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Description of *Tylenchorhynchus thermophilus* n. sp. (Nematoda: Tylenchina) from Saltgrass in Death Valley, California

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Abstract: A stunt nematode, *Tylenchorhynchus thermophilus* n. sp., is described and illustrated from soil collected around roots of saltgrass *(Distichlis spicata)* in Death Valley, California. It is distinguished from the similar species, *T. ewingi, T. mexicanus,* and *T. mashoodi,* in having a longer female body, longer tail with more annules, and larger phasmids. Physical and chemical analysis of soil from saltgrass roots showed it to consist of 71% sand and possess high salinity (salt content of 0.51%) and a pH of 9.3.

Key words: California, Death Valley, *Distichlis spicata,* morphology, new species, saltgrass, stunt nematode, taxonomy, temperature, *Tylenchorhynchus ewingi, T. mashoodi, T. mexicanus, T. thermophilus.*

For about 3 years during the late 1950s, one of us (AMG) worked on nematodes of sugarbeets at the USDA Agricultural Research Station in Salinas, California. During this time, a small number of nematode samples were collected from certain plants in the desert areas of the southeastern part of California. This report on samples obtained from Death Valley describes a new *Tylenchorhynchus* species from saltgrass and some details on associated soil and climate.

MATERIALS AND METHODS

Soil and root samples from saltgrass (*Distichlis spicata* (L.) Green) were collected at random sites in Death Valley National Monument, California. About 2 liters of similar soil were obtained for physical and chemical analysis (U.S. Salinity Laboratory, USDA ARS, Riverside, CA). All samples were taken within the zone below sea level, which reaches a maximum of −86 m (−282 ft), the lowest point in the Western Hemisphere. Specimens were separated from soil by sieving and Baermann funnel extraction, after which both specimens and roots were fixed and processed to glycerine by the formalin-glycerine method of Golden (3,4). Some specimens were mounted in glycerine and briefly examined in Salinas, and the remaining material was stored in vials of glycerine; all were brought to Beltsville in 1959. Recently, this material was further examined. For the new species described herein, morphometric data were obtained and processed with an image analysis system attached to a compound microscope. Photomicrographs were made with an automatic 35-mm camera on a compound microscope equipped with a differential interference contrast system. Drawings were prepared using Adobe Illustrator 5 on a Macintosh Quadra 660AV computer. All measurements are in micrometers (μm) unless otherwise specified. For scanning electron microscopy (SEM), specimens fixed and infiltrated with glycerine by Golden's method (3,4) were mounted on stubs, coated with 20 nm gold palladium, and examined with a JEOL 35C at 6kV.

SYSTEMATICS

Tylenchorhynchus thermophilus n. sp.
(Figs. 1–5)

Holotype (female, in glycerine): Length 780; width 26.6 at midbody; a = 29.3; b = 5.2; c = 14.2; head width 8.5; head height 3.7; head w/h = 2.3; stylet 19.5; DGO 3.3

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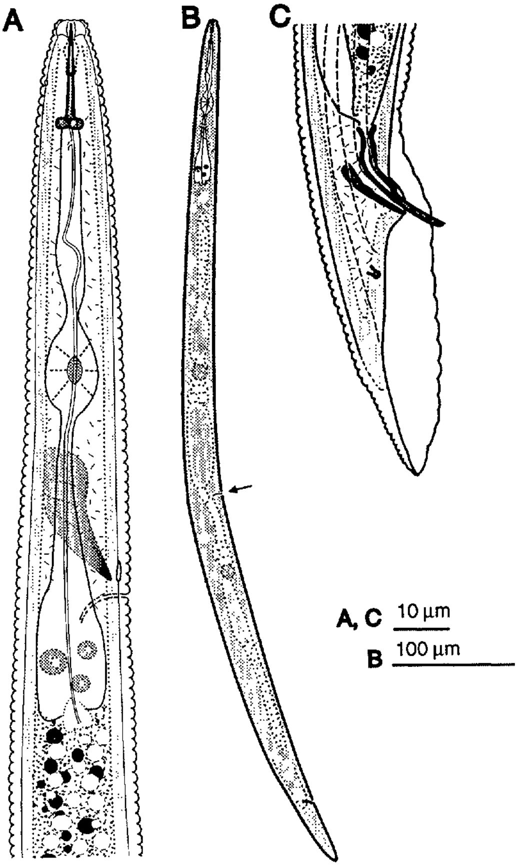

FIG. 1. *Tylenchorhynchus thermophilus* n. sp. A) Anterior region of female. B) Female (arrow at vulva). C) Posterior region of male.

to stylet base; stylet knob width 4.7; stylet knob height 2.4; stylet knob w/h = 1.96; center of median bulb valve 75.4 to head end; base of esophageal gland bulb 149.5 to head end; excretory pore 120.0 to head end; vulva 415.0 to head end; V = 53.2%; lateral field width 8.9; tail length 54.9; tail annules 25; phasmids 51.0 to tail tip.

Female (n = 12, in glycerine): Morphometrics in Table 1. Body vermiform, often with slight ventral curvature and some tapering at extremities (Figs. 1B,2A). Head bluntly rounded, continuous with body contour, and bearing three or four annules; cephalic framework moderately sclerotized (Figs. 1A,2B–C). With SEM, labial disc flattened laterally, dorsally, and ventrally, resulting in a squarish pattern; margin of labial disc interrupted laterally by amphidial openings (Fig. 5A). Posterior to labial disc, a continuous lip annule, broadest on lateral sides. Stylet strong, with large, rounded knobs, anterior margins directed forward slightly (Figs. 1A,2B–C). Dorsal gland orifice (DGO) near stylet base. Median esophageal bulb spheroid with refractive valvular apparatus in center (Figs. 1A,2D–E). Basal esophageal bulb with small conoid cardia. Hemizonid prominent, 1–2 annules anterior to distinct excretory pore (Figs. 1A,2E–F). Excretory pore near anterior end of basal esophageal bulb. Cuticular annules about 2 µm wide, becoming coarser near tail terminus (Figs. 3E–F,5B). Lateral field width about one-third the body width, not areolated, with four incisures, outer two slightly crenate (Figs. 3D,5C). Vulva a transverse slit (Figs. 2G,5D); vagina extending inward one-half body width and at right angles to body axis. Spermatheca round to broadly oval, with sperm (Fig. 2H). Ovaries amphidelphic, outstretched; anterior ovary often extending to within 10–50 µm of basal esophageal bulb, posterior ovary sometimes within 25–70 µm of rectum (Fig. 1B). Intrauterine eggs large, filling body cavity (Figs. 1B,2G), 74–75 µm long and 18–19 µm wide (N = 5). Postuterine sac small or absent, one anal body width or less in length. Tail tapering, conoid; terminus bluntly conoid, without striations (Figs. 3A–C,E–F). Phasmids prominent, located about 80% or more of tail length from tip (Figs. 3G,5B).

Allotype (male, in glycerine): Length 723; width 19.7 at midbody; a = 36.6; b = 5.1; c = 14.2; head width 7.5; head height 3.3; head w/h = 2.3; stylet 19.3; DGO 2.3 to stylet base; stylet knob width 4.7; stylet knob height 2.2; stylet knob w/h = 2.1; center of median bulb valve 68.2 to head end; base of esophageal gland bulb 141.0 to head end; excretory pore 105.8 to head end; lateral field width 6.9; tail length 50.8; phasmids 39.0 to tail tip; spicule length 23.5; gubernaculum length 13.4.

Male (n = 12, in glycerine): Morphometrics in Table 1. Except for sexual dimorphism, male similar to female in most respects (Figs. 4B–D,H). Lip pattern slightly

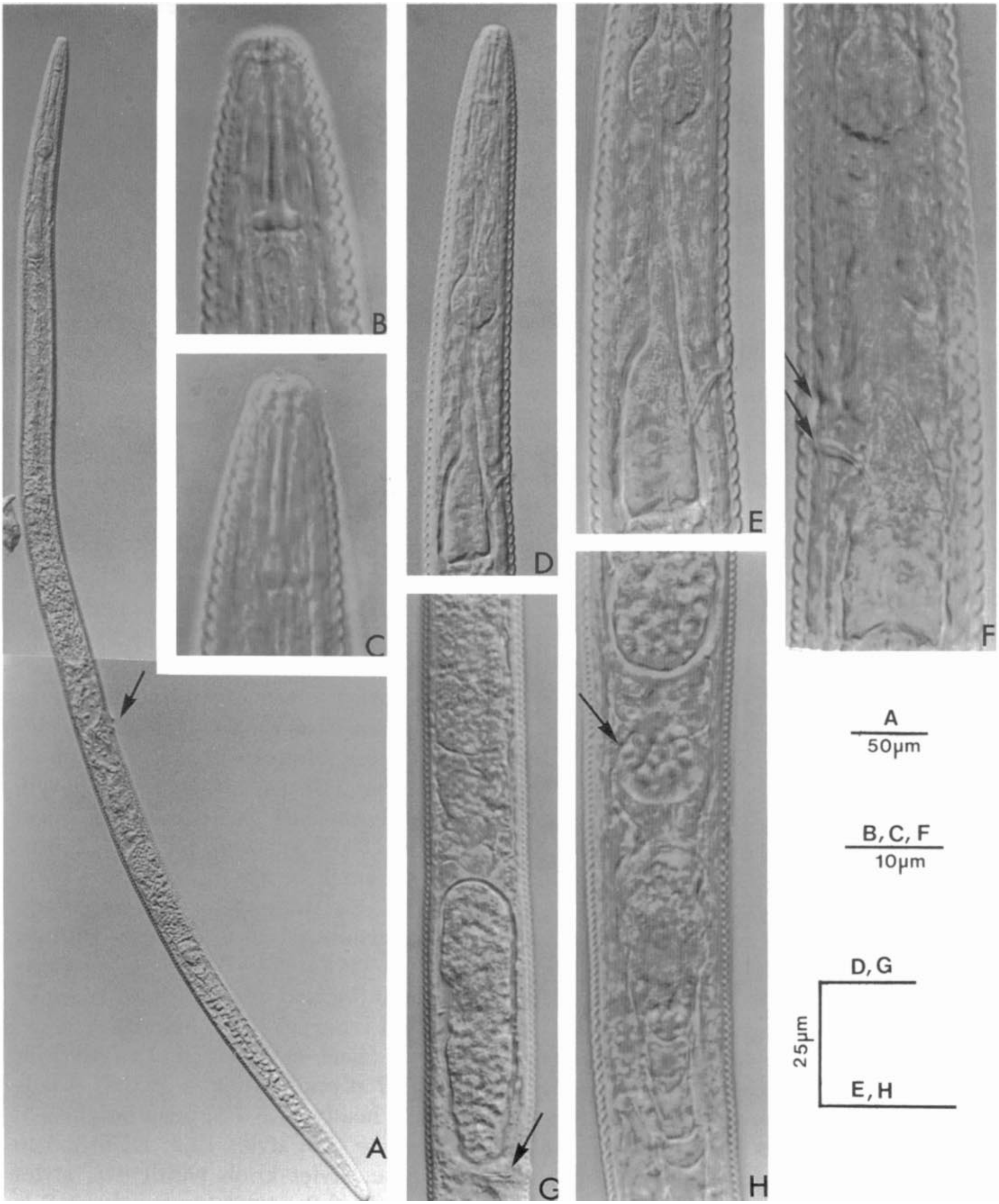

FIG. 2. Photomicrographs of female of *Tylenchorhynchus thermophilus* n. sp. A) Female (arrow at vulva). B,C) Head and stylet. D,E) Anterior region. F) Esophageal region (arrows at hemizonid and excretory pore). G) Vulva (arrow) and egg. H) Spermatheca (arrow) and portions of egg (above) and ovary (below).

more elevated than that of female; labial disc more irregular in shape, particularly on dorsal and ventral sides (Figs. 4A,5E). Male body length, body width, and lateral field width less than that of female; ratio "a" larger in male than in female. Testis single, outstretched anteriorly. Tail enveloped by crenate-edged bursa; phasmids opening on tail about 75% of tail length from tip (Figs. 1C,5F). Spicules arcuate, distally flanged; tip narrow, pointed, without notch (Fig. 1C). Gubernaculum well devel-

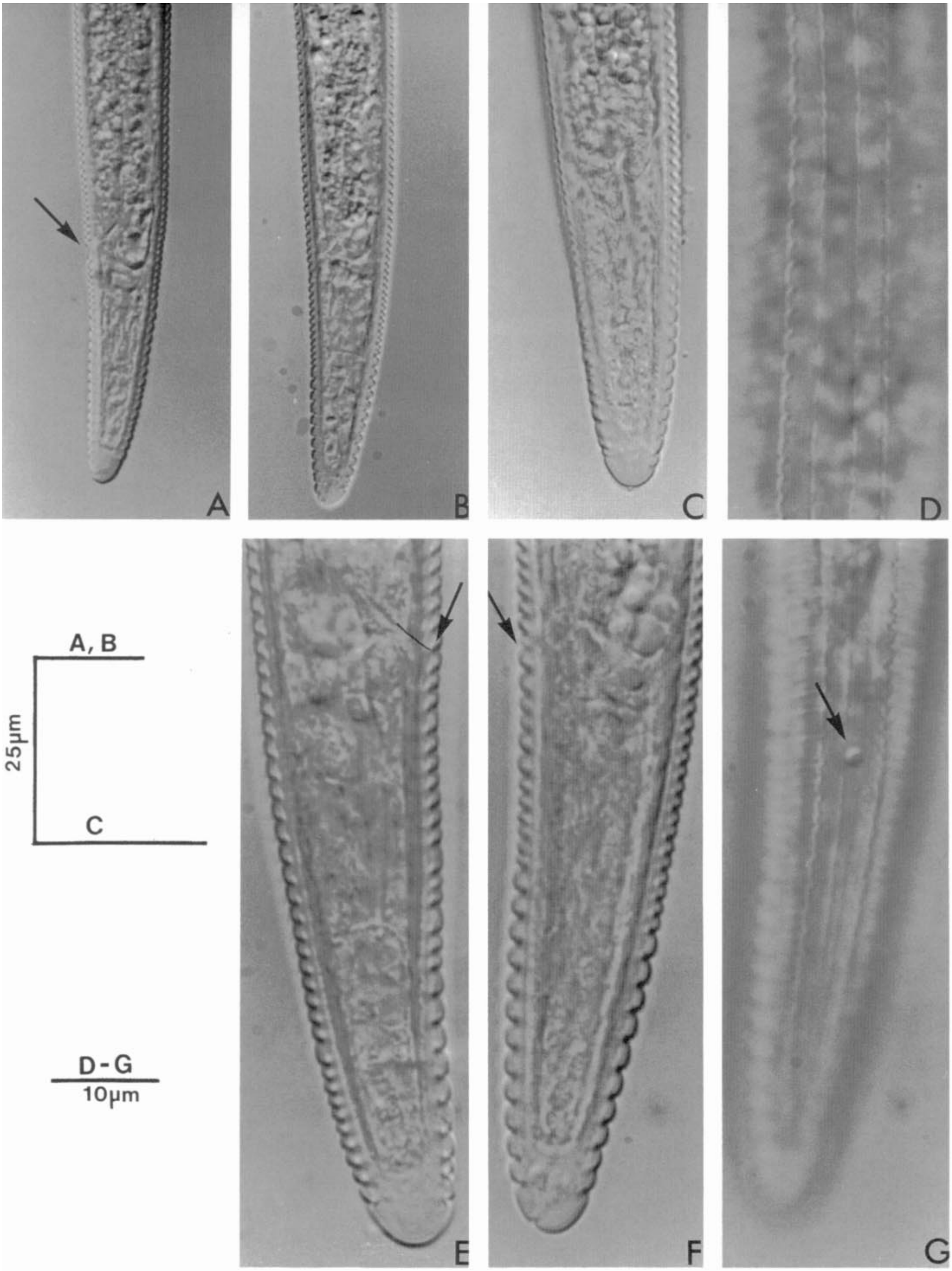

FIG. 3. Photomicrographs of female of *Tylenchorhynchus thermophilus* n. sp. A–C) Posterior region (arrow at anus). D) Lateral field at midbody (outer incisures crenated). E,F) Tail region (arrows indicate anus; rectal lumen enhanced in Fig. 3E for clarity). G) Phasmid (arrow) in lateral field.

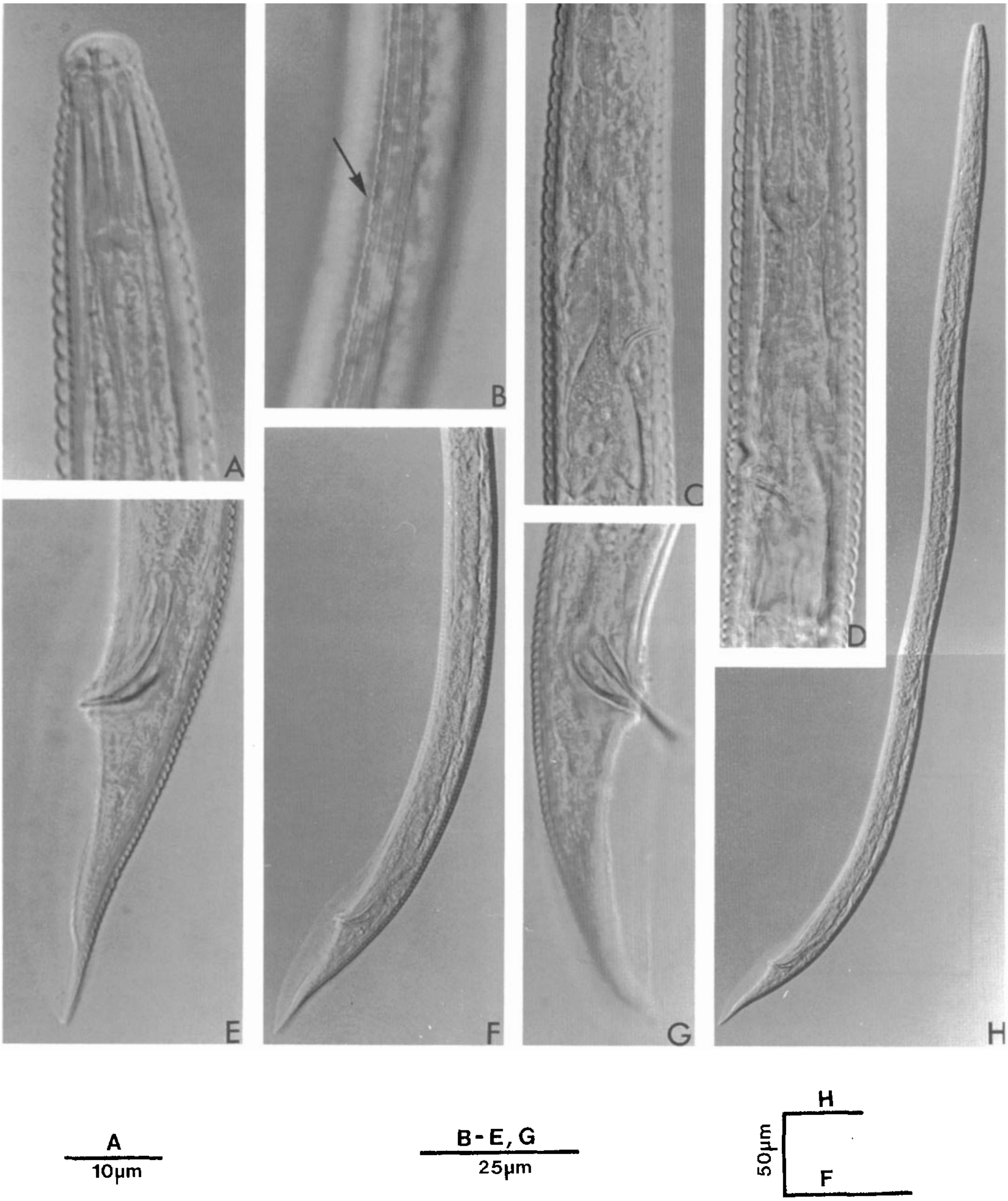

FIG. 4. Photomicrographs of male of *Tylenchorhynchus thermophilus* n. sp. A) Head and stylet. B) Lateral field (arrow) near midbody. C,D) Esophageal region (note hemizonid and excretory pore). E–G) Posterior region. H) Male.

oped, rod-like, with some ventral curvature proximally (Figs. 1C,4E–G).

Type host and locality

Soil around roots of saltgrass (*Distichlis spicata* (L.) Green) in Death Valley National Monument, California. Samples collected at random, beginning near junction of Highways 190 and 178 (just south of Borax Museum) and then south on 178 for about 25 km to a point south of Devil's Golf Course near Badwater and east of the lowest point below sea level in the Western Hemisphere: −86 m (−282 ft), collected 2 April 1958 by A. Morgan Golden.

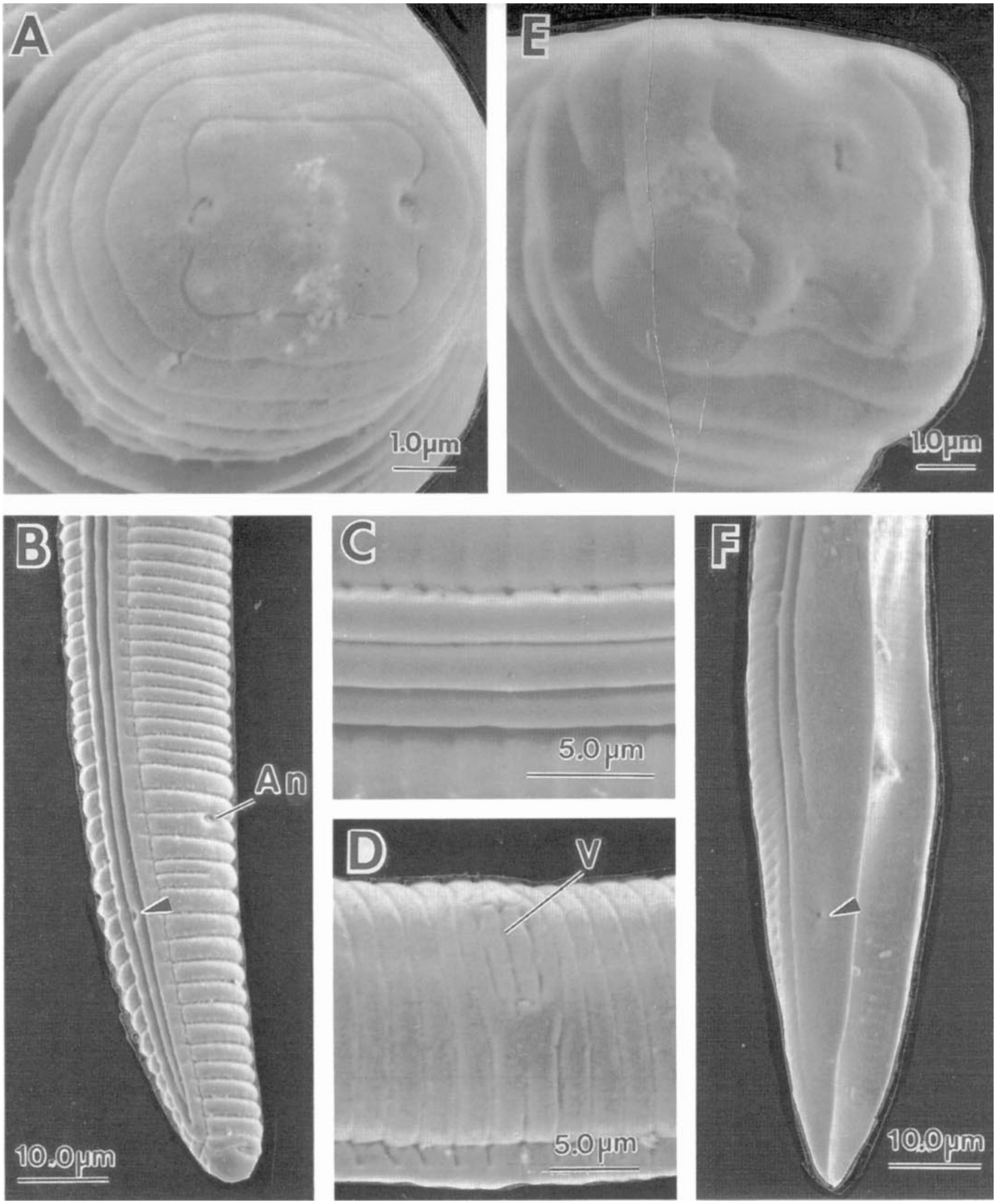

FIG. 5. Scanning electron micrographs of *Tylenchorhynchus thermophilus* n. sp. A) Face view of female. B) Tail of female showing position of anus (An) and phasmidial opening (arrowhead). C) Lateral field near midbody of female. D) Ventrolateral view of vulva (V). E) Face view of male lip pattern tilted slightly submedially. F) Posterior region of male and location of phasmidial opening (arrowhead).

Type specimens

Holotype (female): Isolated from soil from the type host and locality. Slide T-502t, deposited in the U.S. Department of Agriculture Nematode Collection, Beltsville, Maryland, USA.

Allotype (male): Slide T-503t, same data and repository as holotype.

Paratypes (males and females): Same data

TABLE 1. Morphometrics of females and males of *Tylenchorhynchus thermophilus* n.sp.

Character	Female (n = 12)		Male (n = 12)	
	Mean ± SD	Range	Mean ± SD	Range
Linear (μm)				
Body length	783 ± 45.5	696–851	720 ± 44.7	663–805
Body width at midbody	26.6 ± 1.5	24.7–29.6	21.2 ± 0.9	19.7–22.6
Head width	8.1 ± 0.4	7.5–8.8	7.4 ± 0.2	7.0–7.5
Head height	3.5 ± 0.4	2.8–4.0	3.2 ± 0.3	2.8–3.8
Stylet length	19.5 ± 0.3	18.9–20.2	19.1 ± 0.2	18.8–19.3
DGO to stylet base	2.8 ± 0.5	2.1–3.6	2.3 ± 0.1	1.9–2.3
Stylet knob width	4.7 ± 0.4	4.1–5.5	4.4 ± 0.2	4.2–4.7
Stylet knob height	2.3 ± 0.2	2.1–2.6	2.1 ± 0.2	1.9–2.3
Median bulb valve to head end	71.3 ± 3.5	66.8–78.1	69.5 ± 2.8	64.9–74.3
Base of esophageal bulb to head end	142 ± 7.1	130–150	135 ± 5.7	125–142
Excretory pore to head end	117 ± 4.6	111–125	112 ± 4.9	106–119
Vulva to head end	426 ± 26.1	381–463.5		
Annule width at midbody	2.0 ± 0.3	1.4–2.7	1.9 ± 0.2	1.7–2.3
Lateral field width	8.9 ± 0.7	7.7–9.5	7.0 ± 0.2	6.6–7.0
Tail length	56.3 ± 4.9	46.3–65.0	47.9 ± 3.7	43.7–56.4
Tail annules	26.7 ± 3.7	21.0–34.0		
Phasmid to tail tip	45.5 ± 4.5	39.2–51.3	36.1 ± 2.9	32.9–42.3
Spicule length			23.3 ± 0.5	22.1–23.5
Gubernaculum length			13.7 ± 0.5	13.2–14.1
Ratios				
a	29.5 ± 2.3	25.8–33.3	34.0 ± 2.9	30.5–39.8
b	5.5 ± 0.3	5.2–6.2	5.3 ± 0.2	5.1–5.7
c	14.0 ± 1.0	12.8–16.0	15.1 ± 1.1	14.2–17.8
Head width/height	2.3 ± 0.2	2.0–2.7	2.3 ± 0.2	2.0–2.7
Stylet knob width/height	2.0 ± 0.2	1.8–2.6	2.1 ± 0.2	1.8–2.2
Percentages				
V%	54.4 ± 1.0	52.9–55.8		

and repository as holotype. Additional paratypes deposited in the University of California-Riverside Nematode Collection (UCRNC), Riverside, California.

Diagnosis

Tylenchorhynchus thermophilus n. sp. can be distinguished from other *Tylenchorhynchus* spp. by two or more of the following characters: Female body length 696–851, male length 663–805; female tail 46–65 long, with 21–34 annules; prominent phasmids; head bluntly rounded, not set off; stylet length 19–20, with prominent knobs; postanal intestinal sac one ABW or less, or absent; outer two incisures of lateral field crenate; spicule tip without notch; gubernaculum rod-shaped, proximal end rounded.

Relationships

Tylenchorhynchus thermophilus n. sp. is most similar to *T. ewingi* Hopper, 1959 (5), *T. mexicanus* Knobloch & Laughlin, 1973 (6), and *T. mashoodi* Siddiqi & Basir, 1959 (7). Female *T. thermophilus* n. sp. are longer (696–851) than the females of these three species (*T. ewingi,* 553–752; *T. mexicanus,* 550–790; *T. mashoodi,* 615–760) and have longer tails (43–65) with more annules (21–34) (*T. ewingi,* 43, 15; *T. mexicanus,* 34, 12–22; *T. mashoodi,* 40, 13–16). The stylet knobs of *T. thermophilus* n. sp. are larger than in the other three species, and the anterior edges are directed slightly forward, rather than sloping posteriorly. *Tylenchorhynchus thermophilus* n. sp. differs additionally from *T. ewingi* in having a bluntly rounded rather than hemispherical head, and a small (one body width or less) postanal intestinal sac, rather than a large sac (greater than one body width). The new species differs further from *T. mexicanus* in having longer males (663–805 vs. 540–760); a small postanal intestinal sac (none in *T. mexicanus*), crenate rather than smooth outer lateral incisures; prominent phasmids (distinct but small in *T. mexicanus*); spicule tips entire, not bifurcate; and proximal end of gubernaculum gently curved, rather than crescent or hook-shaped. *Tylenchorhynchus thermophilus* n. sp. also differs from *T. mashoodi* in having longer males (663–805 vs. 590–710), a postanal intestinal sac (none in *T. mashoodi*), and prominent phasmids (distinct but small in *T. mashoodi*).

Discussion

Comparison of SEM lip patterns of *T. thermophilus* n. sp. with patterns of a number of additional *Tylenchorhynchus* species (Baldwin, Mundo-Ocampo, and Bell, unpubl.) suggests that the lip pattern of *T. thermophilus* n. sp. has a greater degree of fusion than other species examined. Many other *Tylenchorhynchus* species have distinctly set-off subdorsal and subventral lips.

In addition to the above new species, some other nematodes were also collected from saltgrass in Death Valley. Females of an undescribed *Meloidogyne* sp. and two females of an undescribed criconematid species similar to *Trophotylenchulus* spp. were found on roots. Males and juveniles of the *Meloidogyne* sp., one male of the criconematid, *Helicotylenchus* spp., *Tylenchorhynchus* spp., a few Dorylaimida, and several Cephalobidae were collected from soil. Unfortunately, the lack of sufficient specimens prevents accurate identification and description at this time. We plan to make additional collections soon to complete the study of these and other forms that might be found.

The soil from which *T. thermophilus* n. sp. and other nematodes were collected is classified as a very fine sandy loam, consisting of 71% sand, 21.6% silt, and 7.4% clay. The soil has high salinity (with a salt content of 0.51%); high boron and sodium contents, and a high pH of 9.3. Annual rainfall averages 5 cm (2 inches) or less, and high temperatures, especially in summer months, are common. The second highest air temperature in the shade ever recorded, 56.7 C (134 F), was in Death Valley, exceeded only by 57.7 C (136.4 F) in Libya (1,2). These soil and climatic factors appear to present harsh conditions for the survival and development of nematodes. Perhaps nematodes are less delicate and more adaptable to their adverse ecological surroundings than generally recognized, and further investigations along these lines as well as determination of the kinds of nematodes involved might well be fruitful and warranted.

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