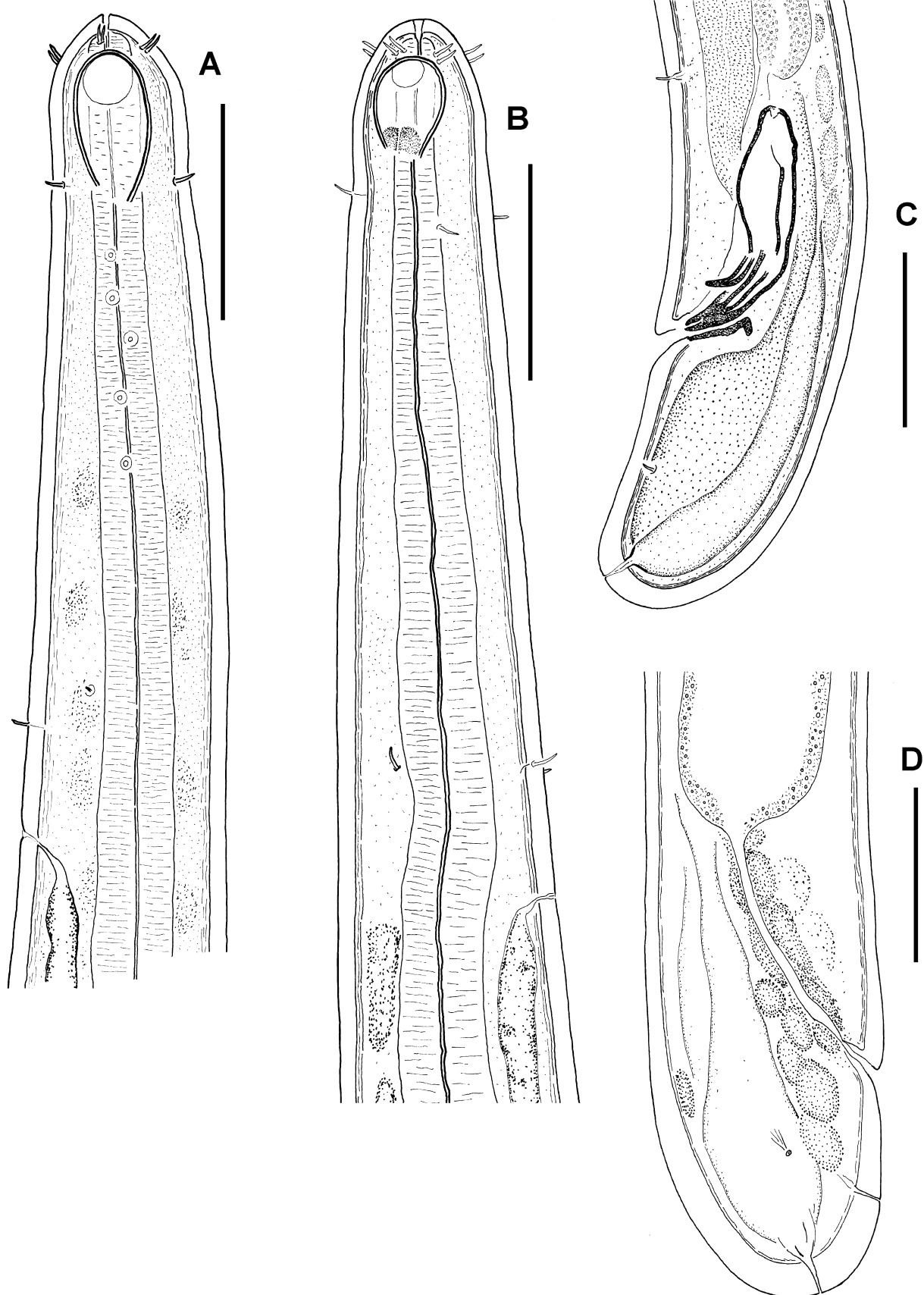


FIGURE 2. *Litinium quangi* sp. n., anteriors and tails. **A:** holotype male, anterior body end; **B:** allotype female, anterior body end; **C:** holotype male, posterior body end; **D:** allotype female, tail. Scale bars: 20 μm.

Vulva situated at ~ one fifth of body length from anterior end. Single posterior antidromously reflected ovary disposed ventrally and slightly to the left of the intestine. Uterus elongate and voluminous; uterus empty in both females examined. A short spermatheca just posterior to the uterus filled densely with minute round spermatozoa.

Only anterior male gonad present, situated ventrally to the intestine.

Spicules short, flat, arcuate, with internal cuticular linear longitudinal stripes, with posterior ends pointed and anterior ends slightly narrowed. One short (0.8–2, μm long) midventral precloacal seta present, just anterior to the anterior ends of the spicules, 32–35 μm from the cloacal opening.

Tail very short, rounded. Terminal pore and canal well developed, slightly subterminal. A pair of short subventral seta mid-tail length in both males and females; one ventral papilloid sensilla situated at mid-tail length discernible in some specimens.

Diagnosis. *Litinium*. Body length 2523–2918 μm ; *a* 81–118; *c* 72.1–97.2; *c'* 1.12–1.63. Inner labial, outer labial, cephalic setae very short, 1.4–2.6 μm . Amphideal fovea ovoid in outline, with horseshoe-shaped cuticular rim. Cephalic setae at level of posterior end of the amphideal fovea. One precloacal midventral supplementary seta at level of anterior end of the spicules.

TABLE 1. Morphometry of *Litinium quangi* sp. n. Measurements in μm .

Character	Specimens					
	Holotype male	Paratype male 1	Paratype male 2	Paratype male 3	Allotype female	Paratype female 1
L	2523	2762	2726	2918	2877	2696
a	109	103	115	118	83.6	81.2
b	9.59	9.18	9.37	10.8	10.3	11
c	72.1	81.2	89.4	94.1	97.2	?
V, %	-	-	-	-	18.7	18.5
c'	1.63	1.49	1.36	1.47	1.12	?
diam.c.s.	8.4	9.1	7.8	8	7.6	9
diam.am.	12.4	9.9	9.5	11.8	11.4	11
diam.n.r.	21.7	22.7	26.3	23.4	24	23.6
diam.ca.	26	31.2	33.8	27.9	30	32
diam.midb.	23.2	26.8	23.7	24.7	34.4	33.2
diam.ani	21.5	23	22.5	21.1	26.4	27.8
i.l.s.	2	2.2	2	2.1	1.5	1.4
o.l.s.	2.6	2.1	2.1	2.2	1.5	1.5
c.s.	2.2	2	1.9	1.4	2.5	2.4
dis.c.s.	15.6	19	?	15	?	?
dis.am.	2.9	4.3	4.5	3.6	3.8	3.2
am.l.	11	8.1	8.7	11.1	9.8	9.3
am.w.	8.1	?	?	7.4	6.8	?
dis.v.pore	75	?	68	72.7	80.5	?
spic.arc	30.4	30.4	32.9	33.1	-	-

Differential diagnosis. *Litinium quangi* sp. n. shares the ovoid shape of the amphideal fovea having a small round aperture with *L. aequale*, *L. curticauda*, *L. parmatus*, *L. subterraneum* and *Litinium* sp. 1 of Quang *et al.* (2008) but other known species have a fovea shaped as a half moon. *Litinium quangi* differs from all species by having only one midventral preanal seta instead of two or more setae. The female of *L. quangi* differs from *L. parmatus* with unknown males by having smaller anterior sensilla (1.1–2.5 vs 18 μm) and a shorter rounded tail (*c'* 1.12 vs 4.2, conical tail). *Litinium quangi* differs from the most similar and sympatric species *L.* sp. 1 of Quang *et al.* (2008) by having shorter outer labial and cephalic setae (respectively, 2.1–2.6 μm and 1.4–2.2 μm vs 5.2 μm

and 4.4 μm) and one vs two midventral precloacal setae. *Litinium guangi* differs from *L. curticauda* in the number of precloacal supplementary setae and by the greater distance from the head apex to the ventral pore (68–75 μm vs 39.5–48 μm), shorter spicules (30–33 μm vs 43–49 μm), slightly longer tail (c 72.1–94.1 and c' 1.36–1.63 vs 110–119 and 0.83–0.94, respectively).

Etymology. Species name is given in honour of Dr. Quang Ngo Xuan, the first author of the paper describing several Oxystominidae species from the Can Gio mangrove forest where two unnamed *Litinium* species were collected.

***Litinium curticauda* Tchesunov, Nguyen Dinh Tu & Nguyen Vu Thanh sp. n.**

Fig. 3, Table 2

Quang Ngo Xuan *et al.*, 2008: 7–9, fig. 4 (*Litinium* sp. 2)

Material. One holotype male. The specimen is deposited in Vietnam National Museum of Nature (18 Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam) with the slide number VNMN.0010.

Locality. South Vietnam coast, Dong Nai River Delta, Can Gio National Reserve. 10°32'176"N and 106°45'919"E, 0.5 m deep. Sediment consisted of silt and clay (80.5%) and sand (19.5%). NaCl content 13.5‰.

Description of the holotype. Body long, cylindrical, gradually attenuated from the cardia level to the anterior cephalic apex. Cuticle very thick and smooth over the entire body. Cuticle anterior to the amphideal fovea 1.6 μm thick, posterior to the amphideal fovea 2.5 μm , posterior to the cardia 2.6 μm , tail terminal cuticle 4.7 μm .

Both six inner and six outer labial sensilla united in a crown of twelve equal, short setae situated about 2.5 μm from the cephalic apex. Four very short cephalic setae situated posterior to the anterior crown of setae at the level of the posterior margin of the amphideal pouch. Each cephalic seta implanted in anterior end of a longitudinal 'slit' in the cuticle. Amphideal fovea rather large, situated between the crown of the inner plus outer setae and the cephalic setae. The amphideal fovea longitudinally ovoid in shape, with a distinct peripheral cuticular ridge surrounded the fovea anteriorly and laterally but not posteriorly. Amphideal aperture transversally oval, at the anterior end of the fovea. Some minute papillae scattered along lateral sides of the preneural body.

Distinct midventral excretory pore with a thin duct situated at a quarter of the distance from the cephalic apex to the nerve ring. Apparently part of a ventral gland; neck however only traced a short distance posterior; cell body not clear. A second less distinct midventral pore with a thin intracuticular canal but without any signs of a duct is present; situated 27 μm posterior to the anterior ventral pore.

Mouth opening tiny and structurally simple, evidently lipless. Buccal cavity not developed, anteriormost internal cuticle thin and not differing from the following cuticular lining of the pharynx. For most of its length, pharynx is slender, with barely discernible transverse striation. At the posterior end, the pharynx widens and has clear transverse muscular striations. Cardia short, semicircular and surrounded by intestinal tissue. Internal canal of the cardia thin and straight. Internal lumen of the midgut filled partly with fine granular non-refractive material.

Anterior testis with distinct longitudinal fibres (spermatozoa?), situated to the right of the intestine. Posterior testis absent. Spicules short and slightly arcuate, broad, with internal longitudinal stripes, with both anterior and posterior spicule ends pointed. Gubernaculum comprises a pair of short cuticular bars. Two short midventral precloacal supplementary setae: anterior one at the level of the posterior end of the spicules, 39 μm from the cloaca, posterior one just anterior to the cloacal opening, 5 μm from the cloaca. Both precloacal midventral setae 1.7 μm long. Distinct bursal musculature in the tail.

Tail very short and terminally rounded, cuticle terminally slightly thickened. Spinneret not apparent as such except for a thin subterminal intracuticular canal. Two (one lateral and one latero-dorsal) papillae on the tail.

Remark. The specimen described above is evidently conspecific with the male denoted as *Litinium* sp. 2 by Quang *et al.* (2008). Dimensions of both males are presented in Table 3.

Diagnosis. *Litinium*. Body length 2866–3431 μm , a 63–67.6, c 110–119, c' 0.83–0.94. Inner labial, outer labial setae short, 1.4–1.5 μm , cephalic setae 1.5–2.1 μm . Amphideal fovea ovoid in outline, with horseshoe-shaped cuticular rim. Cephalic setae at the level of the posterior end of the amphideal fovea. Two midventral supplementary setae, anterior one situated at the level of anterior tips of the spicules, posterior one just anterior to the cloacal opening.

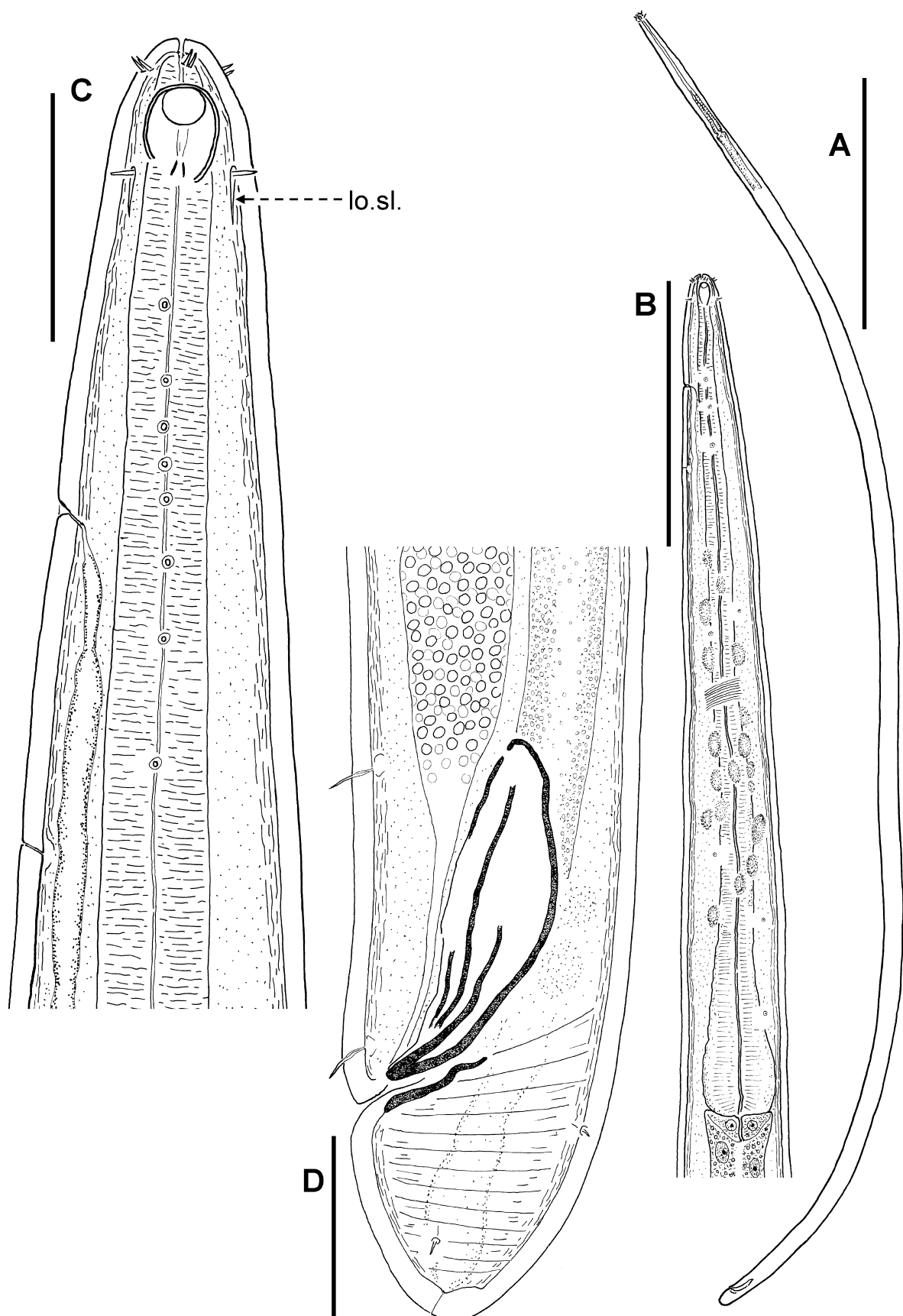


FIGURE 3. *Litinium curticauda* sp. n., holotype male. **A:** entire; **B:** anterior body; **C:** anterior end; **D:** posterior end. Arrow indicates a longitudinal slit in the cuticle where cephalic seta is inserted (lo.sl.). Scale bars: A 500 μ m; B 100 μ m; C, D 20 μ m.

TABLE 2. Morphometry of *Litinium curticauda* sp. n. Measurements in μm .

Characters	Male specimens	
	Holotype male	<i>Litinium</i> sp. 2, after Quang <i>et al.</i> , 2008
L	2866	3431
a	67.6	63
b	9.67	9.8
c	119	110
c'	0.83	0.94
diam.c.s.	6.9	?
diam.am.	11.3	15.9
diam.n.r.	31.5	40.7
diam.ca.	37.6	45.2
diam.midb.	42.4	52.5
diam.ani	29	33.3
i.l.s.	1.4	?
o.l.s.	1.4	?
c.s.	1.5	2.1
dis.c.s.	11.4	?
dis.am.	3.7	6.1
am.l.	7.2	12
am.w.	6	5.2
dis.v.pore	39.5	48
spic.arc.	49	46.5

Differential diagnosis. *Litinium curticauda* sp. n. belongs to a group of species having ovoid amphideal fovea with round to oval anterior apertures (*L. aequale*, *L. parmatum*, *L. quangi*, *L. subterraneum*). The new species differs from *L. parmatum* and *L. subterraneum* in having a short rounded tail (c' 0.83–0.94 vs 4.2, 3.47–3.48, respectively), from *L. aequale*, *L. parmatum*, *L. subterraneum* with shorter anterior sensilla (1.4–1.5 μm vs 9–10 μm , 6.9–18 μm , 2.5–4 μm , respectively). The species most similar to *L. curticauda* is the sympatric *L. quangi*; differing from it by having two precloacal setae instead one, index a (63–67.6 vs 103–118), c' (0.83–0.94 vs 1.36–1.63), distance from the cephalic apex to the ventral pore (39.5–48 μm vs 68–75 μm), and length of spicules (46.5–49 μm vs 30–33 μm).

Etymology. Species name means 'short tail'.

***Litinium abyssorum* Tchesunov, Nguyen Dinh Tu, Nguyen Vu Thanh sp. n.**

Fig. 4, Table 3

Material. One holotype male and one allotype female. The specimens are deposited in the Senckenberg Natural History Museum (Frankfurt am Main, Germany) with slide numbers SMF 16981 (holotype male) and SMF 16982 (allotype female).

Locality. South-east Atlantic Ocean, Angola Basin, 16°17.0'S, 005°27.0'E, depth 5389 m, silt—total carbon content 0.62%, mud content 95.23%, chlorophyll-*a* content 1.67 $\mu\text{g/g}$. DIVA-I expedition, st. 346/2, Multicorer 3; 27 July 2000.

Description. Body slim, cylindrical. Cuticle smooth and evenly thick (about 2 μm) over entire body.

Anterior end shaped as truncated cone; ratio of body diameter at the level of inner labial setae to that of the cephalic setae is 2 in the male and 1.8 in the female. There are two circles of six setae (inner labial setae and outer labial setae), consecutive but close to each other. The setae of both circles slender and cylindrical, nearly equal in length. Distance from the apex to the inner labial setae 2 μm in the male and 7 μm in the female. Circle of four

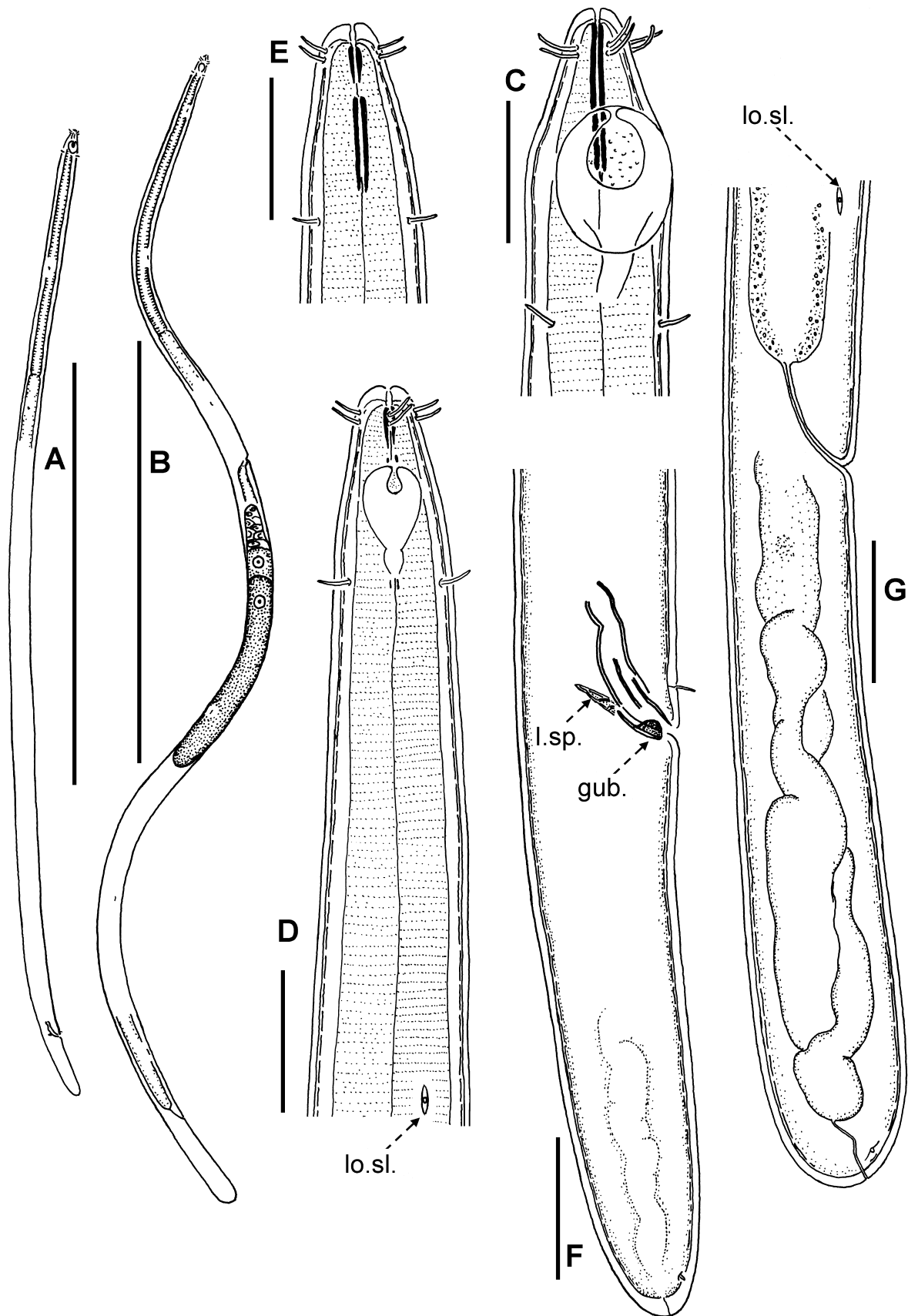


FIGURE 4. *Litinium abyssorum* sp. n. **A:** holotype male, entire; **B:** allotype female, entire; **C:** holotype male, anterior end; **D:** anterior end of the allotype female; **E:** anterior end of the allotype female, optical section; **F:** holotype male, posterior body; **G:** allotype female, tail. Arrows indicate somatic papillae in longitudinal slits in the cuticle (lo.sl.), gubernaculum (gub.), left vestigial spicule (l.sp.). Scale bars: A, B 300 μ m; C–G 10 μ m.

cephalic setae situated posterior to the amphideal fovea, far posterior to the circle of outer labial setae; cephalic setae slender cylindrical and slightly shorter than setae of the two anterior circles. Amphideal fovea in male large, rounded in outer outline, with deep sinuous invagination on the surface at the anterior edge. Amphideal nerve emerges as broad funnel from beneath the posterior amphideal fovea. Amphideal fovea in female shaped in outline as an upside-down pear, with a small groove on its anterior edge; posterior smaller lobe of the fovea set off with a constriction. A number of minute somatic sensilla distributed sublaterally along the; each inserted in the middle of a short longitudinal 'slit' in the cuticle.

Mouth opening tiny. Somatic cuticle thickened slightly around the mouth opening. Buccal cavity not developed as such (internal lumen of the anterior pharynx not enlarged), but internal lining of the anterior pharynx thickened and cuticularised forming a narrow buccal capsule 13 μm long in the male and 15 μm long in the female. Pharynx gradually widening to the cardia; with clear internal cuticular lining; no muscular cross striation apparent in pharynx.

Nerve ring not seen. Ventral gland not visible.

Testes not discernible. A midventral seta 2 μm long 2 μm anterior to the cloacal opening. No precloacal midventral supplementary papillae. Right spicule short, weak, slightly curved, with slightly curved anterior handle. Left spicule reduced to a short straight rod-like structure with its pointed tip directed dorsally. Gubernaculum a short bar parallel to the spicule at its posterior part.

One posterior ovary antidromously reflexed and situated on the right of the intestine. Vulva depressed, surrounded by thickened cuticle.

Tail cylindrical, with rounded tip. There is a terminal pore, thin canal and coiling ducts of caudal glands with light transparent content. Caudal gland cell bodies with nuclei not visible. There is a minute lateroventral subterminal papilla on either side of the tail.

TABLE 3. Morphometry of *Litinium abyssorum* sp. n. Measurements in μm .

Character	Specimens	
	Holotype male	Allotype female
L	710	897
a	50.7	69
b	4	4.31
c	15.7	13.3
c'	3.61	5.76
V, %	-	35.4
diam.c.s.	11	9
diam.am.	11	7.5
diam.n.r.	14	12
diam.ca.	15	12
diam.midb.	14	13
diam.ani	12	9
i.l.s.	3.5	3
o.l.s.	4	3
c.s.	2.5	2.5
dis.c.s.	23	14.5
dis.am.	7.5	6
am.l.	10	6
am.w.	8	5
spic.arc (right)	12.5	-
spic.arc (left)	8	-

Diagnosis. *Litinium*. Body length 710–897 μm ; a 50.7–69; c 13.3–15.7; c' 3.61–5.76. Inner labial, outer labial, cephalic setae 2.5–4 μm in length. Amphideal fovea large, with deep anterior sinuous invagination of the external contour. Cephalic setae posterior to the amphideal fovea. One precloacal midventral supplementary seta just anterior to cloacal vent. Spicules unequal, the left spicule vestigial.

Differential diagnosis. *Litinium abyssorum* sp. n. differs from all other *Litinium* species with known males by having unequal spicules. Further, *L. abyssorum* sp. n. has a peculiar amphideal fovea with deep anterior invagination similar to those of *L. bananum*, *L. volutum*, *L. obtusilobus* and *L. profundorum*. *Litinium abyssorum* differs from *L. bananum* by smaller body length (710–897 μm vs 2140–3225 μm , shorter anterior setae (2.5–4 μm vs 10–14 μm), presence vs apparent absence of precloacal midventral seta; from *L. volutum* by simpler shape of the amphideal fovea without curls, one vs four preanal papillae in male and longer tail (c' 5.76 vs 1.5, in females), from *L. profundorum* by longer tail (c 15.7 vs 40.6 and c' 3.6 vs 1.2) and two vs one precloacal midventral setae, from *L. obtusilobus* by short cephalic setae (2.5 μm vs 5 μm) and relatively longer tail (c' 5.8 vs 1.5).

Etymology. Species name is derived from Hellenic "abyssus" (abyss, chasm).

***Litinium profundorum* Tchesunov, Nguyen Dinh Tu, Nguyen Vu Thanh sp. n.**

Fig. 5

Material. One holotype male. The specimen is deposited in Senckenberg Natural History Museum Frankfurt with the slide number SMF 16983.

Locality. South-east Atlantic Ocean, Angola Basin, 16°17.0'S, 005°27.0'E, depth 5389 m, silt—total carbon content 0.62%, mud content 95.23%, chlorophyll-*a* content 1.67 $\mu\text{g/g}$. DIVA-I expedition, st. 346/2, Multicorer 3; 27 July 2000.

Description. Body slender, nearly cylindrical. Cuticle smooth and evenly thick (1.5–2 μm) over entire body. L 1196 μm , a 52, b 4.54, c 40.6. Body diameter at the level of: cephalic setae 10.5 μm , amphideal fovea 8.5 μm , nerve ring 18 μm , cardia 22.5 μm , midbody 23 μm , cloaca 21 μm .

Anterior end rounded, conoid. Mouth opening minute. There are two circles of six inner and six outer labial setae close to one another. All setae slender and cylindrical. Inner labial setae 2 μm long, two times shorter than the outer labial setae (4 μm long). Inner labial setae situated at a distance 8–10 μm from the cephalic apex. Four slender cylindrical cephalic setae situated posterior to the amphideal fovea, at a distance 14 μm from the cephalic apex, their length 5.5 μm .

Amphideal fovea 8 μm long and 6 μm wide (71% of corresponding body diameter), ovoid to cordate in outline, the anterior edge with large rounded invagination on the surface; at posterior end fovea becomes wide amphideal nerve. Distance from cephalic apex to amphideal fovea 4.5 μm . Somatic sensilla represented by sparse lateral and sublateral papillae along the body.

Buccal cavity not developed as such. The anteriormost region (9 μm long) of the internal lining of the pharynx thickened and cuticularised but not differing sharply from subsequent cuticular lining. Pharynx gradually widening to the cardia. Cross striation in the pharynx not clearly seen. Dorsal sector of pharynx contains many light transparent pharyngeal cells. Ventral pore not seen.

Testes not discernible. Spicules paired and equal, short (20 μm long), and relatively broad, with internal stripes, posterior end slightly narrowed, anterior end knobbed. Gubernaculum a small compact body located postero-ventrally of spicules. Two equal midventral supplementary organs anterior to the cloacal opening, anterior one 54 μm , posterior 33 μm from the cloaca. Each comprises a small cuticular swelling with an apical crater from which a slender cylindrical seta 3–3.5 μm long protrudes.

Tail short, rounded to conoid, 1.2 anal diameters long (c'). Terminally, internal layer of the cuticle transformed into a light-refractile cap-like structure. Spinneret or even terminal duct not evident. Caudal glands barely discernible.

Diagnosis. *Litinium*. Body length 1196 μm ; a 52; c 40.6; c' 1.2. Inner labial setae 2 μm , outer labial setae 4 μm , cephalic setae 5.5 μm in length. Amphideal fovea large, with very deep anterior sinuous invagination making the fovea halfmoon-shaped. Cephalic setae at a short distance posterior to the cephalic setae. Two subsequent midventral precloacal supplementary organs with short setiform processes. Spicules equal. Tail short, with terminal sclerotization of the internal cuticular layer in shape of a truncated cone.

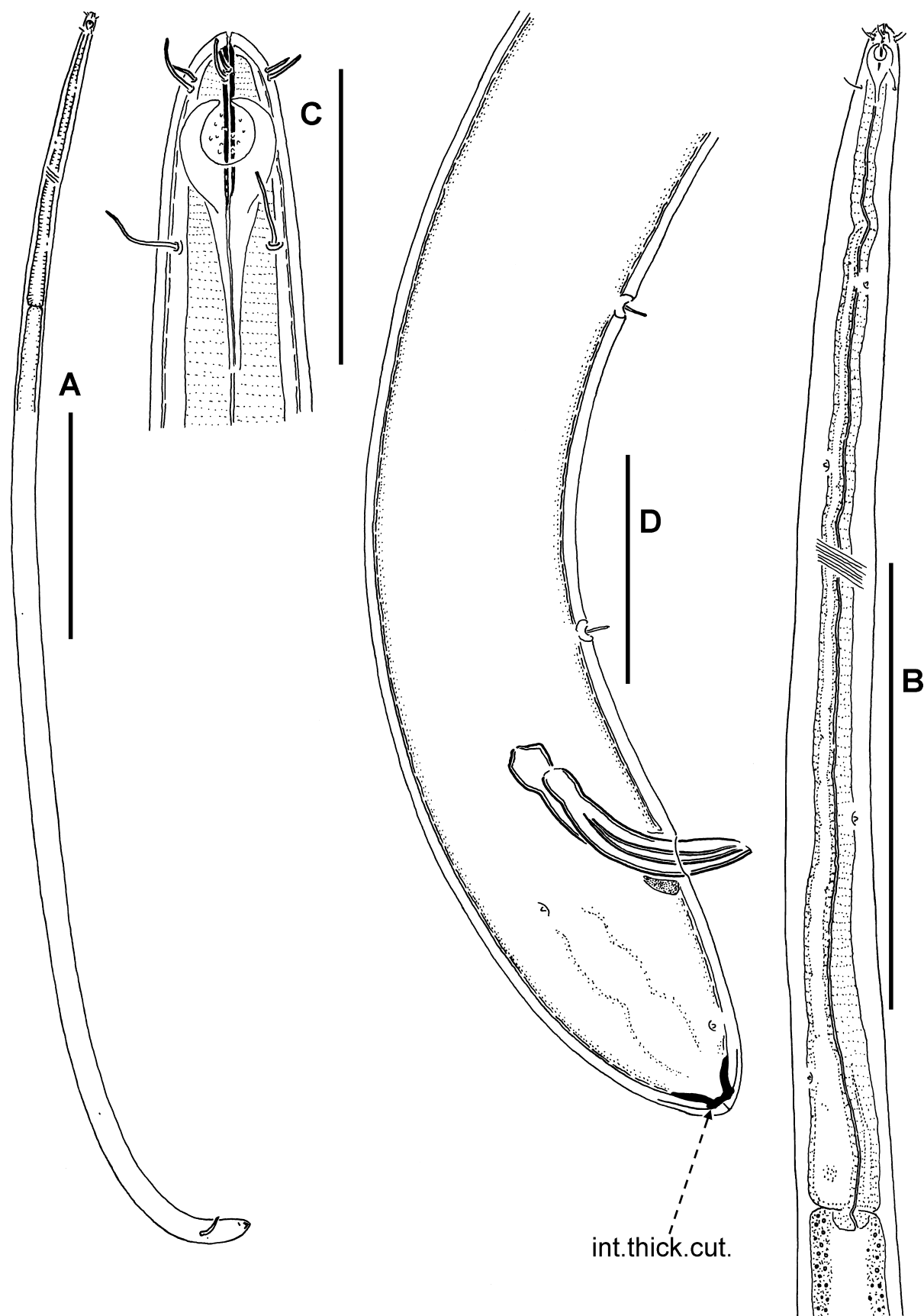


FIGURE 5. *Litinium profundorum* sp. n., holotype male. **A:** entire; **B:** anterior body; **C:** anterior end; **D:** posterior body. Arrow indicates the internal thickened cuticular layer (int.thick.cut.) in the tail terminus. Scale bars: A 200 μ m; B 100 μ m; C, D 10 μ m.

Differential diagnosis. *L. profundorum* sp. n. relates to *L. bananum*, *L. volutum*, *L. abyssorum* and *L. obtusilobus* in shape of large halfmoon-formed amphideal fovea. *L. profundorum* differs from *L. bananum* by smaller body (1196 μm vs 2140 μm), lower index *a* (52 vs 98), shorter tail (*c* 40.6 vs 19.8, *c'* 1.2 vs 6–8) and shorter anterior setae (2–5.5 μm vs 10–14 μm); from *D. volutum* by higher indices *a* and *b* (52 vs 25, 4.5 vs 9, respectively), shorter anterior setae (2–5.5 μm vs 10.5–15 μm) and two vs four precloacal supplementary setae. *Litinium profundorum* is closest to *L. abyssorum* in general appearance and size but differs by having a shorter tail (*c* 40.6 vs 15.7 and *c'* 1.17 vs 3.61), two vs one precloacal supplementary setae, and equal spicules. Another species close to *L. profundorum* is *L. obtusilobus*, but because both species are known by only one gender (male in *L. profundorum* and female in *L. obtusilobus*) proper comparison is not possible. *Litinium profundorum* has similar measurements to those of *L. obtusilobus* except for length of inner labial setae (2 μm vs 4 μm long). The structural character differentiating *L. profundorum* from *L. obtusilobus* is the distinct light-refractile sclerotization of the inner cuticle layer of the tail tip.

Etymology. Species name is derived from Latin "profundum" (deep sea).

Pictorial key for valid species of *Litinium*

(Fig. 6, Table 4)

We propose a guide for rapid identification of species of *Litinium* based on the principles and practice of Platt (1984) and his coauthors (e.g. Platt & Warwick 1983). The guide consists of two parts, a set of simplified pictures for each valid species (Fig. 1) and a table of the important dimensions showing how they vary from one species to another (Table 1). The species pictures are arranged in a sequence of gradual decreasing length of anterior setae (inner labial, outer labial and cephalic setae) from the top left to the bottom right corner of the page. Other characters important for species recognition are shape of the amphideal fovea, tail shape, and number and position of the midventral precloacal supplementary setae. A species identification made from the pictures can be verified by comparison with data in Table 1.

TABLE 4. Morphometry of valid *Litinium* species (values rounded, males and females lumped together). Measurements in μm .

Species	Characters								
	Body L	a	c	c'	i.l.s.–o.l.s.	c.s.	spic.	number of preanal supplements	distance of posterior most supplement to cloaca
<i>abyssorum</i>	710–897	51–70	13–16	3.6–5.8	3–4	2.5	8–12	1	2
<i>aequale</i>	1663–1900	56–67	76	0.86 calc	9–10	9–10	27	2	?
<i>bananum</i>	2140–3225	98–146	20	6–8	12–14	10	21	?	?
<i>curticauda</i>	2866	68	119	0.83	1.5–1.5	1.5	43–49	2	5
<i>obtusilobus</i>	680, 1600	32–45	21–40	1.5	4–4	5	-	-	-
<i>parmatum</i>	2610	79	37	4.2	7–7	18	-	-	-
<i>profundorum</i>	1196	52	41	1.2	2–4	5.5	20	2	33
<i>quangi</i>	2523–2918	81–118	72–97	1.1–1.6	1.5–2.5	1.5–2.5	30–33	1	32–35
<i>subterraneum</i>	1532–2305	70–85	27–32	3.5–5.7	2.5–4	2–4	21–23	2	23–34
<i>volutum</i>	1177	25	44	1	13–15	11	28	4	?

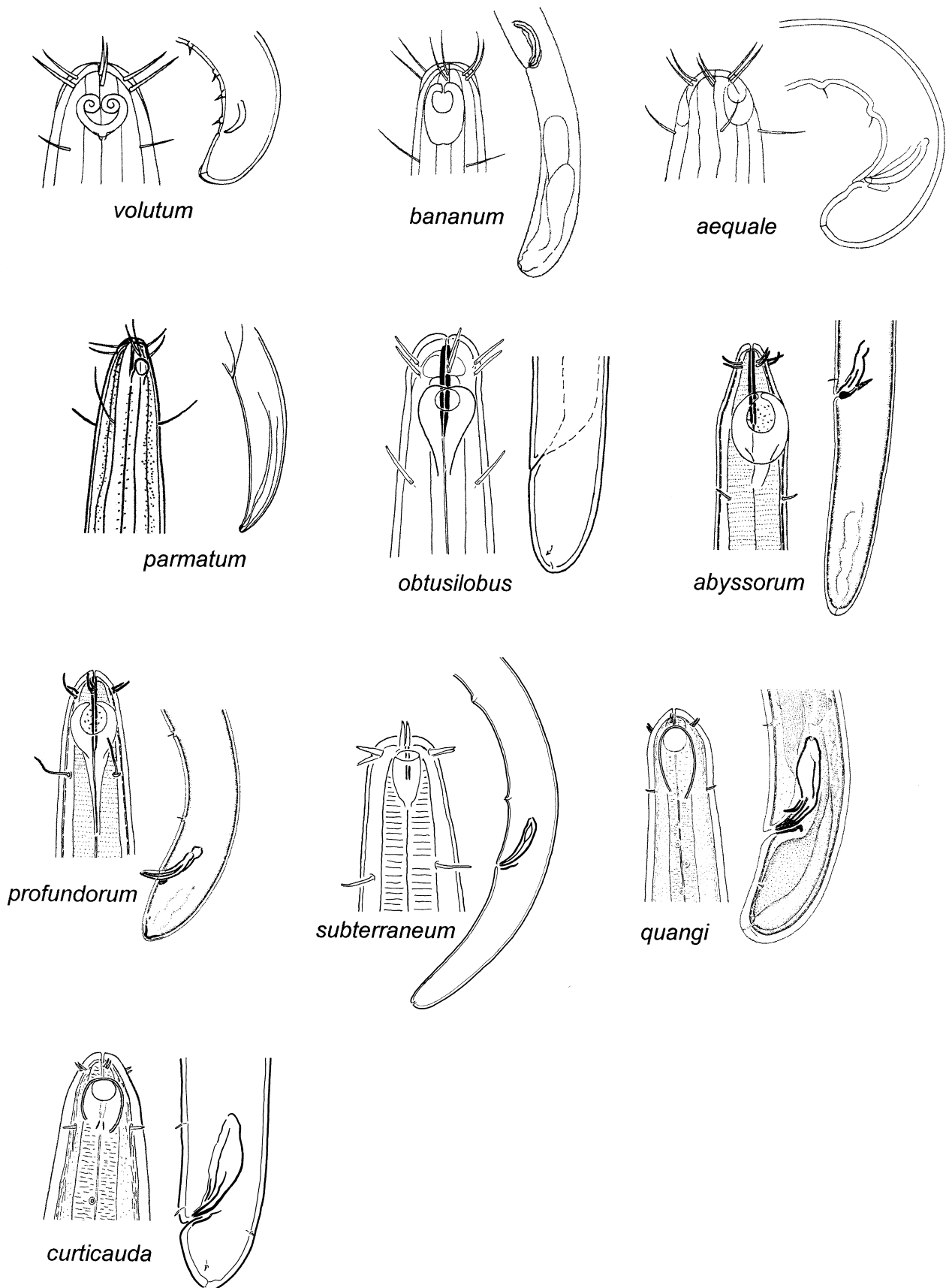


FIGURE 6. Pictorial guide for valid *Litinium* species. Caricatured images of species taken from published descriptions: *abyssorum*—orig.; *aequale*—Gerlach, 1958; *bananum*—Gerlach, 1956; *curticauda*—orig.; *obtusilobus*—Bussau, 1993; *parmatum*—Wieser, 1954; *profundorum*—orig.; *quangi*—orig.; *subterraneum*—Tchesunov *et al.*, 2010; *volutum*—Gerlach, 1962.

Several species of *Litinium* are known from either males (*L. curticauda*, *L. profundorum*, *L. volutum*) or females (*L. obtusilobus*, *L. parmatum*) only. This may make species identification difficult because of sexual dimorphism in shape of the amphideal fovea that occurs in some species. Thus, in *L. aequale*, the aperture is depicted in the middle of the fovea of females but at the anterior edge of the fovea of males. However, descriptions of females and males were made by different authors and strict comparison is not possible because the male head is not drawn in a fully lateral position. In *L. bananum*, the dimorphism of the amphideal fovea is more evident: in the female, the aperture is situated within the frame of the amphideal fovea but more close to its anterior edge while in the male the aperture breaks the anterior edge of the fovea thus making the latter crescent-shaped. Other known species, described using both sexes, have no marked dimorphism in amphid outline or other characters other than size (males may be smaller).

In the pictorial key, icons of males are given where possible. Males are preferable for identification as they have additional characters such as precloacal organs. In the Table 1, size values of males and females are given together.

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References

- Allgén, C. (1935) Die freilebende Nematoden des Öresunds. *Capita Zoologica*, 6 (3), 1–192.
- Bussau, G. (1993) *Taxonomische und ökologische Untersuchungen an Nematoden des Peru-Beckens*. PhD thesis, University of Kiel, 621 pp.
- Chitwood, B.G. (1935) Nomenclatorial notes I. *Proceedings of the Helminthological Society of Washington*, 2, 51–54.
- Cobb, N.A. (1920) One hundred new nemas (type species of 100 new species). *Contributions to a Science of Nematology* (Baltimore), 9, 217–343.
- De Coninck, L.A. (1965) Classe des Nématodes—Systématique des Nématodes et sous-classe des Adenophorea. In: Grassé, P.P. (Ed.), *Traité de Zoologie*, 4, pp. 586–681.
- De Man, J.G. (1893) Cinquième note sur les Nématodes libres de la mer du Nord et de la Manche. *Mémoires de la Société Zoologique de France*, 20, 33–90.
- Gagarin, V.G. (2009) Two species of free-living nematodes of order Enoplida from Mediterranean Sea. *Invertebrate Zoology*, 6, 13–20. [in Russian]
- Gerlach, S.A. (1956) Diagnosen neuer Nematoden aus der Kieler Bucht. *Kieler Meeresforschungen*, 12, 85–109.
- Gerlach, S.A. (1958a) Die Nematodenfauna der sublitoralen Region in der Kileler Bucht. *Kieler Meeresforschungen*, 14, 64–90.
- Gerlach, S.A. (1958b) Deuxième contribution à la faune des Nématodes des eaux interstitielles littorales de Madagascar. *Mémoires de l'Institut scientifique de Madagascar (F)*, 2, 343–365.
- Gerlach, S.A. (1962) Freilebende Meesernematoden von den Malediven. *Kieler Meeresforschungen*, 17, 81–108.
- Gerlach, S.A. & Riemann, F. (1974) The Bremerhaven checklist of aquatic nematodes. A catalogue of Nematoda Adenophorea excluding the Dorylaimida. Part 2. *Veröffentlichungen des Instituts für Meeresforschung in Bremerhaven*, Supplement 4, Heft 2, 405–734.
- Lorenzen, S. (1981) Entwurf eines phylogenetischen Systems der freilebenden Nematoden. *Veröffentlichungen des Instituts für Meeresforschung in Bremerhaven*, Supplement 7, 1–472.
- Mokievsky, V.O., Tchesunov, A.V., Udalov, A.A. & Toan, N.D. (2011) Quantitative distribution of meiobenthos and the structure of the free-living nematode community of the mangrove intertidal zone in Nha Trang Bay (Vietnam) in the South China Sea. *Russian Journal of Marine Biology*, 37, 272–283.
<http://dx.doi.org/10.1134/s1063074011040109>

- Platt, H.M. (1984) Pictorial taxonomic keys: their construction and use for the identification of freeliving marine nematodes. *Cahiers de Biologie Marine*, 25, 83–91.
- Platt, H.M. & Warwick, R.M. (1983) *Free-living marine nematodes. Part I. British Enoplids. Pictorial keys to world genera and notes for the identification of British species. Synopses of the British Fauna (New Series) No. 28*. Cambridge University Press, Cambridge, 307 pp.
- Quang, N.X., Thanh, N.V., Chau, N.N., Smol, N. & Vanreusel, A. (2008) One new and two unknown species of free-living marine nematodes from Cangio mangrove forest, Hochiminh City, Vietnam. *Journal of Biology (Hanoi)*, 30, 1–11.
- Seinhorst, J.W. (1959) A rapid method for the transfer of nematodes from fixative to anhydrous glycerin. *Nematologica*, 4, 67–69.
<http://dx.doi.org/10.1163/187529259x00381>
- Smol, N., Muthumbi, A. & Sharma, J. (2014) Order Enoplida. In: Schmidt-Rhaesa, A. (Ed.), *Handbook of Zoology, Gastrotricha, Cycloneuralia and Gnathifera, vol. 2 (Nematoda)*, De Gruyter, Berlin/Boston, pp. 193–249.
- Soetaert, K., Vincx, M., Heip, C. (1995) Nematode community structure along a Mediterranean shelf-slope gradient. *P.S.Z.N. I: Marine Ecology*, 16, 189–206.
<http://dx.doi.org/10.1111/j.1439-0485.1995.tb00405.x>
- Tchesunov, A.V., Mokievsky, V.O. & Thanh, N.V. (2010) Three new free-living nematode species (Nematoda, Enoplida) from mangrove habitats of Nha Trang, Central Vietnam. *Russian Journal of Nematology*, 18, 155–172.
- Tietjen, J.H. (1971) Ecology and distribution of deep-sea meiobenthos off North Carolina. *Deep Sea Research*, 18, 941–957.
[http://dx.doi.org/10.1016/0011-7471\(71\)90001-5](http://dx.doi.org/10.1016/0011-7471(71)90001-5)
- Wieser, W. (1954) Beiträge zur Kenntnis der Nematoden submariner Höhlen. Ergebnisse der österreichischen Tyrrhenia-Expedition 1952, Teil II. *Österreichische zoologische Zeitschrift*, 5, 172–230.