

## ***Steinernema neocurtillis* n. sp. (Rhabditida: Steinernematidae) and a Key to Species of the Genus *Steinernema*<sup>1</sup>**

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**Abstract:** *Steinernema neocurtillis* n. sp. isolated from the mole cricket *Neocurtilla hexadactyla* Perty can be distinguished from other members of the genus by characteristics of the first-generation male and the third-stage infective juvenile (IJ). In the male, the distance from the anterior end to the excretory pore (DAE) is less than the body width at the excretory pore; D% (DAE divided by length of esophagus × 100) is low at 19. The gubernaculum length is greater than three-fourths the spicule length. Range of the ratio gubernaculum length divided by spicule length is 0.82–0.93 in the first-generation male and 0.92–1.00 in the second-generation male. In the IJ, the distance from the anterior end to the excretory pore is extremely short (18 μm), causing the D% and E% (DAE divided by tail length × 100) to be low (D% = 23 and E% = 12). Average body length of the IJ is 885 μm.

**Key words:** entomopathogenic nematode, mole cricket parasite, morphology, nematode, new species, *Neocurtilla hexadactyla*, *Steinernema neocurtillis* n. sp., taxonomy.

A survey of the nematode parasites and associates of the mole crickets *Scapteriscus borellii* Giglio-Tos, *S. vicinus* Scudder, *S. abbreviatus* Scudder, and *Neocurtilla hexadactyla* Perty was conducted in Florida. Among the nematodes found was a new species of *Steinernema* Travassos, 1927 (= *Neoapectana* Steiner, 1929), parasitizing *Neocurtilla hexadactyla*, the northern mole cricket. In the fall of 1986, 11 of 42 adult *N. hexadactyla* collected near the town of La Crosse (Alachua County), Florida by Dr. W. G. Hudson (former graduate student; now University of Georgia Cooperative Extension Service, Tifton, Georgia) were infected with a steinernematid nematode. In the spring of 1987, 13 of 40 adult *N. hexadactyla* from the area were infected with the same nematode. Since that time, none of the few *N. hexadactyla* collected from the area have been found infected.

We describe the nematode herein as *Steinernema neocurtillis* n. sp., named after the genus of the host insect from which the nematode was collected.

### MATERIALS AND METHODS

*Neocurtilla hexadactyla* collected from the field were placed individually in vials. First- and second-generation adult nematodes were obtained by dissecting naturally infected crickets 2–4 days and 5–7 days, respectively, after the crickets died. Third-stage infective juveniles (IJ) were obtained when they emerged from the cadavers 7–15 days after the mole crickets died. Some of the nematodes were examined live, others were relaxed and killed in warm water (40 C), and still others were fixed in formalin-propionic acid (4:1) (5) or in lactophenol. The specimens were mounted in glycerine. Coverglass supports were used in all cases to avoid flattening specimens.

**Scanning electron microscopy:** Adults fixed in lactophenol were rinsed in water and prepared for the SEM by the method of Stone and Green (11). IJ were fixed in 3% glutaraldehyde buffered with 0.1 M so-

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dium cacodylate at pH 7.2 for 24 hours at 8 C. They were postfixed with 2% osmium tetroxide solution for 12 hours at 25 C, dehydrated in a graded ethanol series, critical point dried with liquid CO<sub>2</sub>, mounted on SEM stubs, and coated with gold. Spicules and gubernacula were prepared as suggested by Nguyen and Smart (6). The specimens were examined with a Hitachi S-450 or S-570 SEM.

#### SYSTEMATICS

##### *Steinernema neocurtillis* n. sp. (Figs. 1-7)

*Holotype* (male, first generation): Length 1,343 µm; width 103 µm; stoma length 4.7 µm; stoma width 7.8 µm; distance from head to: excretory pore 27 µm; to nerve ring 113 µm; to end of esophagus 164 µm; body width: at excretory pore 36 µm; at anus 39 µm; testis length from reflexion to terminus 366 µm; tail length 27 µm; spic-

ule 62 µm long, 14 µm wide; gubernaculum 51 µm long, 7.8 µm wide; mucron 3.0 µm long.

*Male, first generation*: Measurements of 10 males in Table 1. Body enlarged, curved posteriorly (Fig. 1D), C-shaped when heat-killed. Head rounded, labial papillae not seen in side view (Fig. 1A,G;3A). Stoma very shallow to almost absent, usually with a pronounced sclerotized structure at anterior end (Fig. 1A,G;3A). Distance from anterior end to excretory pore less than width of head at excretory pore. Esophagus subcylindrical anteriorly, isthmus indistinct, basal bulb slightly swollen. Gonad monorchic, reflexed. About 60% of males with normal testis (Fig. 1D), 40% with reduced or collapsed testis (Fig. 2A,B,E). In males with normal testis, distance from base of esophagus to anterior end of testis always shorter than distance from anterior end of nematode to base of esophagus. Spicules (Fig. 1C,E;3B-D;4A) paired, brown in color. Head (manu-

TABLE 1. Measurements (µm) of first- and second-generation males of *Steinernema neocurtillis* n. sp. (n = 10).

Character	First generation			Second generation		
	Mean	(SD)	Range	Mean	(SD)	Range
Body length	1,593	(231)	1,283-1,988	1,115	(60)	1,042-1,217
Greatest width	111	(20)	77-144	56	(4)	48-61
Stoma length	4.7	(0.8)	4-6	3.8	(1)	3-5
Stoma width	6.9	(2)	3-9	5.1	(0.6)	4-6
EP†	31	(5)	19-34	26	(4)	20-34
EPW†	37	(6)	27-44	25	(2)	22-28
NR‡	123	(15)	108-158	112	(8)	94-123
ES§	165	(29)	125-231	153	(7)	136-161
Testis reflexion	360	(90)	279-512	209	(21)	180-250
Anal body width	41	(4)	39-50	32	(1.7)	29-34
Tail length	25	(6)	19-39	18	(2.3)	14-22
Spicule length	59	(4)	52-64	44	(1.5)	42-46
Spicule width	12	(1.7)	9-14	8.4	(1)	6-9
Gubernaculum length	52	(4)	44-59	42	(1)	41-44
Gubernaculum width	8	(1)	6-9	5.5	(0.7)	4-6
Mucron length	4	(0.8)	3-5	0		0
D = EP:ES (%)	19	(4)	13-26	17	(2)	14-23
EW <sup>  </sup>	0.74	(0.09)	0.64-0.92	1.01	(0.11)	0.88-1.24
SW <sup>  </sup>	1.43	(0.14)	1.18-1.64	1.40	(0.08)	1.24-1.51
GS <sup>  </sup>	0.89	(0.04)	0.81-0.93	0.95	(0.02)	0.91-1.00

† EP = distance from anterior end to excretory pore; EPW = body width at excretory pore.

‡ NR = distance from anterior end to nerve ring.

§ ES = distance from anterior end to base of esophagus.

<sup>||</sup> EW = EP divided by body Width at excretory pore; SW = Spicule length divided by anal body Width; GS = Gubernaculum length divided by Spicule length.

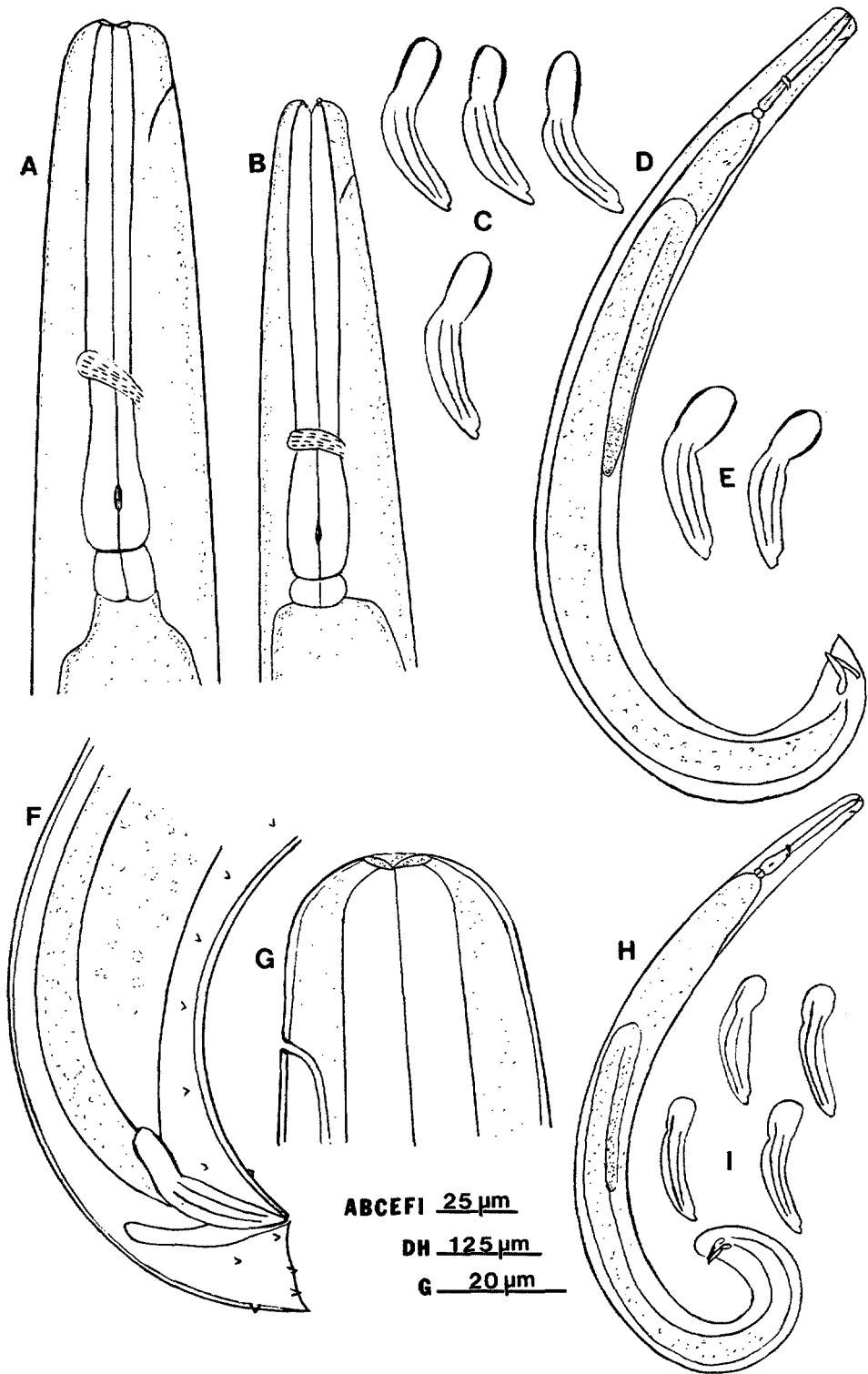


FIG. 1. Males of *Steinernema neocurtillis* n. sp. A, C-G) First-generation male. A) Anterior region. C, E) Variation in spicules. D) Entire body. F) Posterior region showing 23 papillae arranged as eleven pairs and one single. G) Enlargement of anterior end of A. B, H, I) Second-generation male. B) Anterior region. H) Entire body. I) Variation in spicules.

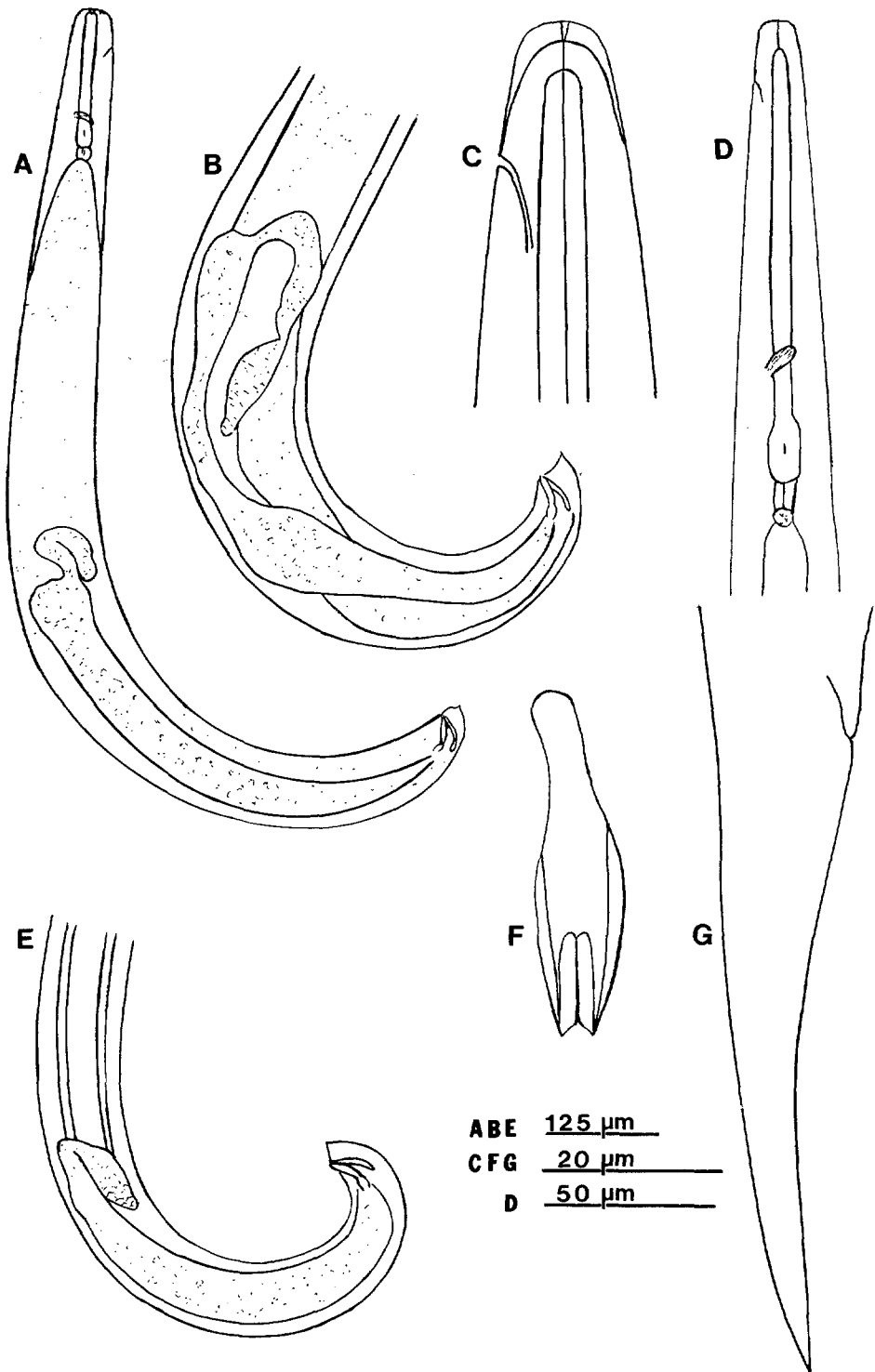


FIG. 2. *Steinernema neocurtillis* n. sp. A,B,E,F) First-generation male. A,B,E) Collapsed or reduced testes. F) Ventral view of gubernaculum. C,D,G) IJ. C,D) Anterior region. G) Tail.

brium) of spicules elongate, in some, twice as long as wide, about one third the spicule length (Fig. 1C,E;3B); shaft (calomus) very

short or absent; blade (lamina) thick, tapering slightly posteriorly, about twice as long as head; blade terminus blunt with a

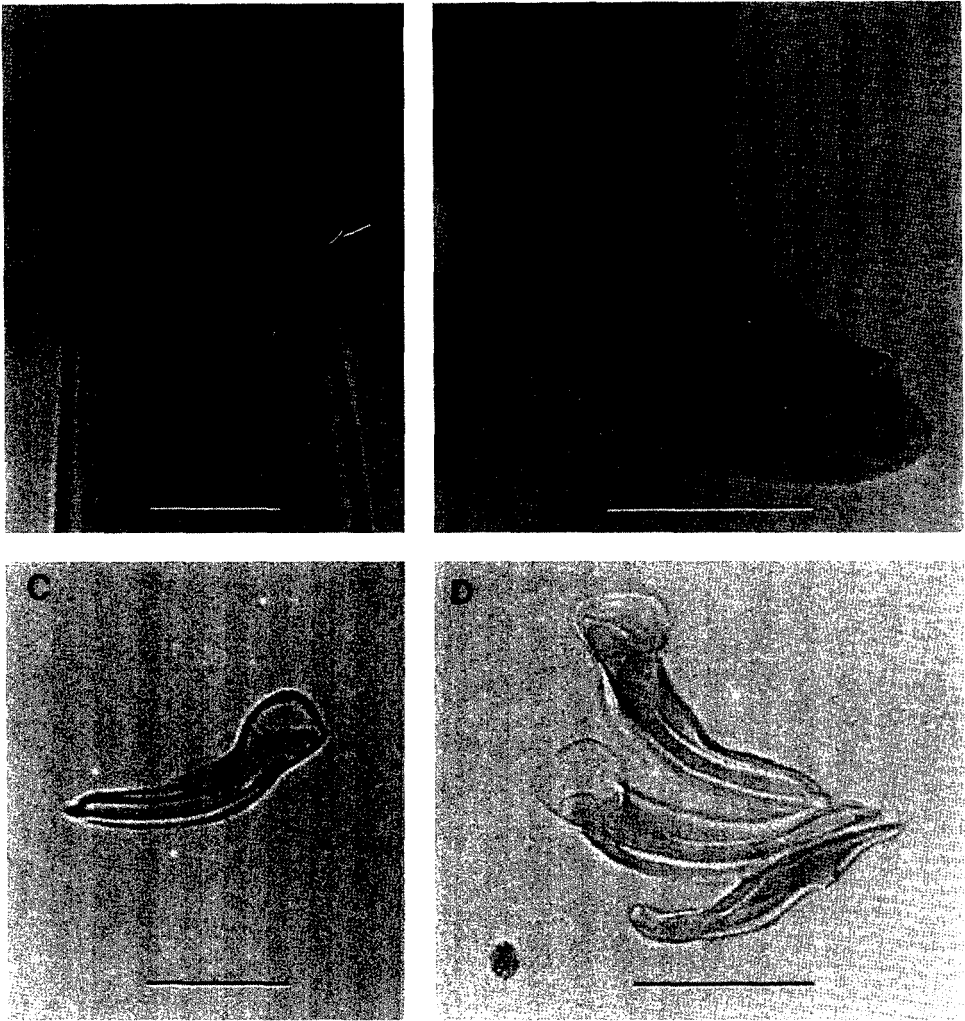


FIG. 3. Light micrographs of first-generation males of *Steinernema neocurtillis* n. sp. A) Anterior region (bar = 15  $\mu\text{m}$ ). B) Posterior region (bar = 58  $\mu\text{m}$ ). C) Spicule (bar = 25  $\mu\text{m}$ ). D) Spicules and gubernaculum (bar = 25  $\mu\text{m}$ ).

depression on ventral side (Fig. 3C,D;4A); head: blade angle 132 degrees (120–141) ( $n = 10$ ); velum absent. Each spicule with two internal ribs. Gubernaculum long, boat-shaped, anterior part long, ventrally curved (Fig. 3D,4B), more than three-fourths spicule length; gubernaculum length divided by spicule length 0.89 (0.82–0.93). Genital papillae 23, distributed as 11 pairs and one single (Fig. 1F). Tail conoid; tail terminus of 70% of males with short mucron (Fig. 1D,F:2A,B,E).

*Male, second generation:* Measurements of 10 males in Table 1. Second-generation male similar to that of the first generation except smaller, thinner, and distance from

head to reflexion of testis much longer. Collapsed testis, found in first generation, rare in second generation. Spicules and gubernaculum shorter and thinner than those of first-generation male (Fig. 1I;4C,D). Spicule with head: blade angle 151 degrees (143–160) ( $n = 10$ ).

Gubernaculum almost as long as spicules, gubernaculum length divided by spicule length (G/S) 0.95 (0.92–1.0) (in other species G/S 0.52–0.75). Mucron on tail terminus rare.

*Female, first generation:* Measurements of 20 females in Table 2. Body cuticle smooth or with faint annules. Lateral field and phasmids not observed. Head rounded,

TABLE 2. Measurements ( $\mu\text{m}$ ) of first- and second-generation females of *Steinernema neocurtillis* n. sp. ( $n = 20$ ).

Character	First generation						Second generation		
	Normal			Giant			Mean	(SD)	Range
	Mean	(SD)	Range	Mean	(SD)	Range			
Body length	4,714	(838)	3,531-6,250	11,384	(883)	10,313-13,000	1,934	(288)	1,482-2,718
Greatest width	187	(14)	159-215	248	(18)	225-289	99	(13)	78-120
Stoma length	8.5	(1.3)	6-11	14	(2)	11-17	6	(0.7)	5-8
Stoma width	10.8	(1.4)	8-14	15	(3)	9-20	6	(0.7)	5-8
EP†	37	(8)	23-53	44	(9)	31-59	29	(4)	20-37
NR‡	189	(20)	153-231	243	(29)	200-295	148	(11)	127-163
ES§	254	(31)	181-315	320	(29)	279-356	197	(15)	166-217
Tail length	61	(8)	47-78	61	(11)	45-75	67	(5)	56-73
Anal body width	65	(13)	50-100	75	(11)	50-87	35	(4)	30-45
Vulva%	50	(3)	46-56	50	(4)	42-54	53	(1.6)	49-55
D = EP:ES (%)	15	(3)	8-20	14	(3)	9-18	15	(2)	9-17

† EP = distance from anterior end to excretory pore.

‡ NR = distance from anterior end to nerve ring.

§ ES = distance from anterior end to base of esophagus.

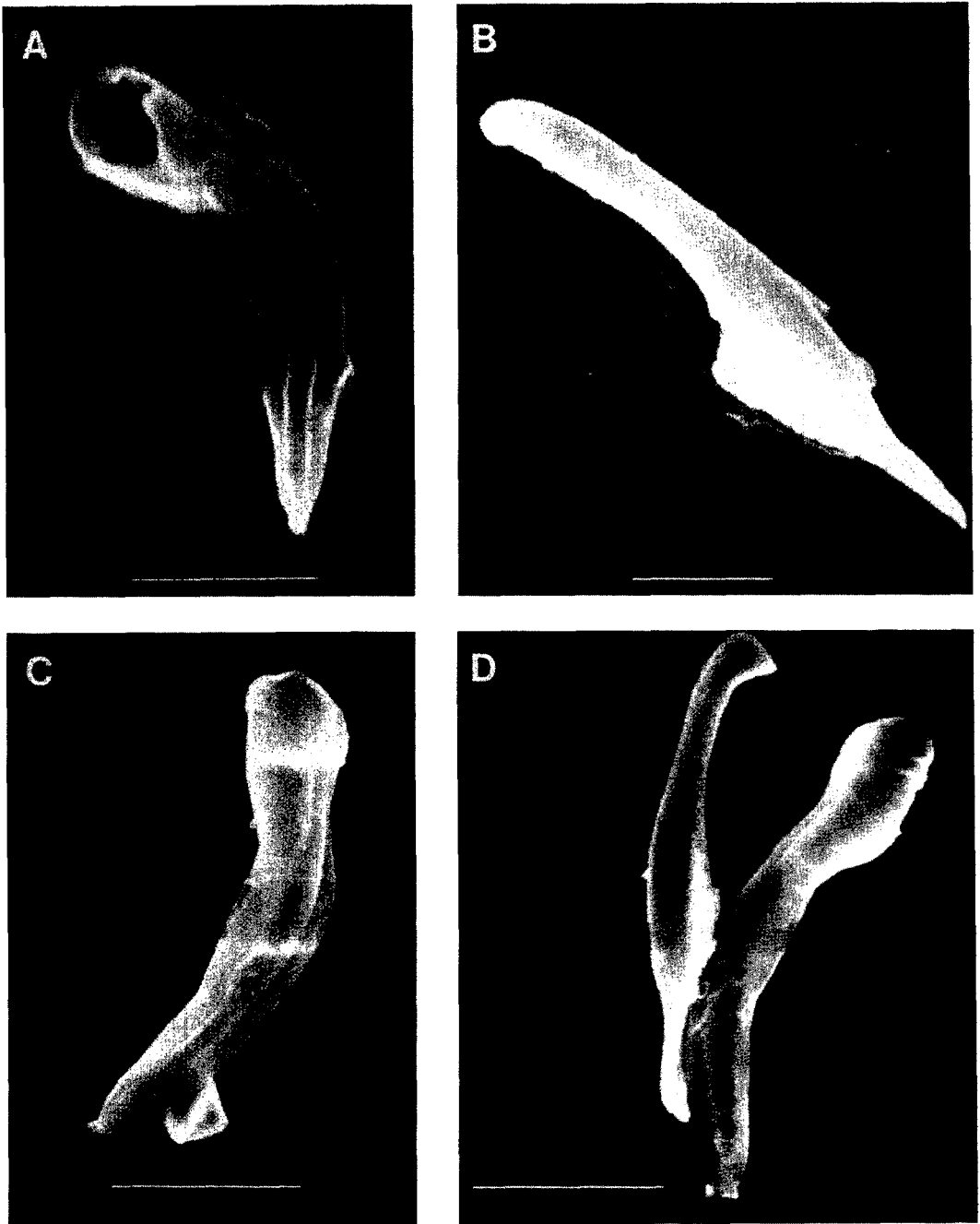


FIG. 4. *Steinernema neocurtillis* n. sp. A,B) First-generation male. A) Spicule (bar = 20  $\mu\text{m}$ ). B) Gubernaculum (bar = 10  $\mu\text{m}$ ). C,D) Second-generation male. C) Spicule (bar = 15  $\mu\text{m}$ ). D) Spicule and gubernaculum (bar = 15  $\mu\text{m}$ ).

continuous with body; perioral disc present (Fig. 5H;7A); labial papillae six, obscure, not seen in side view (seen clearly in side view of other species), four cephalic papillae (Fig. 5H;7A). Lips indistinct. Am-

phids not observed. Stoma shallow, circular anteriorly, subtriangular posteriorly (Fig. 5H). Cheilorhabdions prominent (Fig. 5A,E), well sclerotized. Another smaller sclerotization posterior to

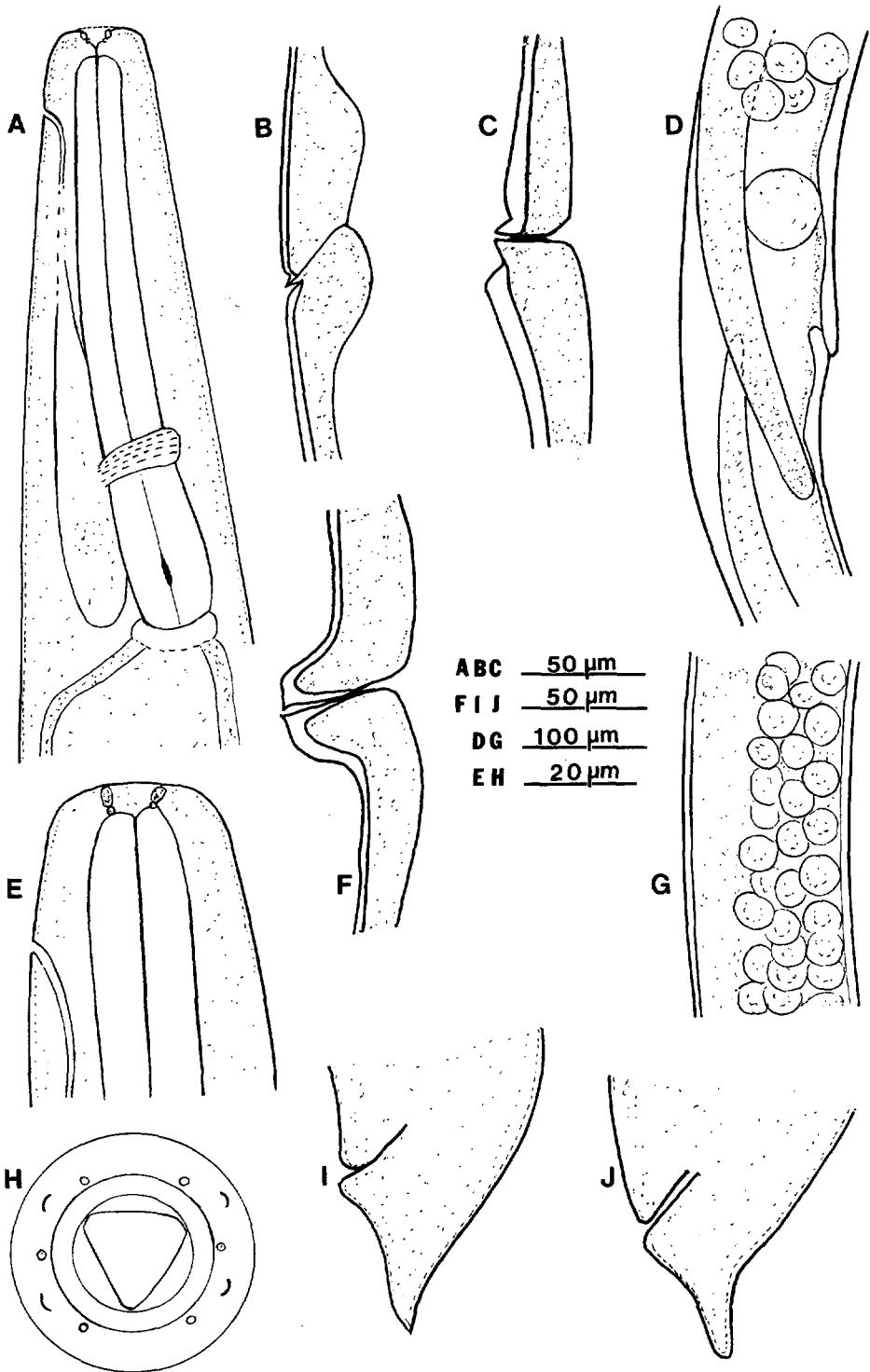


FIG. 5. First-generation females of *Steinernema neocurtillis* n. sp. A) Anterior region. B) Vulval region of a young female. C, F) Variation in vulval region and shapes of epitygma. D) Vulval region of a young female showing short terminal ends of reflexed ovaries. E) Enlargement of anterior end of A. G) A portion of body with eggs. H) Face view. I, J) Variation in female tails.



cheilorhabdions, presumably the prorhabdions. Esophagus with procorpus cylindrical, muscular; metacorpus slightly swollen; isthmus indistinct; basal bulb slightly enlarged (Fig. 5A). Nerve ring surrounds isthmus, usually obscure. Pronounced esophagointestinal valve present. Distance of excretory pore from anterior end usually shorter than body width at excretory pore (Fig. 5A,E). Excretory cell large (Fig. 5A). Gonads amphidelphic, reflexed, often containing many eggs (Fig. 5D,G). Vulva, a transverse slit; protruding on females with juveniles in body (Fig. 5C,F) but not protruding on young females (Fig. 5B); double-flapped epiptygma present (Fig. 5B,C,F). Vagina sclerotized, short, about one-fourth body width, perpendicular to body in mature females (Fig. 5C,F), but directed posteriorly in young females (Fig. 5B). Body width greater anterior to vulva than posterior to vulva (Fig. 5D). Tail shape variable (Fig. 5I,J), ventral postanal swelling present or absent, tail usually shorter than anal body width. About 25% of population with tail longer than anal body width.

*Female, giant form of first generation:* Measurements of 10 giant females in Table 2. In addition to the normal females of the first generation, a giant form of the female occurs. The giant form is characterized by a twisted body and is two to three times longer than normal females of the first generation (10,313–13,000  $\mu\text{m}$  compared to 3,531–6,250  $\mu\text{m}$ ). Other structures are as described for normal females.

*Female, second generation:* Measurements of 20 females in Table 2. Similar to first-generation female but smaller (length = 1,943  $\mu\text{m}$ , width = 99  $\mu\text{m}$  compared to 4,714  $\mu\text{m}$  and 187  $\mu\text{m}$ , respectively), and median bulb of esophagus slightly more enlarged (Fig. 6A). Ovaries containing at most three rows of eggs (Fig. 6B,C). Tail, which tapers to a point, longer than anal body width; ventral postanal swelling present (Fig. 6E,7B).

*Juvenile, third-stage infective (IJ):* Measurements of 50 juveniles in Table 3. Body thin, elongate. Sheath (second-stage cuti-

cle) present but sometimes lost. Labial region continuous (Fig. 2C,D). Oral aperture narrow (Fig. 7C). Labial papillae not seen; four cephalic papillae prominent (Fig. 7C) (six labial and four cephalic papillae prominent in *S. carpocapsae*; Fig. 7D). Amphids prominent with SEM (Fig. 7C). Distance from anterior end to excretory pore extremely short, 18  $\mu\text{m}$  vs. 38–83  $\mu\text{m}$  in other species (Table 5). D% (distance from anterior end to excretory pore divided by esophagus length) and E% (distance from anterior end to excretory pore divided by tail length) 12 and 23, respectively (Table 3). Esophagus with thin anterior part, basal bulb more or less elongate with visible valve (Fig. 2D). Lateral field with five incisures. Tail attenuate, tapering gradually (Fig. 2G).

### Biology

We were unable to rear the nematode in vivo. IJ placed in soil in petri dishes infected and killed *N. hexadactyla*, but few IJ were produced in the cadavers. Infected mole crickets collected from the field produced large numbers of IJ.

### Type host and locality

Hemocoel of northern mole cricket, *Neocurtilla hexadactyla* collected near La Crosse (Alachua County), Florida.

### Type specimens

*Holotype (male, first generation):* Isolated from hemocoel of the northern mole cricket, *Neocurtilla hexadactyla* collected near La Crosse (Alachua County), Florida. Slide number NT-460t, deposited in the United States Department of Agriculture Nematode Collection (USDANC), Beltsville, Maryland.

*Allotype (female, first generation):* Same data as holotype. Slide number NT-461t, deposited in the USDANC, Beltsville, Maryland.

*Paratypes (first-generation males and females and third-stage infective juveniles):* Same data as holotype. Three males and five females of the first generation and several third-stage infective juveniles in lactophenol, vial

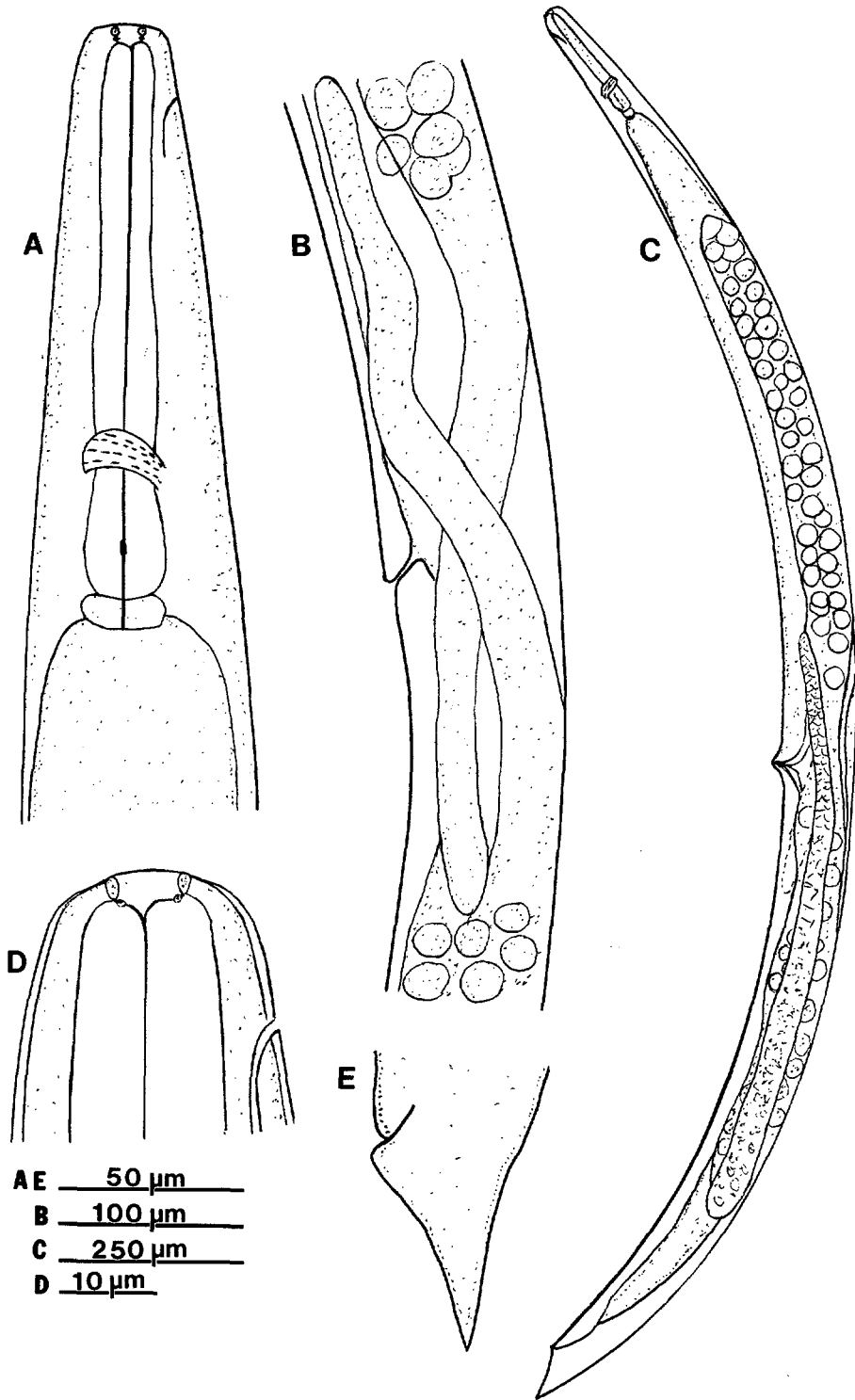


FIG. 6. Second-generation females of *Steinerema neocurtillis* n. sp. A) Anterior region. B) Vulval region showing terminal ends of reflexed ovaries and eggs. C) Entire female, D) Enlargement of anterior end of A. E) Tail.

TABLE 3. Measurements ( $\mu\text{m}$ ) of the third-stage juvenile of *Steinernema neocurtillis* n. sp. ( $n = 50$ ).

Character	Mean	(SD)	Range
Body length	885	(44)	741–988
Greatest width	34	(2.7)	28–42
EP†	18	(1.7)	14–22
NR‡	107	(4)	100–119
ES§	144	(7)	130–159
Tail length	80	(5)	64–97
A	26	(2)	22–29
B	6	(0.3)	5–7
C	11	(0.8)	9–14
D = EP:ES (%)	12	(1)	10–15
E = EP:tail length (%)	23	(2)	18–30

† EP = distance from anterior end to excretory pore.  
 ‡ NR = distance from anterior end to nerve ring.  
 § ES = distance from anterior end to base of esophagus.

number NT-324p, deposited in USDANC, Beltsville, Maryland; one male, one female of the first generation, and several third-stage IJ deposited in the Florida Collection of Nematodes, Florida Department of Agriculture and Consumer Service, Gainesville, Florida; one male and one female of the first generation, and several IJ deposited in the California Collection of Nematodes, University of California Davis Nematode Collection, Davis, California.

*Diagnosis:* Male body small. Distance from anterior end to excretory pore less than body width at that level and only 19% of esophagus length. Gubernaculum length always more than three-fourths the spicule length, 0.89 (0.82–0.92) of spicule length in the first generation, and 0.95 (0.92–1.00) in the second generation. Female labial papillae not seen under light microscope in lateral view; double-flapped epiptygma present. Body of the third-stage IJ 885  $\mu\text{m}$  in length; D% and E% very low at 12 and 23, respectively.

*Relationships:* *Steinernema neocurtillis* can be distinguished in all stages from all other species of the genus by the very short distance from the anterior end to the excretory pore of all stages. In third-stage IJ, this length is 18  $\mu\text{m}$  (14–22  $\mu\text{m}$ ) compared to 38  $\mu\text{m}$  (30–110  $\mu\text{m}$ ) or greater in all other species (Table 5), and the low D% and E% (D% = 12 [10–15] and E% = 23 [18–30] for *S. neocurtillis* and D% = 26 or greater and E% = 60 or greater for other

species [Table 5]). This species also differs from other species by the ratio gubernaculum length divided by spicule length, which is greater than 0.75 for this species (0.89 [0.82–0.92] in the first generation and 0.95 [0.92–1.00] in the second generation) compared to less than 0.75 for the other species except *S. scapterisci*. Further, *Steinernema neocurtillis* can be distinguished from other species by the average body length of the IJ and the E% (Table 5).

#### IDENTIFICATION OF SPECIES IN THE GENUS STEINERNEMA

With the increasing number of species and strains in the genus *Steinernema*, identification becomes more difficult. As the holotype of most species is the first-generation male, characteristics of the male, when available, must be used for accurate identification. For most nematode species, characteristics of juveniles are of limited value, and identification of species is rarely based on juveniles. For *Steinernema*, however, the IJ is the stage most often encountered, and for that reason, identification based on that stage has been attempted. Morphometrics of the IJ, however, cannot be used to separate all species. However, the IJ, in conjunction with the first-generation male, can be used for accurate identification of all species. Females of *Steinernema* generally are not used for species identification because the size varies considerably depending on the quality and quantity of the nutrient source and other unknown conditions. Nonetheless, some structures in the female may be useful for species identification.

In the first-generation male, in addition to the D% suggested by Poinar (8), we found three useful ratios—EW, SW, and GS (see footnote to Table 4). These ratios are as follows:

$$\text{EW} = \frac{\text{Excretory pore from anterior end}}{\text{Width of body at excretory pore}}$$

$$\text{SW} = \frac{\text{Spicule length}}{\text{Width of body at cloaca}}$$

$$\text{GS} = \frac{\text{Gubernaculum length}}{\text{Spicule length}}$$

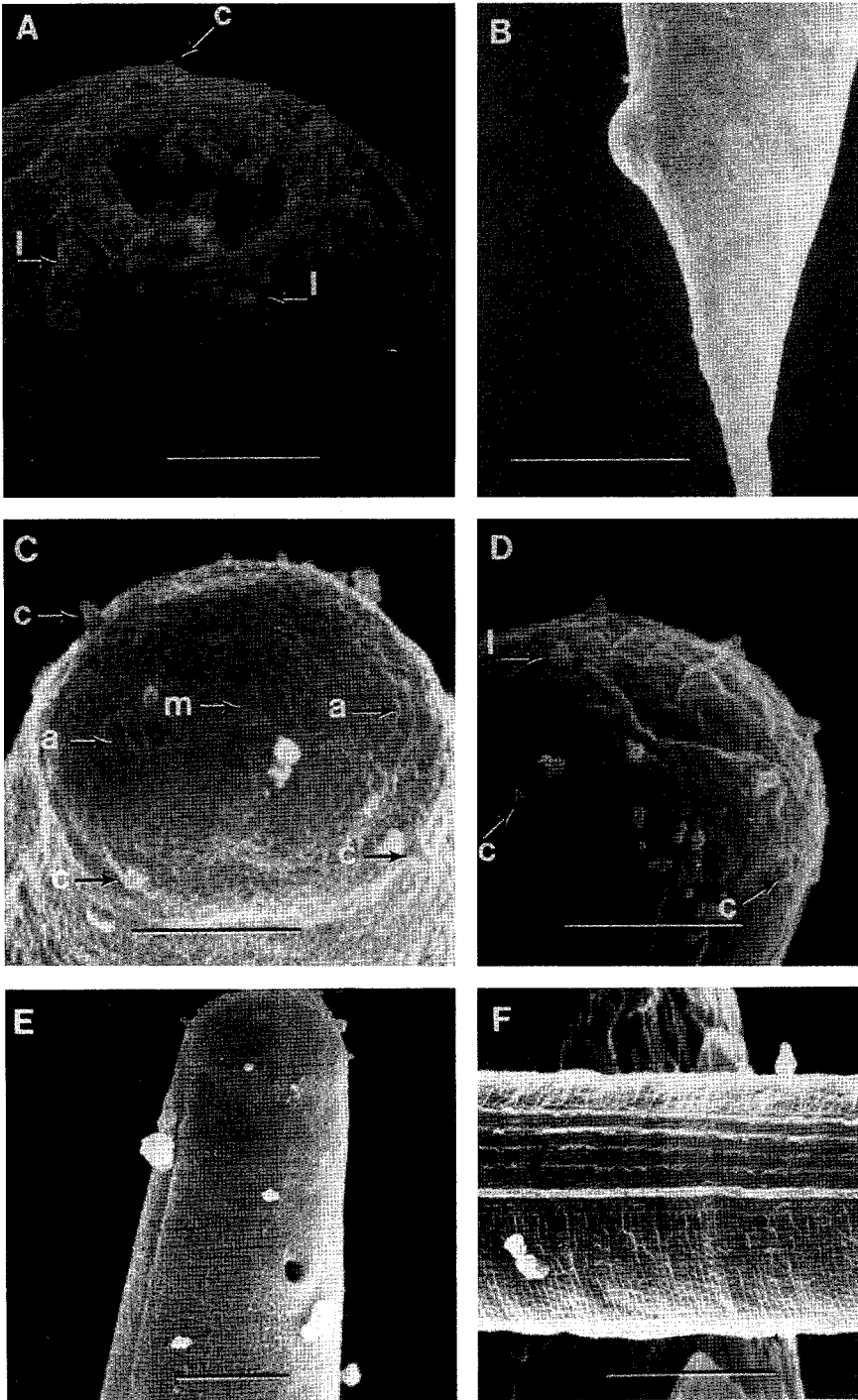


FIG. 7. SEM micrographs. A–C,E,F) *Steinernema neocurtillis* n. sp. A) face view of first-generation female. c = cephalic papillae, l = labial papillae (bar = 5  $\mu$ m). B) Second-generation female tail (bar = 20  $\mu$ m). C,E,F) IJ. C) Face view; m = oral aperture, a = amphids, c = cephalic papillae; labial papillae not seen (bar = 3  $\mu$ m). E) Anterior region (bar = 5  $\mu$ m). F) Lateral field showing five incisures (bar = 15  $\mu$ m). (D) *Steinernema carpocapsae* face view; c = cephalic papillae, l = labial papillae; amphids and oral aperture not seen (bar = 5  $\mu$ m).

TABLE 4. Important criteria in first-generation males for the identification of *Steinernema* species (in descending order of spicule length).†

Species	Spicule‡	Gubernaculum	D%	EW	SW	GS	MUC	n	Reference
<i>intermedia</i>	91 (84–100)	64 (56–75)	67 (58–76)	1.6 (1.5–2.0)	1.2 (1.0–1.4)	0.7 (0.6–0.8)	a	10	Present study
<i>anomali</i>	84 (81–91)	55 (49–60)	93 (88–102)	2.0 —	2.1 —	0.7 (0.6–0.7)	a	10	(3)
<i>scapterischi</i>	83 (72–92)	65 (59–75)	38 (32–44)	1.5 (1.2–1.6)	2.5 (2.0–2.8)	0.8 (0.7–0.8)	p	10	Present study
<i>glaseri</i>	77 (64–90)	55 (44–59)	70 (60–78)	2.4 (2.2–2.7)	2.1 (1.6–2.4)	0.7 (0.6–0.9)	a	10	Present study
<i>affinis</i>	70 (67–86)	46 (37–56)	61 (60–66)	1.7 —	1.2 —	0.7 (0.6–0.7)	p	10	(9)
<i>feltiae</i>	70 (65–77)	41 (34–47)	60 (51–64)	1.5 (1.3–1.6)	1.1 (1.0–1.3)	0.6 (0.5–0.6)	p	?	(7)
<i>ritteri</i>	69 (58–75)	44 (33–50)	47 (44–50)	1.4 —	1.6 (1.4–1.6)	0.6 (0.6–0.7)	a	30	(2)
<i>carpocapsae</i> §	66 (58–77)	47 (39–55)	41 (27–55)	1.4 (1.1–2.2)	1.7 (1.4–2.0)	0.7 (0.6–0.9)	p	60	Present study
<i>kushidai</i>	63 (48–72)	44 (39–60)	51 (42–59)	1.9 —	1.5 —	0.7 —	a	20	(4)
<i>neocurtillis</i>	58 (52–64)	52 (44–59)	19 (13–26)	0.7 (0.6–0.9)	1.4 (1.2–1.6)	0.9 (0.8–0.9)	p	10	Present study
<i>rara</i>	47 (42–52)	34 (23–38)	50 (44–51)	1.9 —	0.9 (0.9–1.1)	0.7 (0.6–0.7)	p	20	(1)

† All data in table (with ranges in parentheses) are either from measurements made in the present study or calculated from the data presented by the author listed in the last column, except for column "EW." In column "EW," data with ranges were measured in the present study, and data without ranges were calculated from the illustration of the author listed in the last column.

‡ Spicule and gubernaculum in  $\mu\text{m}$ ; D = distance from anterior end to excretory pore divided by esophagus length; EW = Distance from anterior end to Excretory pore divided by body Width at excretory pore; SW = Spicule length divided by anal body Width; GS = Gubernaculum length divided by Spicule length; MUC = mucron; n = number of specimens. Under MUC, a = absent, p = present.

§ Measurements from 10 males each of six strains: Agriotos, All, Breton, DD-136, Italian, and Mexican.

TABLE 5. Important morphometric characters of third-stage infective juveniles of *Steinernema* species.

Species	L†	EP	D%	E%	n	Reference
<i>affinis</i>	693 (608–880)	62 (51–69)	49 (43–53)	94 (74–108)	15	(9)
<i>anomali</i>	1034 (724–1408)	83 (76–86)	55 (52–59)	119 (106–130)	25	(10)
<i>carpocapsae</i>	558 (438–650)	38 (30–60)	26 (23–28)	60 (54–66)	25	(10)
<i>feltiae</i>	849 (736–950)	62 (53–67)	45 (42–51)	78 (69–86)	25	(10)
<i>neocurtillis</i>	885 (741–988)	18 (14–22)	12 (10–15)	23 (18–30)	50	Present study
<i>glaseri</i>	1130 (864–1448)	102 (87–110)	65 (58–71)	131 (122–138)	25	(10)
<i>intermedia</i>	671 (608–800)	65 (59–69)	51 (48–58)	96 (89–108)	25	(10)
<i>kushidai</i>	589 (524–662)	46 (42–50)	41 (38–44)	92 (84–95)	50	(4)
<i>rara</i>	511 (443–573)	38 (32–40)	35 (30–39)	72 (63–80)	25	(10)
<i>ritteri</i>	510 (470–590)	43 (40–46)	46 (44–50)	88 (79–97)	20	(2)
<i>scapterisci</i>	572 (517–609)	39 (36–48)	31 (27–40)	73 (60–80)	20	(8)

† L = length; EP = distance from anterior end to excretory pore; D% = EP divided by esophagus length × 100; E% = EP divided by tail length × 100; n = number of specimens.

In some species, these useful ratios can be estimated easily with the light microscope. For the IJ, the body length, the distance of the excretory pore from the anterior end and the E% are important; the D% may not be of value because the base of the esophagus usually is obscured. Important criteria for identifying species of *Steinernema* are summarized in Tables 4 and 5.

*Key to species of the genus Steinernema based on IJ and first-generation male*

(Meanings of abbreviations are listed in Tables 4 and 5)

1. Body length of IJ > 800 μm ----- 2  
 Body length of IJ < 800 μm ----- 5
2. Average length of IJ > 950 μm (1,034–1,130), E% > 100; in male, mucron absent, SW > 1.60 ----- 3  
 Average length of IJ < 950 μm (849–885), E% < 100; in male, mucron present or absent, SW < 1.60 ----- 4
3. In IJ, distance from anterior end to excretory pore 76–86 μm; in male, D% 93 (88–102), spicule tip swollen ----- *S. anomali*

In IJ, distance from anterior end to excretory pore 87–110 μm; in male, D% 70 (60–78), spicule tip with large aperture which, under light microscopy, resembles a notch ----- *S. glaseri*

4. In IJ, distance from anterior end to excretory pore extremely short, 18 μm (14–22 μm); in male, D% 19 (13–26); GS > 0.75 (0.82–0.93) ----- *S. neocurtillis*
- In IJ, distance from anterior end to excretory pore 62 μm (53–67 μm); in male, D% 60 (51–64); GS < 0.75 (0.52–0.61) ----- *S. feltiae*
5. Average length of IJ 682 ± 11 μm (608–880 μm) ----- 6  
 Average length of IJ 550 ± 40 μm (443–662 μm) ----- 7
6. In IJ sheath, spinelike structure in tail tip present; in male, spicule length 70 μm (67–86 μm), mucron present ----- *S. affinis*  
 In IJ sheath, spinelike structure in tail tip absent; in male, spicule length 91 μm (84–100 μm), mucron absent ----- *S. intermedia*

7. Average body length of IJ about 510  $\mu\text{m}$  ..... 8  
 Average body length of IJ > 540  $\mu\text{m}$  ..... 9
8. In IJ, E% 88 (79–97); in male, mucron absent, EW = 1.35, SW = 1.56 ..... *S. ritteri*  
 In IJ, E% 72 (63–80); in male, mucron present, EW = 1.88, SW = 0.94 ..... *S. rara*
9. In IJ, E% 92 (84–95); in male, mucron absent, EW = 1.90 --- *S. kushidai*  
 In IJ, E% < 92 (54–80); in male, mucron present, EW = 1.45 ..... 10
10. In IJ, E% 73 (60–80); in male, SW = 2.52 (2.04–2.80), spicule length 83 (72–92)  $\mu\text{m}$  ..... *S. scapterisci*  
 In IJ, E% 60 (54–66); in male, SW = 1.72 (1.40–2.00), spicule length 66 (58–77)  $\mu\text{m}$  ..... *S. carpocapsae*

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