

## *Filenchus flagellicaudatus* n. sp. and *Lelenchus schmitti* n. sp. (Nemata: Tylenchidae) from Molokai, Hawaii

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*Abstract:* *Filenchus flagellicaudatus* n. sp. and *Lelenchus schmitti* n. sp. are described from Pepe'opae bog on Molokai, Hawaii. *Filenchus flagellicaudatus* n. sp. is distinguished from all other *Filenchus* spp. by stylet length (10 µm), robust metacarpus, elongated basal bulb, and extraordinarily long, whip-like tail ( $c = 2.6$ ,  $c' = 31.8$ ). *Lelenchus schmitti* n. sp. differs from other *Lelenchus* spp. by its shorter body length, weak dorso-ventral compression of the head region, and a more posterior vulva ( $V = 49-52$ ). The spacious amphid pocket is introduced as a useful character for the differentiation of *Lelenchus* spp. from other Tylenchidae.

*Key words:* amphid, *Filenchus flagellicaudatus*, Hawaii, *Lelenchus leptosoma*, *Lelenchus schmitti*, Molokai, taxonomy.

Analysis of nematode assemblages from native plant communities on Molokai Island, Hawaii, revealed numerous species, especially among Tylenchidae, that could not be assigned to known taxa (Bernard and Schmitt, 2005). The goal of the present paper is to present descriptions of two new species of Tylenchidae from Molokai.

### MATERIALS AND METHODS

Soil and litter samples (ca. 2 liters each) were collected at Pepe'opae, Molokai, a cool, montane bog (el-

evation 1,280 m) overlaid with a dense, 1-m-thick cover of ferns and dwarfed woody plants, especially 'ō'hia (*Metrosideros polymorpha* Gaud.) and pukiawe (*Styphelia tameiameia* (Cham. & Schlectend.) F. v. Muell.). Samples were transported to the laboratory in coolers, and nematodes were extracted by means of a semi-automatic elutriator (Byrd et al., 1976). Nematodes were fixed in hot 4% formaldehyde, processed to anhydrous glycerin, and mounted on Cobb slides. Illustrations were made with the aid of a drawing tube on a differential interference contrast microscope. Photomicrographs were made with a Nikon Coolpix 990 digital camera (Nikon, Tokyo), and their contrast was enhanced with Adobe Photoshop software (Adobe Systems, San Jose, CA).

### SYSTEMATICS

#### *Filenchus flagellicaudatus* n. sp.

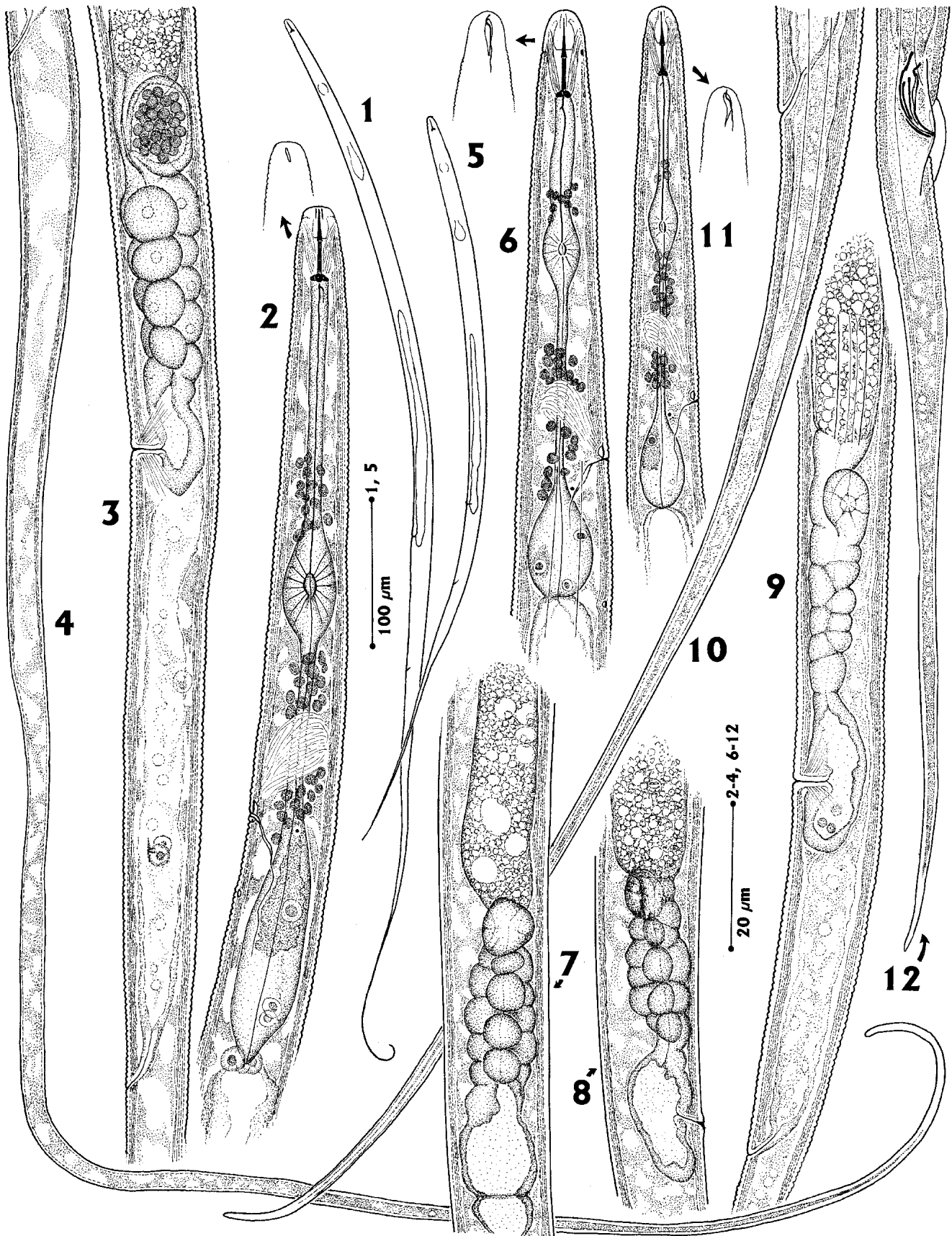
(Table 1; Figs. 1–4, 13–16)

Measurements are summarized in Table 1.

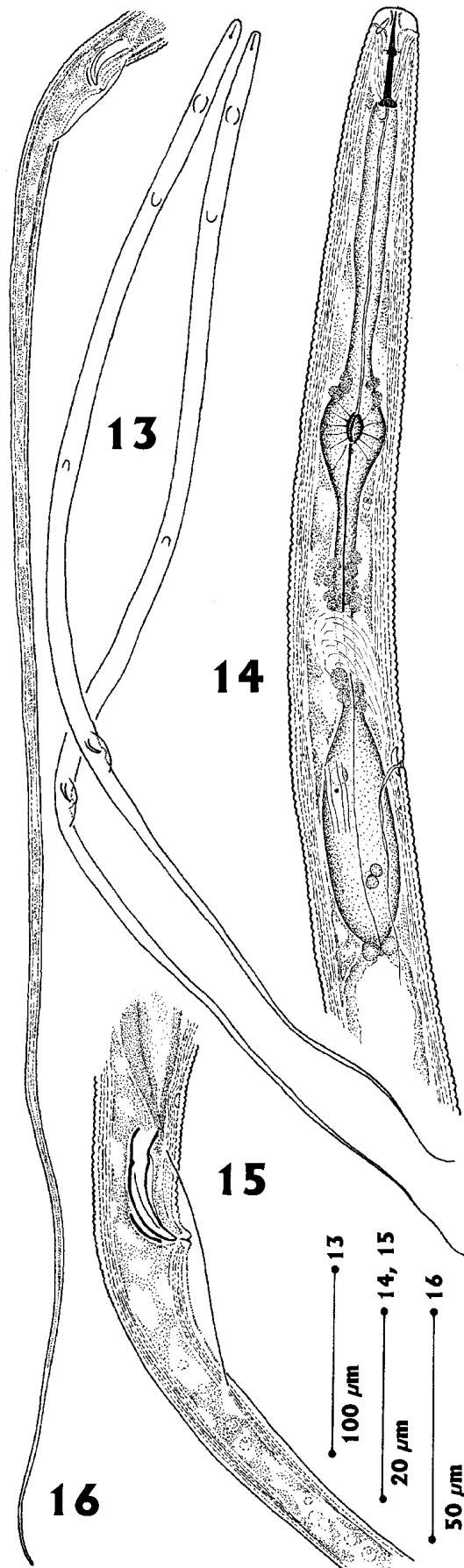
*Females:* Body slender, slightly curved ventrally when

TABLE 1. Measurements and morphometrics of type specimens of *Filenchus flagellicaudatus* n. sp. and *Lelenchus schmitti* n. sp.

	<i>F. flagellicaudatus</i> n. sp.			<i>L. schmitti</i> n. sp.			
	Holotype female	Paratype females (n = 2)	Paratype males (n = 2)	Holotype female	Paratype females (n = 5)		Paratype male
					Mean	Range	
Length (µm)	741	750	724, 797	510	503	465–577	396
Stylet length (µm)	9.7	9.8	10.6, 9.4	11.0	10.8	10.0–11.0	7.8
Head end to anus (L') (µm)	455	440	414, 432	301	311	291–356	278
Head end to vulva (µm)	366	350	—	260	254	240–290	—
Vulva to anus (µm)	86	90	—	51	57	51–66	—
Tail length (µm)	286	310	311, 365	209	193	174–221	118
Maximum body width (µm)	15	13	12, 11	12	14	13–15	10
Esophagus base to head end (µm)	116	107	109, 108	85	83	80–88	70
Basal bulb length/width	4.1	5.4	4.3, 3.7	1.6	1.5	1.4–1.7	1.8
a	49	58	60, 72	41	36	33–39	39.6
b	6.4	7.0	6.6, 7.4	6.0	6.1	5.4–7.2	5.7
c	2.6	2.4	2.6, 2.4	2.4	2.6	2.5–2.7	3.4
c'	31.8	37.3	32.9, 38.6	29.9	25.3	23.6–26.9	15.1
MB (%)	44	43	40, 42	38	40	39–42	44
V (%)	49	47	—	51	51	49–52	—
V' (%)	80	80	—	83	82	80–83	—
Tail length/vulva-anus distance	3.3	3.4	—	4.1	3.4	3.1–3.6	—
Spicule length (µm)	—	—	13.2, 13.0	—	—	—	12.3
Gubernaculum length (µm)	—	—	4.2, 4.0	—	—	—	5.4



FIGS. 1-4. *Filenchus flagellicaudatus* n. sp., female. 1) Female habitus. 2) Anterior region and amphid aperture. 3) Vulva-anus region. 4) Tail (artificially curved to fit limitations of printed page). FIGS. 5-12. *Lelenchus schmitti* n. sp. 5) Female habitus. 6) Female anterior region and amphid aperture. 7, 8) Posterior portion of female reproductive system. 9) Vulva-anus region. 10) Female tail. 11) Male anterior region and amphid aperture. 12) Male tail.



FIGS. 13–16. *Filenchus flagellicaudatus* n. sp., male. 13) Habitus. 14) Anterior region. 15) Spicule region. 16) Tail.

heat-relaxed (Fig. 1); esophageal region gradually tapering to anterior end (Fig. 2). Body gradually tapering posterior to vulva (Fig. 3). Lateral field not seen. Tail very long and whip-like, narrowing suddenly at about one-third its distance and terminating as a dorsally curving filament (Fig. 4).

Lip region continuous with neck region, not offset, with two or three obscure basal annulations. Cephalic sclerotization light. Amphid apertures oblique, linear slits on sides of cephalic region (Fig 2). Stylet slender, conus slightly shorter than shaft; knobs sloping posteriorly, apices rounded (Fig. 2). Cephalids not seen. Dorsal gland orifice within 1  $\mu\text{m}$  of stylet knobs. Median bulb robust, slightly elongated, with well-developed valve (Fig. 2). Basal bulb large and elongated, tapering posteriorly to its junction with intestine, cardia composed of three cells. Dorsal gland nucleus in anterior half of basal bulb, subventral gland nuclei posterior. Hemizonid level with anterior end of basal bulb, the secretory-excretory canal passing through it; deirids level with hemizonid; hemizonion about 10  $\mu\text{m}$  posterior to hemizonid. Intestinal fasciculi absent.

Gonad outstretched, spermatheca offset, broadly oval, filled with small, spherical sperm (Fig. 3). Uterus apparently a tricolumella. Postvulval sac short, less than one body-width in length. Vagina perpendicular to body. Vulval epitygma and vulval flaps absent. Phasmids present at about two-thirds of the distance from vulva to anus, each represented by a nucleus associated with a minute peg reaching an obscure longitudinal slit on the surface (Fig. 3).

*Males:* Habitus similar to that of female (Fig. 13). Lateral field with four thin longitudinal incisures, without areolation (Fig. 14). Caudal alae narrow, edges not crenulated (Fig. 15). Tail similar to that of female but tapering gradually to whip-like tip, without noticeable constriction (Fig. 16). Phasmids not seen.

*Type locality and habitat:* Pepe'opae, Molokai, Hawaii, 5 August 1991, D. P. Schmitt and E. C. Bernard, collectors.

*Type specimens:* Holotype and paratype females and males deposited in the USDA Nematode Collection, Beltsville, Maryland.

*Etymology:* The specific epithet is derived from the Latin words *flagellum* (little whip) and *cauda* (tail).

*Diagnosis:* *Filenchus flagellicaudatus* n. sp. is distinguished from all other *Filenchus* spp. by a combination of the following characteristics: stylet slender, 10  $\mu\text{m}$  long; metacarpus large, basal bulb elongated; tail very long and drawn out as a filiform terminus.

*Relationships:* In its possession of an extraordinarily long tail ( $c < 3$ ), vulva location, and many other dimensions, *F. flagellicaudatus* n. sp. resembles *F. normanjonessi* Raski & Geraert, 1987. The new species is distinguished by its shorter and more slender stylet (10  $\mu\text{m}$  vs. 13  $\mu\text{m}$  in *F. normanjonessi*) and large, elongated basal bulb (pyriform in *F. normanjonessi*). *Filenchus thornei* Andrassy

“England population” (Grewal, 1991) has an elongated basal bulb and a stylet of similar length, but its tail is much shorter ( $c = 4.5\text{--}4.6$ ). The overall dimensions of the esophagus are remarkably similar to those of *Ditylenchus flagellicauda* Geraert & Raski, 1990 (Geraert and Raski, 1990), but *F. flagellicaudatus* n. sp. has small sperms in an offset spermatheca (large sperms in an axial spermatheca in *D. flagellicauda*).

*Lelenchus schmitti* n. sp.  
(Table 1, Figs. 5–12, 17, 18)

Measurements are summarized in Table 1.

**Females:** Body slender, curved ventrally when heat-relaxed (Fig. 5); esophageal region tapering to anterior end. Lateral field with four incisures, the two inner incisures often obscure. Tail long, filiform, tapering evenly to a thin, subacute tip (Fig. 10).

Anterior region high, rounded, smooth, generally appearing continuous with body but slightly narrowed at some angles. Cephalic sclerotization very light. Amphid apertures longitudinal, sinuous, beginning at anterior end and extending posteriorly about 10  $\mu\text{m}$  (Figs. 6,17). Anterior part of ventral aperture lip projecting dorsally (Figs. 6,17). Amphid tube expanded into pocket-like cavity (Figs. 6,18). Stylet slender, anterior part of conus needle-like; conus and shaft of equal length; knobs sloping posteriorly, apices rounded. Cephalids at the level of the conus base and stylet knobs. Dorsal gland orifice about 1  $\mu\text{m}$  from stylet knobs. Median bulb moderately weak, valve small (Fig. 6). Isthmus very slender. Basal bulb pyriform; dorsal gland nucleus slightly posterior; subventral gland nuclei ob-

scure but apparently well-separated (Fig. 6). Distinct esophago-intestinal cells not seen. Hemizonid slightly anterior to basal bulb; secretory-excretory pore opening just behind hemizonid. Hemizonion at level of esophago-intestinal junction. Deirids posterior to level of hemizonid, level with anterior end of basal bulb. Intestinal fasciculi absent.

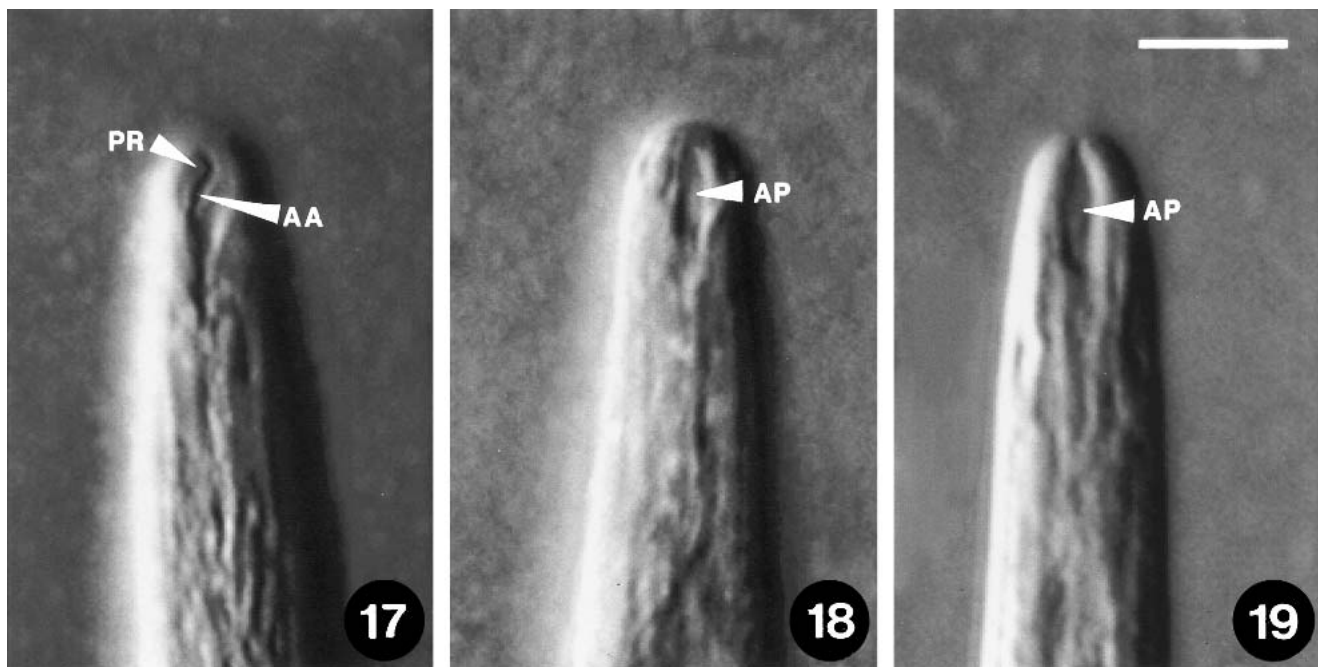
Gonad outstretched, spermatheca oval, offset, devoid of sperm. Uterus a quadricolumella. Postvulval sac short, less than one body-width in length. Vagina perpendicular to body or slightly inclined anteriorly. Vulval epiptygma and vulval flaps absent. Phasmids not seen.

**Male:** Similar to female in head shape and most other characteristics. Amphid apertures longitudinal, long, sinuous, with dorsal projection of ventral edge as in female; amphidial pocket distinct (Fig. 11). Esophageal characters proportionally similar to those of female, with slender isthmus. Tail filiform (Fig. 12), proportionally shorter than that of female. Caudal alae small, edges smooth. Spicules arcuate, gubernaculum linear in lateral view.

**Type locality and habitat:** Pepe’opae, Molokai, Hawaii, 5 August 1991, D. P. Schmitt and E. C. Bernard, collectors.

**Type specimens:** Holotype female, five paratype females, and paratype male deposited in the USDA Nematode Collection, Beltsville, Maryland.

**Etymology:** This species is named with pleasure for the eminent nematologist Dr. Donald P. Schmitt, whose interest in the indigenous nematode fauna of Hawaii led to the collection of the species described in this paper.



FIGS. 17–19. Cephalic regions of *Lelenchus* spp. 17) Amphid aperture of *L. schmitti* n. sp. 18) Amphidial pocket of *L. schmitti* n. sp. 19) Amphidial pocket of *L. leptosoma* from Alaska. AA: amphid aperture; AP: amphidial pocket; PR: projection of ventral lip of amphid aperture. Scale bar = 10  $\mu\text{m}$ .

*Diagnosis:* *Lelenchus schmitti* n. sp. is differentiated from all other currently recognized *Lelenchus* spp. by its diminutive body length (465–577  $\mu\text{m}$ ), weak dorso-ventral compression of head, stylet length (10–11  $\mu\text{m}$ ), smaller V' ratio (head to vulva length/head to anus length, 80–83), small caudal alae (20  $\mu\text{m}$ ), and lack of prominent lateral field.

*Relationships:* *Lelenchus schmitti* n. sp. most closely resembles *L. filicaudata* Raski & Geraert, 1985 in general proportions. However, the tail of *L. filicaudata* is described and illustrated as hair-like in its posterior third, whereas in *L. schmitti* n. sp. the tail is slender but not hair-like, with a narrowly rounded tip. The caudal alae of *L. schmitti* n. sp. are about 20  $\mu\text{m}$  long, whereas, those of *L. filicaudata* are 29–30  $\mu\text{m}$  long. *Lelenchus schmitti* n. sp. is shorter (465–577  $\mu\text{m}$  vs. 516–617  $\mu\text{m}$  for *L. filicaudata*), has a more posterior vulva (V = 49–52 vs. 45–50), and has a proportionally less elongated tail ( $c' = 24\text{--}27$  vs. 25–33), but these measurements overlap. The head of *L. schmitti* n. sp. dorso-ventrally is flattened only very slightly, whereas in *L. filicaudata* the compression is distinct.

#### DISCUSSION

Females of Tylenchidae generally are considered to have a quadricolumellar uterus (Geraert and Raski, 1987), but the evidence for this arrangement in *Filenchus* spp. is equivocal. The genus was reported to have a tricolumellar uterus by Geraert (1981), but this status was considered unconfirmed by Geraert and Raski (1987). In some recent descriptions of *Filenchus* spp. (e. g., Mizukubo, 1993; Raski and Geraert, 1986; Zeidan and Geraert, 1991), a quadricolumella is specifically mentioned; in others (e. g., Brzeski, 1997a, 1997b; Karegar and Geraert, 1998a, 1998b) this character is not described. The illustrations of the uteri in some of these papers suggest that they were partially collapsed or shrunken, perhaps during fixation and processing, which would make the determination of the number and arrangement of cells difficult. In *F. flagellicaudatus* n. sp., the reproductive tract is not collapsed or shrunken, and so the tricolumellar nature of the uterus is clearly visible as three rows of four or five cells per row. This arrangement accords with Geraert's (1981) original concept of the structure in *Filenchus* spp. The variability of this character is inadequately known but may be a useful character in assessing whether the genus *Filenchus* is monophyletic.

A second unusual feature of *F. flagellicaudatus* n. sp. is the presence of phasmids, which were visible in the females but not the males. Although phasmids typically are very obscure in Tylenchidae, they have been reported from species in many genera, often in a dorso-lateral position (Siddiqi, 1985). Karegar and Geraert (1998a, 1998b) noted in several *Filenchus* spp. the presence of phasmid-like sensilla near the vulva in the lat-

eral field or offset dorsolaterally from the lateral field. Offset phasmids also have been noted in other Tylenchida, such as the juveniles of *Meloidogyne konaensis* (Eisenback et al., 1994). In *Filenchus* spp., the paired nature of these structures near the vulva or between the vulva and anus in at least some species suggests that we can call them phasmids and consider them homologous to phasmids in other Tylenchida.

The generic placement of filiform-tailed Tylenchidae can still be difficult, despite important revisionary work conducted within the past 20 years. *Lelenchus* Andrassy was revised by Raski and Geraert (1985), who considered the genus defined by a high, smooth cephalic region narrowed dorso-ventrally; amphid apertures formed of elongate, longitudinally oriented slits beginning near the oral cap; slender, fusiform median bulb; very slender isthmus; lateral vulval membranes; and long, almost filamentous tail. Several species previously placed in *Lelenchus* but not meeting these criteria were transferred to *Filenchus* Andrassy. Raski and Geraert (1986) later reviewed *Filenchus*, separating it from *Tylenchus* Bastian (as redefined by Andrassy [1954]) by the presence of elongate, slit-like amphid apertures. *Lelenchus* and *Filenchus* were not compared in Raski and Geraert (1986). Even with these careful studies, in light microscopy the two genera cannot be reliably separated based on amphidial aperture alone. For instance, *F. normanjonessi* has very long amphid apertures beginning on the labial plate and running the length of the cephalic region. (Raski and Geraert, 1986). Of probable value is the character "smooth cephalic region narrowed dorso-ventrally," which, however, may be impossible to determine without scanning electron microscopy. Of greater utility in light microscopy may be the presence of capacious, pouch-like amphidial tubes or pockets (Maggenti, 1981) accommodated by the high, rounded cephalic region (Figs. 17–19). Species transferred from *Lelenchus* to *Filenchus* by Raski and Geraert (1985) have shallow cephalic regions and no visible amphid apertures. *Lelenchus schmitti* n. sp. does not have a strongly dorso-ventrally flattened cephalic region, but the anterior region is high and round, with distinct longitudinal amphid apertures covering prominent amphidial pockets (Figs. 17,18). The same characters are present in specimens of *L. leptosoma* (de Man, 1880) Meyl 1961 from Alaska and Hawaii (Fig. 19). Therefore, it appears that species of *Lelenchus* can be separated readily from *Filenchus* spp. by these cephalic and amphidial characteristics.

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