

Trichodorus elefjohnsoni n. sp. (Nemata: Trichodoridae) from Undisturbed Appalachian Forest

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Abstract: A new species of Trichodoridae, *Trichodorus elefjohnsoni*, is described from undisturbed regions of Great Smoky Mountains National Park, United States. It resembles *T. orientalis* De Waele & Hashim, 1984, *T. persicus* De Waele & Sturhan, 1987, and *T. taylori* De Waele, Mancini, Roca, & Lamberti, 1982 in arrangement of ventromedian cervical papillae and posterior preanal supplements, but differs by combinations of the following characteristics: body length 516-731 µm; spicule length 33-50 µm, spicules densely striated, constricted medially; vaginal sclerotizations ovate; one pair of lateral body pores near vulva.

Key words: nematode, North Carolina, stubby-root nematode, taxonomy, Tennessee, *Trichodorus elefjohnsoni*.

Great Smoky Mountains National Park (GRSM), in the southern part of the Appalachian range, harbors the largest remaining areas of primeval eastern forest in the United States. About 20% of the park's area is considered "high in virgin forest attributes" (5): presence of big and old trees, lack of logging and homesteading, no direct or indirect signs (excluding trails) of human activity. An additional 8% of GRSM is categorized as "big trees plus diffuse human activity" (5): similar to areas high in virgin forest attributes but with occasional evidence of homesites, noncorporate logging, etc. These sites may provide valuable clues to the primeval nematofauna of eastern North America, and thus to the biogeography of nematodes on the continent, which probably has been obscured by extensive and prolonged agricultural activity. This investigation is the first in a series describing the nematodes of GRSM, in order to develop a biogeographical analysis of the southern Appalachian nematofauna.

MATERIALS AND METHODS

Nematodes were extracted from soil collected at sites high in virgin attributes or in areas with big trees and diffuse distur-

bance (5). Hand-picked nematodes were fixed in hot (60 C) 4% formalin, then processed to pure glycerin according to Seinhorst's rapid method (6), and mounted on permanent slides in glycerin. Drawings and measurements were made from glycerin-mounted specimens with the aid of a drawing tube. Decraemer (1) was used as a supplementary guide to the preparation of the description.

SYSTEMATICS

Trichodorus elefjohnsoni n. sp.
(Figs. 1-10)

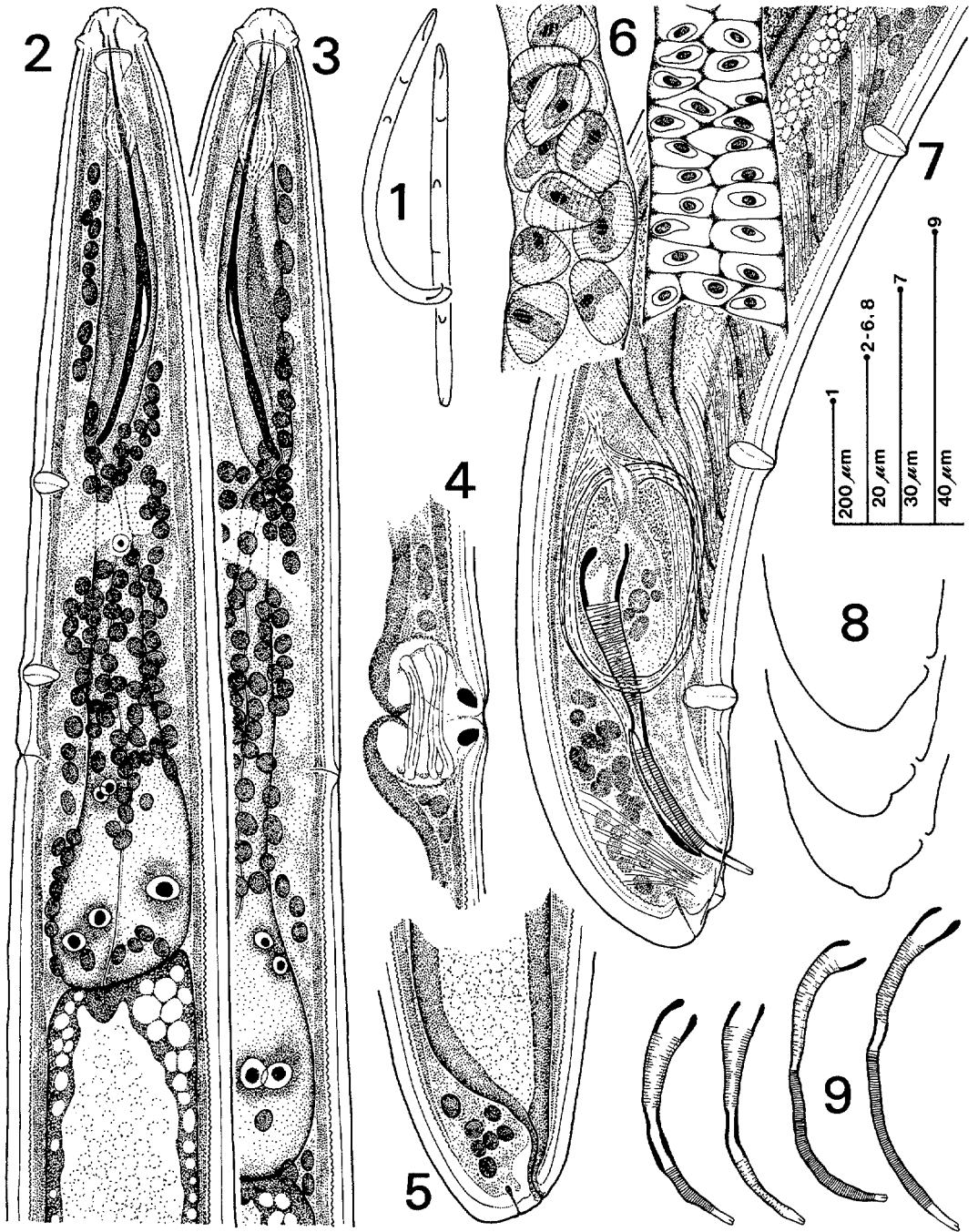
Measurements of holotype male, paratype males, and paratype females are presented in Tables 1 and 2.

Male: Posterior half curved (Fig. 1); cuticle usually swollen after fixation, number of layers appearing as two or three. Onchiostyle slender and arcuate. Two ventromedian cervical papillae present: anterior papilla usually just posterior to stylet base, occasionally anterior to stylet base; position of posterior papilla variable, but always located closer to excretory pore than to anterior papilla. Five esophageal gland nuclei present: anterior ventrosublateral nuclei usually near level of excretory pore; posterior ventrosublateral nuclei in posterior fourth of esophagus; dorsal nucleus position variable but anterior to posterior ventrosublateral nuclei (Fig. 2). Esophageal glands usually slightly extended posteriorly but not overlapping intestine. Nerve

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FIGS. 1-9. *Trichodorus elefjohnsoni* n. sp. 1) Habitus of heat-relaxed male and female. 2) Male, anterior region. 3) Female, anterior region. 4) Vulval region, lateral view. 5) Female tail. 6) Sperms (left) and spermatocytes in male reproductive system. 7) Male from Laurel Falls, posterior region. 8) Male, variations in tail shape. 9) Variations in spicules among specimens from (l-r): Ramsay Cascades, Ramsay Cascades, Fork Ridge, Grotto Falls.

ring just behind stylet. One pair of lateral cervical pores near nerve ring.

Sperms large, ovate, surface-striated, nu-

clei pediform; spermatocytes densely packed, surfaces smooth, nuclei narrow-elliptical (Fig. 6). Spicules weakly cepha-

TABLE 1. Morphometrics of male holotype and 20 male paratypes of *Trichodorus elefjohnsoni*.

	Holotype	Paratypes			
		Mean	Range	SD	CV
Measurements in μm					
Length	594	608	521-731	57.3	9.4
Width	34	29	24-34	2.9	10.0
Stylet length	52	53	45-60	3.5	6.6
Esophagus length	122	128	107-151	11.4	8.9
Anterior end to excretory pore	91	85	73-97	8.1	9.5
Anterior end to CP1	57	57	48-67	5.0	8.8
CP1 to CP2	25	21	13-30	4.3	20.5
CP2 to excretory pore	9	7	4-9	1.5	21.4
Spicule length	41	40	33-50	4.8	12.0
Gubernaculum length	17	17	14-24	2.5	14.7
Cloaca to SP1	17	22	15-28	4.3	19.5
SP1 to SP2	30	23	14-30	4.9	21.3
SP2 to SP3	35	32	21-41	5.5	17.2
Ratios and percentages					
a	18	21	17-24	1.7	8.1
b	4.9	4.8	4.1-5.7	0.4	8.2
T	66	62	56-68	4.0	6.5

lated, often sinuous, length variable, slender, constricted at middle (Figs. 7,9,10). Spicules striated except at each end and in the constricted zone, the striae usually denser on the calamus than on the manubrium; velum absent; spicule tips bifid. Three preanal supplements; posterior supplement (SP 1) within range of retracted spicules on specimens with longer spicules (Fig. 7), near the proximal ends of the retracted spicules on specimens with shorter spicules (Fig. 10). Rudimentary bursa present, obscure, more visible in living than in fixed specimens. Tail tip cuticle slightly thickened; terminus rounded to

bluntly digitate (Figs. 7,8). One pair of subventral papillae posterior to cloaca and one pair of ventrosubterminal pores.

Female: Body straight or slightly curved ventrally when heat-relaxed (Fig. 1). Cuticle as in male. Onchiostyle slender as in male; esophageal gland nuclei positioned as in male; esophagus not overlapping intestine. Excretory pore at level of posterior procorpus region of esophagus (Fig. 3). Nerve ring just behind stylet base. Reproductive system like that of other *Trichodorus* spp.; sperm present in oval spermathecae. Vaginal region cordate in lateral view, vaginal sclerotizations oval or

TABLE 2. Morphometrics of 20 female paratypes of *Trichodorus elefjohnsoni*.

	Mean	Range	SD	CV
Measurements in μm				
Length	626	516-731	59.4	9.5
Width	30	24-39	4.0	13.3
Stylet length	52	45-60	4.5	8.7
Esophagus length	131	107-156	14.5	11.1
Anterior end to excretory pore	84	73-102	7.3	8.7
Ratios and percentages				
a	21	17-24	2.2	10.5
b	4.8	3.9-5.6	0.36	7.5
V	56	53-60	1.9	3.4
G ₁	21	17-25	2.1	10.0
G ₂	20	17-24	2.1	10.5



FIG. 10. *Trichodorus elefjohnsoni* n. sp. Posterior region of male paratype from Ramsay Cascades, Great Smoky Mountains National Park.

teardrop-shaped in optical cross-section (Fig. 4). Vulva pore-like in ventral view. One pair of lateral body pores, less than one body-width behind vulva. Tail rounded or slightly protuberant subdorsally, anus ventrosubterminal (Fig. 5). One pair of subventral, subterminal pores.

Diagnosis

Trichodorus elefjohnsoni n. sp. differs from other *Trichodorus* spp. in the following combination of characteristics: in male, two ventral cervical papillae, anterior papilla near stylet base; excretory pore in procorpus region; spicules slender, without bristles, but with numerous fine striations in two groups; posterior supplement close to proximal end of spicule or closer to cloaca; in female, vaginal sclerotizations ovate; one pair of lateral body pores near vulva.

Relationships

Trichodorus elefjohnsoni n. sp. most closely resembles *T. orientalis* De Waele & Hashim

(2) in having slender, medially constricted spicules, but in *T. orientalis* the spicules are described (not illustrated) as having fine transverse striae distally only. Females of *T. orientalis* have minute, triangular vaginal sclerotizations, whereas in *T. elefjohnsoni* they are larger and ovate. *Trichodorus elefjohnsoni* also bears some similarity to *T. taylori* De Waele, Mancini, Roca, & Lamberti (3) and to *T. persicus* De Waele & Sturhan (4). *Trichodorus taylori* is a larger species ($L = 813-1,061 \mu\text{m}$ [females], $791-1,019 \mu\text{m}$ [males]) with longer ($57-64 \mu\text{m}$) spicules striated on the calamus only. Spicules of *T. taylori* are stouter and only weakly curved (1,3) compared to those of *T. elefjohnsoni*. The Iranian species *T. persicus* also has stouter spicules, striated only on their distal halves (4), and in females, has two pairs of lateral pores near the vulva, whereas there is just one pair in *T. elefjohnsoni*.

Type host and locality

Holotype male, four paratype males, and four paratype females collected in rhizosphere of tuliptree (*Liriodendron tulipifera* L.) one km north of Laurel Falls, 853 m altitude, Great Smoky Mountains National Park (GRSM), 14 October 1985; six males and five female paratypes in mixed forest of silverbell (*Halesia carolina* L.), buckeye (*Aesculus glabra* Willd.), and hemlock (*Tsuga canadensis* (L.) Carr.), 400 m past Grotto Falls, 1,098 m altitude, GRSM, 29 October 1985; two male and three female paratypes in tuliptree rhizosphere, 800 m below campsite near Porter Creek trail, 1,052 m altitude, GRSM, 7 November 1985; three male and four female paratypes in mixed forest dominated by yellow birch (*Betula lutea* Michx.), buckeye, and red oak (*Quercus rubra* L.), 900 m below Ramsay Cascades, 1,144 m altitude, GRSM, 14 November 1985; five male and four female paratypes in mixed forest dominated by cucumbertree (*Magnolia acuminata* L.), buckeye, and tuliptree, 1 km south-southeast of roadgate on Cosby Campground trail, 915 m altitude, 9 June 1986; one paratype female in rhizosphere

of mountain maple (*Acer pensylvanicum* L.) and blackberry (*Rubus* sp.) 800 m east of Appalachian Trail on Fork Ridge trail, 1,693 m altitude, GRSM, 27 May 1987. All samples collected by Mary Montgomery.

Type designations

Holotype male, six paratype males, and six paratype females deposited in the USDA Nematode Collection, Beltsville, Maryland; three paratype males and three paratype females each in the University of California-Riverside Nematode Collection and the University of California-Davis Nematode Collection; remaining paratypes and additional material deposited in the Tennessee Nematode Collection, University of Tennessee, Knoxville.

Etymology

This new species is named after my colleague and friend, the noted soil microbiologist Dr. Leander F. Johnson, who retired from the University of Tennessee in January, 1990, after 36 years of dedication to phytopathological research and instruction.

DISCUSSION

Trichodorus elefjohnsoni n. sp. occurs primarily in primeval hardwood tracts of GRSM where significant logging has never occurred. It has not been collected from grassy or disturbed forest sites, nor has it been found in GRSM spruce-fir forest. The sample from Fork Ridge (1,693 m altitude), in the spruce-fir zone, came from a pocket of mountain maple-blackberry growth.

By the nature of the spicule shape and ornamentation, *T. elefjohnsoni* is quite distinct from all other previously described North American species. Length of the spicules in *T. elefjohnsoni* (CV = 12.0) is much more variable than is usually reported for *Trichodorus* spp. (1,7). Among five collection sites, there is some degree of gradation in spicule length, with specimens from Ramsay Cascades having the shortest spicules and those from Grotto

TABLE 3. Variation in stylet and spicule lengths (μm) among five populations of *Trichodorus elefjohnsoni* n. sp.

Population	Stylet		Spicule	
	Range†	n	Range	n
Laurel Falls	45–53	10	38–43	5
Porter Creek	47–52	5	40–41	2
Grotto Falls	48–58	11	43–50	6
Cosby				
Campground	50–58	9	35–38	5
Ramsay Cascades	50–60	6	32–33	3

† Male and female values pooled.

Falls the longest (Table 3). Ordinarily, such large differences might suggest at least two distinct species. However, spicular ornamentation is very similar in all males, and all other characters of both males and females, including onchiostyle length (Table 3), are indistinguishable among specimens from the various sites. Variability of spicule length among the collecting sites may be due to severely restricted gene flow because of the numerous gorges and fast-flowing streams that dissect GRSM, which tend to produce isolated populations affected by different host and microenvironmental conditions, or simply to random variation inherent in small sample sizes.

Narrow but distinct caudal alae were visible on living, active specimens, but they were indistinct or invisible on fixed or processed individuals. During movements of males, the alae tended to flatten, then reappear. It seems likely the alae in *Trichodorus* spp. are formed by temporary muscular activity and are not fixed cuticular expansions as in many Tylenchida.

LITERATURE CITED

1. Decraemer, W. 1988. Morphometric variability and value of the characters used for specific identification in *Trichodorus* Cobb, 1913. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Biologie 58:29–44.
2. De Waele, D., and Z. Hashim. 1984. *Trichodorus orientalis* n. sp. (Nematoda: Trichodoridae) from Jordan and Iran. Systematic Parasitology 6:63–67.
3. De Waele, D., G. Mancini, F. Roca, and F. Lambertini. 1982. *Trichodorus taylori* sp. n. (Nematoda: Do-

rylaimida) from Italy. *Nematologia Mediterranea* 10:27-37.

4. De Waele, D., and D. Sturhan. 1987. *Trichodorus persicus* n. sp. (Nematoda: Trichodoridae) from Iran. *Systematic Parasitology* 10:79-83.

5. Pyle, C. 1985. Vegetation disturbance history of Great Smoky Mountains National Park: An analysis of archival maps and records. National Park

Service Research/Resources Management Report SER-77.

6. Seinhorst, J. W. 1959. A rapid method for the transfer of nematodes from fixative to anhydrous glycerin. *Nematologica* 4:67-69.

7. Shishida, Y. 1979. Studies on nematodes parasitic on woody plants. 1. Family Trichodoridae (Thorne, 1933) Clark, 1961. *Japanese Journal of Nematology* 9:28-44.