

# Distribution and Morphology of *Longidorus breviannulatus* Norton & Hoffman, 1975 and *Longidorus fragilis* Thorne, 1974 (Nematoda: Longidoridae) from North America<sup>1</sup>

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**Abstract:** In a survey of ecotypes for longidorids, primarily from the rhizosphere hardwood trees growing in sandy soil along stream banks, 828 soil samples were collected from 37 Arkansas counties in 1999–2001. Eight populations of *Longidorus breviannulatus* were identified from the Arkansas survey samples. A total of 19 populations from California, Illinois, Iowa, Kansas, Michigan, Nebraska, New Jersey, New York, and Wisconsin were identified from the collection of the second author. A few males were found in New York and Nebraska populations and are described herein. Seven populations of *L. fragilis* were identified in the Arkansas survey samples, and one population was found from Indiana. Four juvenile stages of *L. fragilis* are present, and data are given for them herein.

**Key words:** Arkansas, *Longidorus breviannulatus*, *Longidorus fragilis*, morphology, new records, SEM, taxonomy.

*Longidorus breviannulatus* Norton and Hoffmann, 1975, was described from corn in Iowa and with specimens from Delaware and Canada noted. It was later reported from Pennsylvania (Forer, 1977), Illinois, Iowa (Malek et al., 1980; Norton et al., 1982; Norton et al., 1984; Willut and Malek, 1979), Connecticut, Delaware, Florida, Indiana, Massachusetts, Michigan, Nebraska, New York, North Carolina (Norton et al., 1984), New Jersey (Huff, 1985; Norton et al., 1984), and Wisconsin (MacGuidwin, 1989; Norton et al., 1984). Malek et al. (1980) considered *L. breviannulatus* to be the most devastating nematode attacking corn. Large numbers of this species are restricted to soil with high sand content (Norton et al., 1982). It was a reported vector for brome mosaic virus (Huff et al., 1987) and peach rosette mosaic virus (Allen, 1986); however, these reports were refuted by Brown and Trudgill (1997). *Longidorus fragilis* was described from only two Minnesota females by Thorne (1974) and redescribed by Robbins and Brown (1995). In this study, we provided additional information on morphology, distribution, and the occurrence of males of *L. breviannulatus* and juveniles of *L. fragilis*.

## MATERIALS AND METHODS

**Sampling:** The soil samples were primarily collected from the rhizosphere of hardwood trees at a depth of 10 cm to 40 cm from sandy soil of stream banks as part of a survey of 828 soil samples collected from 37 Arkansas counties in 1999–2001. Eight populations of *L. breviannulatus* were identified from the Arkansas survey samples (Table 1). A total of 19 populations from California, Illinois, Iowa, Kansas, Michigan, Nebraska, New

Jersey, New York, and Wisconsin were identified from the collection of the second author (Table 2). A few males were found in New York and Nebraska populations and are described herein. Seven populations of *L. fragilis* were identified in the Arkansas survey samples, and one population was found from Indiana (Table 3).

**Nematode extraction, fixing, and mounting:** As reported in materials and methods in the description of *L. grandis* and *L. longicaudatus* by Ye and Robbins (2003).

**Morphometrics:** Specimens were examined using a Nikon Optiphot II compound microscope with Nomarski differential interference contrast at powers up to  $\times 1,000$  magnification. Drawings and measurements were made using a Nikon drawing tube or an ocular scale and stage micrometer. Tail measurements followed the guidelines given by Zullini et al. (2001). Spicules are measured along the mid-axis. All measurements are in micrometers. Morphometric data were processed using Excel (Ye, 1996) and expressed mean  $\pm$  standard deviation (minimum to maximum). A population is defined herein as the same species from the same site, regardless of host.

**Scanning electron microscopy:** Fresh nematode specimens for SEM were relaxed and killed with heat; fixed in Karnovsky's fixative for 2 hours; washed in two changes of 0.05 M cacodylate buffer (pH 7.2) for 20 minutes; rinsed with distilled water twice; fixed with equal volume of 0.1 M cacodylate and 2% osmium for 2 hours; dehydrated in a graded ethanol series of 30%, 50%, 70%, 80%, 95%, and 100% with 10 minutes in each solution; repeated three times in 100% ethanol; and dried in hexamethyldisilazane for 5 minutes three times. The nematodes were mounted on SEM stubs using toluene-adhesive tape, sputter-coated with approximately 300Å of gold and examined with a ISI-60 SEM at 15 kv.

## SYSTEMATICS

*Longidorus breviannulatus* Norton & Hoffman, 1975  
(Figs. 1–3)

**Measurements:** See Tables 4, 5.

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TABLE 1. Population numbers, associated plants, and locations of *Longidorus breviannulatus* from Arkansas.

Population no.	Associated plant	Locality
Long-66	<i>Amorpha</i> sp.	Beulah near Des Arc, Prairie County
Long-69	Bentgrass ( <i>Agrostis</i> sp. L.)	Branchwood Golf Club, Bella Vista, Benton County
Long-73	Crabapple ( <i>Malus</i> sp. (Mill) Focke)	Arkansas Research & Extension Center, Fayetteville, Washington County
Long-116	Black cherry ( <i>Prunus serotina</i> Ehrh., box elder ( <i>Acer negundo</i> L.), cottonwood ( <i>Populus deltoids</i> March), maple ( <i>Acer</i> sp. L.), sycamore ( <i>Plantus occidentalis</i> L.), willow ( <i>Salix</i> sp. L.)	War Eagle Mill, near Rogers, Benton County
Long-124	Elm ( <i>Ulmus</i> sp. L.), persimmon ( <i>Diospyros virginiana</i> L.), willow ( <i>Salix</i> sp. L.)	Haroldton Access, Arkansas River, Van Buren, Crawford County
Long-140	Cottonwood ( <i>Populus deltoids</i> March)	Toad Suck Park, Perry County
Long-156	Birch ( <i>Betula</i> sp. L.), sweet gum ( <i>Liquidamber styraciflua</i> L.)	South Fork of the Little Red River, Clinton, Van Buren County
Long-226	Maple ( <i>Acer</i> sp. L.), sycamore ( <i>Plantus occidentalis</i> L.)	Fort Smith Park, Fort Smith, Sebastian County

*Description*

*Female:* *Longidorus breviannulatus* is characterized by its flattened, slightly expanded anterior end, conoid tail and parthenogenetic reproduction. Cuticle with fine transverse striations seen with SEM. Vulval opening a transverse slit about 9 µm in length as seen with SEM. Photos of the anterior region including the entire stylet (odontostyle and odontophore), the vulval area and

genital tract (in part), and the posterior region (tail region) showing variation are presented in Fig. 1 for specimens of paratypes, Nebraska and New York (male populations), and four populations from Arkansas (Fig. 2). The polytomous key code of Chen et al. (1997) is modified in parentheses as follows: A23-B(2)3(4)-C(1)2(3)-D2-E2-F23-G123-H2-I12.

TABLE 2. Population numbers and associated plants from outside Arkansas identified as *Longidorus breviannulatus* that were used in this study.

Population no.	Associated plant	Locality
Long-5	Corn ( <i>Zea mays</i> L.)	Paratypes, Erwin Farm, Louisa County, Iowa
Long-21	Golf grass	San Francisco Golf Course, California
Long-30	Unknown	Canadian National Collection
Long-36	Turf	York Country Club, Maine
Long-37	Corn ( <i>Zea mays</i> L.)	White Pigeon, Michigan
Long-38	Mint ( <i>Mentha piperita</i> L.)	Michigan
Long-39	Turf	Bedford Golf & Tennis Club, New York
Long-47	Corn ( <i>Zea mays</i> L.)	New Jersey
Long-53	Corn ( <i>Zea mays</i> L.)	Rock Island County, Iowa
Long-54	Corn ( <i>Zea mays</i> L.)	Havana, Illinois
Long-55	Corn ( <i>Zea mays</i> L.)	Wisconsin
Long-56	Corn ( <i>Zea mays</i> L.)	Various localities, Iowa
Long-159	Corn #A11 ( <i>Zea mays</i> L.)	Central Farmers Crop, Elgin, Nebraska
Long-160	Corn #A12 ( <i>Zea mays</i> L.)	Central Farmers Crop, Elgin, Nebraska
Long-187	Corn ( <i>Zea mays</i> L.)	Colt's Neck, New Jersey
Long-191	Lawn composite	Sutro Forest Park, San Francisco, California
Long-232	Corn ( <i>Zea mays</i> L.)	Reno County, Kansas
Long-233	Corn ( <i>Zea mays</i> L.)	Central Wisconsin
Long-241	Sorghum ( <i>Sorghum vulgare</i> Pers.)	Canada

TABLE 3. Population numbers, associated plants, and locations of *Longidorus fragilis*.

Population no.	Associated plant	Location
Long-59	Unknown	Ripley County, Indiana
Long-97	Cottonwood ( <i>Populus deltoids</i> March), sycamore ( <i>Plantus occidentalis</i> L.)	Mississippi River, 2 miles east of Wapanocca National Wildlife Refuge, Crittenden County, Arkansas
Long-127	Box elder ( <i>Acer negundo</i> L.), cottonwood ( <i>Populus deltoids</i> March), maple ( <i>Acer</i> sp. L.)	Toad Suck Park, Perry County, Arkansas
Long-134	Birch ( <i>Betula</i> sp. L.)	Little Missouri River, old highway bridge by Nevada County, Clark County, Arkansas
Long-141	Grape ( <i>Vitis</i> sp. L.)	Caddo River below Lake De Gray, Hot Spring County, Arkansas
Long-218	Hackberry ( <i>Celtis tenuifolia</i> Nutt.)	Shirey Bay—Rainey Brake Wildlife Management Area, Lawrence County, Arkansas
Long-224	Grape ( <i>Vitis</i> sp. L.), willow ( <i>Salix</i> sp. L.)	Haroldton Access, Arkansas River, near Van Buren, Crawford County, Arkansas
Long-225	Cottonwood ( <i>Populus deltoids</i> March), sycamore ( <i>Plantus occidentalis</i> L.)	Fort Smith Park, Fort Smith, Sebastian County, Arkansas

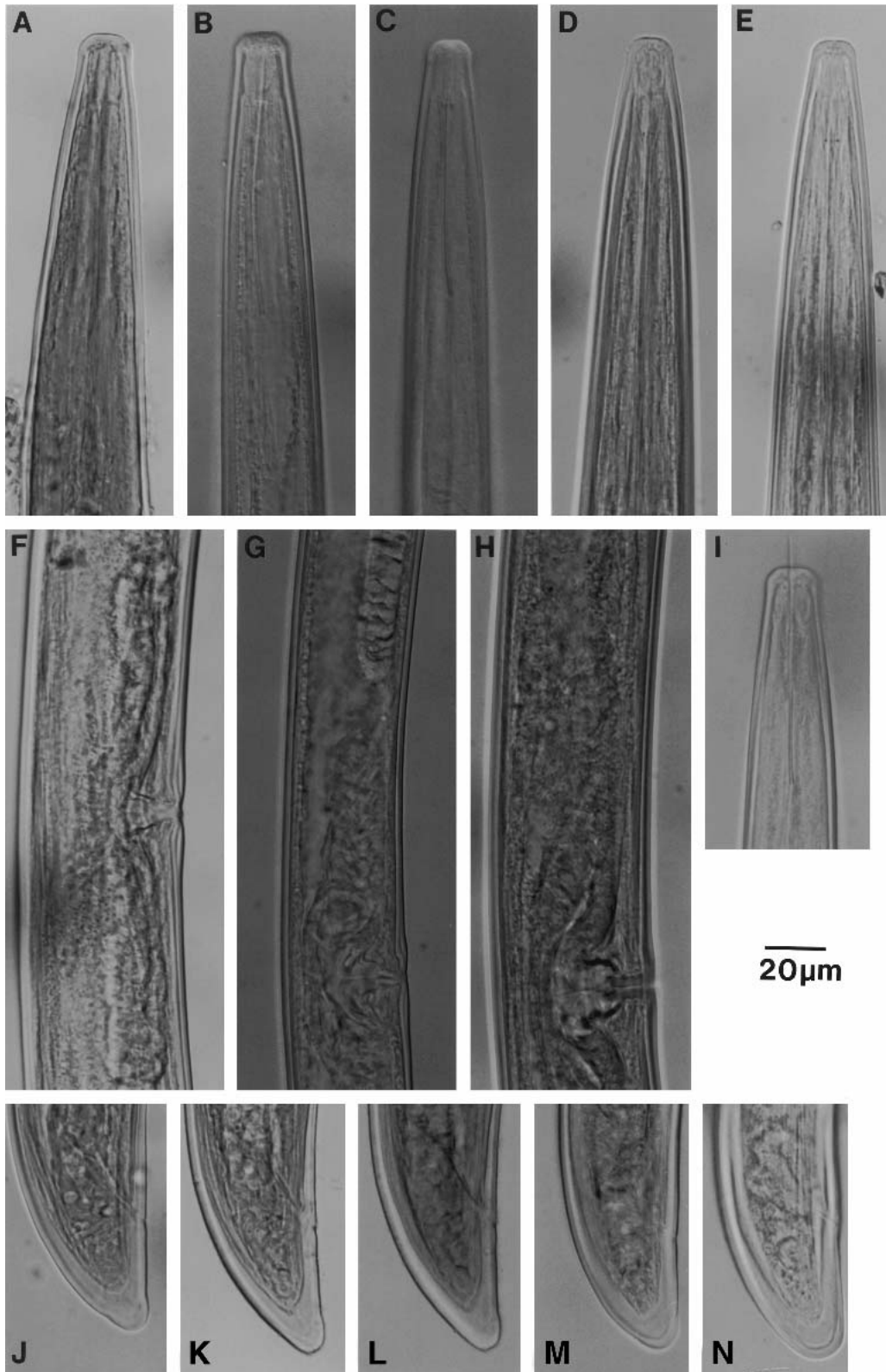


FIG. 1. Photographs of females of paratypes of *Longidorus breviannulatus* (A, F, J-K) from Iowa, Nebraska population (Long-160) with males (B-C, G, I, L-M), and New York population (Long-39) with males (E, H, N). Anterior region showing head shape, odontostyle, odontophore, and guide ring (A-E). Vulval region showing vulval structure and uteri (F-H). Anterior region showing head shape, amphidial pouch, and odontostyle (I). Posterior region showing variation in tail shape (J-N).

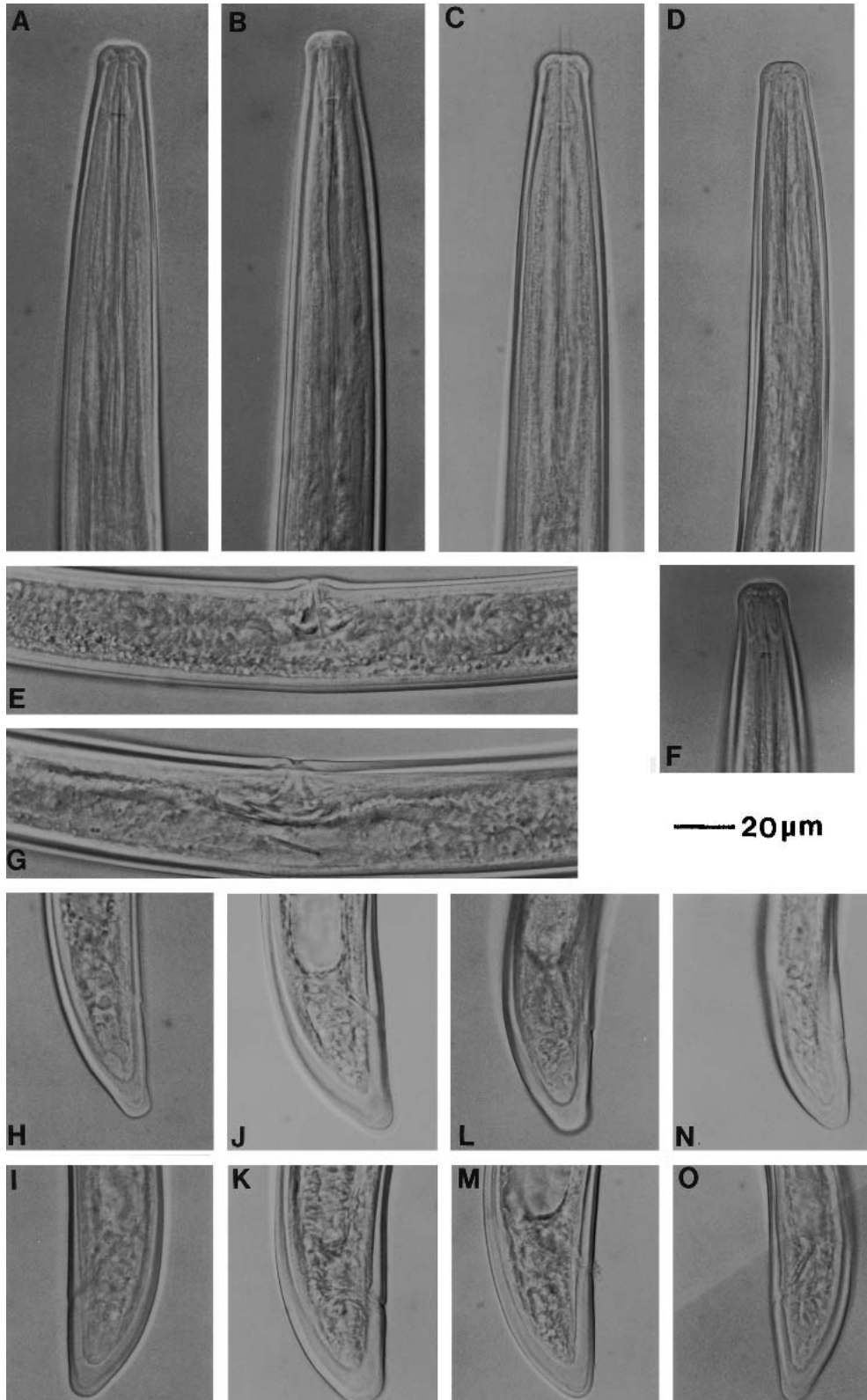


FIG. 2. Photographs of females of *Longidorus breviannulatus* from four Arkansas populations (Long-66, A, E, H-I; Long-116, B, G, J-K; Long-124, C, F, L-M; Long-140, D, N-O). Anterior region showing head shape, odontostyle, odontophore, and guide ring (Fig. A-D). Vulval region showing vulval structure and uteri (E, G). Anterior region showing head shape and amphidial pouch (F). Posterior region showing variations in tail shape (H-O).



FIG. 3. Photographs of *Longidorus breviannulatus* Nebraska population (Long-160) males (A–B, E) and female (D) and New York population (Long-39) males (C, F). Testes, with sperm in vas efferens (A). Male anterior regions showing head shape, odontostyle, odontophore, and guide ring (B–C). Vulval region showing vulval structure, uteri, spincter at distal ends of uteri, oviduct, and reflexed ovary (D). Posterior region showing spicules, supplements, and copulatory muscles (E–F). Fig. F is severely flattened.

TABLE 4. Morphometrics of *Longidorus breviannulatus* females from different populations and locations (Tables 1 and 2).

Morphometrics	Paratypes	Long-5	Long-66	Long-69	Long-73	Long-116	Long-124	Long-140	Long-156	Long-21	Long-30	Long-36
N	14 (4.02-5.15)	7	20	3	2	12	10	9	4	3	13	17
L (mm)	4.76 (4.40-5.20)	4.80 ± 0.29 (4.15-5.20)	4.80 ± 0.29 (4.15-5.20)	5.03 ± 0.31 (4.81-5.38)	5.09 ± 0.33 (4.86-5.32)	5.05 ± 0.49 (4.03-5.97)	5.15 ± 0.70 (4.38-6.60)	4.81 ± 0.36 (4.05-5.37)	5.73 ± 0.74 (5.10-6.80)	4.92 ± 0.43 (4.55-5.39)	5.38 ± 0.54 (4.33-6.28)	4.65 ± 0.39 (3.71-5.11)
a	94 (86-114)	90.2 ± 14.3 (75.0-108.8)	116.4 ± 7.6 (95.4-127.3)	105.5 ± 2.8 (102.3-107.6)	111.0 ± 22.2 (95.3-126.7)	104.3 ± 10.8 (89.6-121.9)	113.3 ± 13.0 (104.3-137.5)	120.8 ± 10.4 (103.8-138.1)	118.9 ± 15.1 (99.5-136.3)	90.2 ± 10.7 (83.9-102.6)	112.9 ± 11.2 (96.2-136.5)	84.7 ± 5.7 (67.5-93.0)
b	16.9 (12.3-23.8)	15.4 ± 1.1 (14.5-17.7)	13.9 ± 1.7 (11.2-19.1)	16.9 ± 1.2 (15.5-17.9)	15.4 ± 0.6 (15.0-15.8)	15.1 ± 1.7 (11.5-17.9)	15.3 ± 1.9 (13.3-18.3)	18.2 ± 2.1 (15.2-21.1)	17.3 ± 3.2 (14.2-21.8)	13.0 ± 3.0 (11.0-16.4)	15.0 ± 2.4 (9.7-18.7)	11.6 ± 1.8 (8.6-15.2)
c	123 (111-143)	123.7 ± 12.7 (109.1-140.0)	131.5 ± 11.9 (110.0-156.7)	121.6 ± 15.4 (104.6-134.5)	138.0 ± 7.0 (133.0-142.9)	139.8 ± 14.3 (112.6-154.3)	138.5 ± 24.3 (113.6-188.6)	134.4 ± 11.3 (114.3-149.2)	160.7 ± 18.2 (139.3-183.8)	105.1 ± 14.3 (95.9-121.6)	145.7 ± 19.5 (113.9-185.8)	98.5 ± 11.9 (71.4 ± 125.7)
c'	1.3*	1.1 ± 0.1 (0.9-1.3)	1.3 ± 0.1 (1.1-1.4)	1.3 ± 0.2 (1.2-1.5)	1.2 ± 0.0 (1.2-1.3)	1.0 ± 0.1 (0.9-1.2)	1.2 ± 0.2 (1.0-1.6)	1.3 ± 0.1 (1.1-1.6)	1.0 ± 0.1 (0.9-1.1)	1.2 ± 0.1 (1.2-1.3)	1.1 ± 0.1 (0.9-1.2)	1.2 ± 0.1 (1.0-1.3)
G1%		5.9 ± 0.7 (5.0-6.8)	8.1 ± 2.8 (4.8-16.8)	7.1 ± 3.7 (4.2-11.3)	6.5 ± 0.6 (6.0-6.9)	8.9 ± 2.8 (5.1-13.4)	6.1 ± 1.4 (3.6-8.1)	7.6 ± 2.2 (4.9-11.5)	6.7 ± 2.0 (5.3-8.2)	6.5 ± 2.1 (5.2-9.0)	6.5 ± 1.0 (4.9-7.7)	9.5 ± 1.3 (6.8-11.8)
G2%		6.2 ± 1.7 (3.8-9.0)	6.8 ± 2.5 (1.8-12.3)	6.1 ± 1.3 (4.7-7.2)	5.9 ± 0.9 (5.2-6.5)	8.4 ± 4.4 (1.7-16.4)	7.4 ± 2.1 (5.4-12.1)	7.2 ± 2.2 (5.2-11.1)	7.8 ± 2.9 (5.7-9.9)	6.7 ± 1.6 (4.9-8.1)	6.8 ± 1.0 (5.7-8.3)	9.0 ± 1.8 (5.5-12.3)
V	46.7 (43.1-50.2)	46.9 ± 1.9 (45.0-50.0)	48.6 ± 1.9 (45.4-53.4)	50.6 ± 0.4 (50.2-51.0)	48.6 ± 0.5 (48.3-49.0)	46.0 ± 2.7 (41.3-50.9)	49.5 ± 4.3 (45.4-58.6)	47.7 ± 1.3 (45.3-49.9)	49.3 ± 1.1 (47.7-50.0)	48.5 ± 2.6 (46.3-51.4)	47.7 ± 2.2 (44.7-52.1)	46.5 ± 1.5 (44.1-49.5)
H%	33*	35.4 ± 3.0 (31.8-40.5)	33.0 ± 4.2 (25.7-40.0)	30.6 ± 10.5 (23.1-42.5)	36.2 ± 5.4 (32.4-40.0)	35.3 ± 3.1 (31.0-40.0)	29.9 ± 6.1 (17.5-37.5)	30.6 ± 3.2 (23.5-34.4)	37.0 ± 4.6 (32.4-43.2)	24.5 ± 1.3 (23.4-26.0)	37.7 ± 5.9 (23.8-46.9)	23.5 ± 3.4 (17.6-30.2)
Odontostyle	83.2 (81-88)	82.7 ± 3.7 (78.0-87.0)	82.1 ± 3.0 (78.0-90.0)	85.3 ± 7.0 (78.0-92.0)	78.0 ± 2.8 (76.0-80.0)	87.5 ± 5.0 (78.0-98.0)	82.5 ± 4.9 (77.0-94.0)	79.8 ± 2.5 (75.0-84.0)	94.0 ± 4.9 (90.0-100.0)	87.1 ± 2.1 (85.2-89.3)	83.2 ± 2.2 (80.0-86.0)	83.2 ± 3.9 (77.0-90.0)
Odontophore	(28-45)	54.8 ± 5.5 (49.0-67.0)	53.1 ± 4.6 (44.0-60.0)	57.0 ± 3.6 (53.0-60.0)	53.0 ± 4.2 (50.0-56.0)	57.7 ± 15.0 (34.0-78.0)	58.0 ± 3.7 (52.0-62.0)	57.3 ± 3.6 (54.0-65.0)	61.0 ± 8.2 (51.0-71.0)	60.7 ± 5.0 (55.7-65.6)	47.9 ± 4.3 (39.0-56.0)	60.2 ± 1.8 (57.0-64.0)
Total stylet	121.9*	137.5 ± 9.2 (129.0-154.0)	135.4 ± 5.6 (126.0-144.0)	142.3 ± 3.8 (138.0-145.0)	131.0 ± 7.1 (126.0-136.0)	133.1 ± 45.0 (0.0-168.0)	140.5 ± 7.5 (131.0-156.0)	137.1 ± 4.3 (131.0-144.0)	155.0 ± 11.7 (141.0-167.0)	147.8 ± 6.1 (140.9-152.5)	130.2 ± 5.0 (123.0-136.0)	143.4 ± 3.8 (138.0-150.0)
Guide ring from anterior end	23 (21-26)	23.7 ± 1.5 (22.0-26.0)	25.6 ± 1.4 (24.0-28.0)	26.7 ± 1.2 (26.0-28.0)	24.0 ± 1.4 (23.0-25.0)	27.4 ± 1.2 (26.0-30.0)	25.1 ± 1.8 (23.0-29.0)	24.1 ± 0.9 (23.0-26.0)	30.5 ± 3.9 (27.0-36.0)	30.1 ± 1.7 (28.7-32.0)	23.8 ± 0.9 (22.5-26.0)	31.5 ± 1.3 (29.0-33.0)
Anterior end width	16-18*	17.7 ± 0.8 (17.0-19.0)	17.4 ± 0.9 (16.0-19.0)	18.3 ± 0.6 (18.0-19.0)	17.0 ± 0.0 (17.0-17.0)	19.5 ± 1.2 (18.0-22.0)	19.2 ± 1.4 (18.0-22.0)	17.0 ± 0.9 (16.0-18.0)	20.5 ± 2.6 (17.0-23.0)	14.8 ± 0.0 (14.8-14.8)	17.4 ± 0.6 (16.5-18.0)	14.0 ± 0.4 (13.0-15.0)
Body width	50 (49-54)	54.9 ± 7.3 (43.0-64.0)	41.4 ± 3.1 (35.0-50.0)	47.7 ± 2.1 (46.0-50.0)	46.5 ± 6.4 (42.0-51.0)	48.5 ± 3.5 (42.0-53.0)	45.4 ± 2.7 (41.0-50.0)	40.0 ± 3.8 (36.0-48.0)	48.8 ± 8.5 (40.0-56.0)	54.7 ± 2.5 (52.5-57.4)	47.8 ± 4.3 (39.0-56.0)	54.9 ± 2.8 (48.0-60.0)
Tail length	40-43*	39.6 ± 3.3 (36.0-44.0)	36.7 ± 2.5 (33.0-40.0)	41.7 ± 3.8 (39.0-46.0)	37.0 ± 4.2 (34.0-40.0)	36.3 ± 3.4 (31.0-42.0)	37.6 ± 4.6 (31.0-45.0)	36.0 ± 3.9 (31.0-44.0)	35.8 ± 3.5 (32.0-40.0)	47.0 ± 2.5 (44.3-49.2)	37.2 ± 2.5 (32.0-42.0)	47.5 ± 3.5 (40.0-52.0)
ABW	31.6*	36.7 ± 3.9 (33.0-42.0)	29.1 ± 1.5 (26.0-32.0)	31.0 ± 1.7 (30.0-33.0)	30.0 ± 2.8 (28.0-32.0)	34.9 ± 2.1 (33.0-38.0)	32.6 ± 2.4 (27.0-36.0)	27.7 ± 1.9 (24.0-30.0)	37.5 ± 4.9 (32.0-43.0)	38.0 ± 1.2 (36.9-39.3)	33.1 ± 1.8 (30.0-36.0)	39.9 ± 1.4 (38.0-43.0)
Hyaline tail tip	13.9*	14.0 ± 1.4 (12.0-16.0)	12.1 ± 1.3 (9.0-14.0)	12.7 ± 4.0 (9.0-17.0)	13.5 ± 3.5 (11.0-16.0)	12.8 ± 1.3 (10.0-15.0)	11.1 ± 1.9 (7.0-13.0)	11.0 ± 1.4 (8.0-13.0)	13.3 ± 2.2 (11.0-16.0)	11.5 ± 0.0 (11.5-11.5)	13.9 ± 1.8 (10.0-16.0)	11.1 ± 1.4 (9.0-14.0)

TABLE 4. *Continued*

Long-37	Long-38	Long-39	Long-47	Long-53	Long-54	Long-55	Long-56	Long-159	Long-160	Long-187	Long-191	Long-232	Long-233
16	16	17	6	6	4	3	3	12	10	2	3	14	5
5.57 ± 0.35 (4.89-6.21)	5.56 ± 0.35 (5.07-6.30)	5.28 ± 0.34 (4.59-5.91)	5.33 ± 0.24 (4.91-5.60)	5.17 ± 0.28 (4.77-5.40)	4.94 ± 0.28 (4.63-5.29)	5.36 ± 0.72 (4.66-6.10)	5.36 ± 0.44 (4.91-5.79)	5.04 ± 0.21 (4.72-5.33)	5.22 ± 0.38 (4.60-6.05)	4.76 ± 0.13 (4.67-4.85)	4.50 ± 0.17 (4.30-4.60)	4.87 ± 0.45 (4.00-5.70)	5.410 ± 0.45 (4.90-6.10)
117.3 ± 9.0 (97.0-131.0)	95.9 ± 5.5 (87.9-106.8)	95.9 ± 5.4 (79.1-103.5)	93.3 ± 12.2 (76.8-105.7)	102.9 ± 10.2 (91.8-117.4)	108.1 ± 5.3 (100.6-113.0)	103.1 ± 9.1 (93.2-111.0)	110.1 ± 7.5 (101.5-114.6)	119.2 ± 7.0 (107.3-126.9)	127.5 ± 10.4 (112.2-151.3)	71.7 ± 3.4 (69.3-74.1)	69.9 ± 5.4 (63.9-74.2)	102.2 ± 9.9 (77.5-111.2)	94.2 ± 10.3 (86.0-110.9)
14.5 ± 0.9 (13.0-16.1)	12.7 ± 0.6 (11.6-13.7)	11.4 ± 0.8 (10.1-12.7)	15.6 ± 1.9 (13.7-18.6)	15.3 ± 0.8 (14.5-16.4)	17.2 ± 1.6 (15.4-19.2)	16.5 ± 1.7 (15.5-18.5)	17.5 ± 4.3 (13.3-21.8)	14.6 ± 1.3 (12.6-17.2)	16.2 ± 2.5 (13.1-21.8)	17.3 ± 0.3 (17.1-17.5)	10.9 ± 1.0 (9.9-11.9)	19.3 ± 4.3 (13.3-25.9)	16.0 ± 2.3 (12.9-19.1)
152.3 ± 13.9 (131.6-176.7)	110.2 ± 10.0 (98.1-131.4)	110.0 ± 9.2 (88.6-124.0)	139.9 ± 11.1 (128.9-152.0)	128.3 ± 10.5 (118.5-146.8)	129.9 ± 7.4 (120.1-136.1)	130.6 ± 9.2 (122.0-140.2)	131.6 ± 18.5 (111.7-148.4)	123.9 ± 8.2 (111.0-136.3)	128.1 ± 11.1 (115.0-151.3)	135.2 ± 24.4 (117.9-152.5)	83.5 ± 3.6 (79.3-86.0)	131.2 ± 14.4 (113.3-164.5)	125.8 ± 13.4 (108.9-138.6)
1.1 ± 0.1 (0.9-1.2)	1.3 ± 0.1 (1.2-1.4)	1.2 ± 0.1 (1.1-1.3)	1.1 ± 0.1 (0.9-1.2)	1.2 ± 0.1 (1.1-1.3)	1.2 ± 0.1 (1.1-1.3)	1.2 ± 0.2 (1.1-1.4)	1.2 ± 0.2 (1.1-1.5)	1.3 ± 0.1 (1.2-1.4)	1.3 ± 0.1 (1.2-1.4)	1.0 ± 0.0 (1.0-1.0)	1.0 ± 0.1 (1.0-1.1)	1.1 ± 0.1 (0.8-1.5)	1.2 ± 0.1 (1.0-1.3)
5.8 ± 0.6 (5.0-7.2)	7.4 ± 0.6 (6.3-8.7)	8.1 ± 1.0 (7.1-10.1)	7.3 ± 2.8 (5.9-12.9)	8.5 ± 3.0 (6.0-13.2)	5.6 ± 0.4 (5.1-5.9)	7.4 ± 0.6 (6.7-8.0)	3.1 ± 1.9 (0.9-4.5)	6.1 ± 0.8 (5.0-7.2)	6.0 ± 1.9 (3.9-9.9)	6.5 ± 0.6 (6.1-7.0)	8.2 ± 0.6 (7.8-8.9)	— —	7.7 ± 2.9 (4.7-12.5)
5.5 ± 0.6 (4.4-6.5)	7.3 ± 0.7 (5.9-8.5)	8.1 ± 1.2 (6.3-10.8)	5.9 ± 0.5 (5.1-6.5)	8.6 ± 2.6 (5.9-12.4)	5.7 ± 0.6 (5.2-6.6)	7.2 ± 1.1 (6.5-8.5)	4.1 ± 1.7 (2.3-5.8)	5.6 ± 0.7 (4.2-6.7)	4.9 ± 1.2 (3.1-6.9)	5.8 ± 0.3 (5.6-6.0)	7.8 ± 0.5 (7.4-8.4)	— —	7.5 ± 2.8 (5.6-12.5)
43.4 ± 1.7 (40.0-46.7)	47.2 ± 1.7 (44.6-50.3)	49.4 ± 1.1 (47.3-51.4)	46.0 ± 1.5 (44.5-48.5)	44.8 ± 2.8 (41.0-48.0)	44.5 ± 2.9 (40.5-46.9)	43.1 ± 2.0 (41.3-45.2)	47.6 ± 4.6 (44.9-52.9)	47.6 ± 1.4 (42.6-52.9)	48.3 ± 1.5 (45.1-50.0)	47.6 ± 1.4 (46.6-48.6)	49.6 ± 1.3 (48.8-51.1)	51.8 ± 1.5 (49.2-54.0)	48.0 ± 1.5 (46.6-50.5)
34.1 ± 4.1 (27.0-41.2)	22.4 ± 3.8 (15.0-29.2)	24.0 ± 2.9 (18.5-28.3)	33.4 ± 2.5 (30.0-36.1)	33.0 ± 1.9 (31.0-35.4)	31.7 ± 3.5 (27.3-35.3)	32.6 ± 3.2 (30.0-36.1)	32.7 ± 4.7 (27.3-35.9)	28.1 ± 4.2 (20.3-34.2)	23.7 ± 1.4 (22.5-27.5)	36.3 ± 2.8 (34.3-38.3)	17.3 ± 1.3 (16.0-18.5)	33.1 ± 4.4 (28.2-45.2)	26.9 ± 3.7 (22.2-31.8)
87.8 ± 2.7 (82.0-92.0)	91.1 ± 2.8 (86.0-96.0)	90.0 ± 2.5 (84.0-94.0)	82.7 ± 3.5 (76.0-86.0)	83.0 ± 2.0 (80.0-85.0)	84.0 ± 1.6 (82.0-86.0)	82.7 ± 2.3 (80.0-84.0)	82.3 ± 0.6 (82.0-83.0)	82.3 ± 2.6 (77.0-85.00)	82.8 ± 3.2 (79.0-89.0)	90.4 ± 6.5 (85.8-95.0)	92.7 ± 2.5 (90.0-95.0)	87.0 ± 2.5 (82.0-90.0)	86.0 ± 3.4 (82.0-90.0)
57.8 ± 3.7 (50.0-64.0)	61.0 ± 2.7 (56.0-65.0)	61.5 ± 2.3 (58.0-66.0)	53.7 ± 3.4 (50.0-60.0)	55.8 ± 2.3 (53.0-58.0)	54.5 ± 3.0 (52.0-58.0)	55.3 ± 3.1 (52.0-58.0)	59.7 ± 3.5 (56.0-63.0)	48.8 ± 4.8 (40.0-56.0)	50.5 ± 6.0 (42.0-64.0)	59.1 ± 14.2 (49.0-69.1)	60.0 ± 9.0 (51.0-69.0)	55.9 ± 8.6 (47.0-74.0)	53.8 ± 2.9 (49.0-57.0)
145.5 ± 4.9 (138.0-154.0)	151.1 ± 3.6 (145.0-157.0)	151.5 ± 3.8 (142.0-158.0)	136.3 ± 2.7 (132.0-140.0)	138.8 ± 1.8 (138.0-142.0)	138.5 ± 2.5 (136.0-142.0)	138.0 ± 5.3 (132.0-142.0)	142.0 ± 4.0 (138.0-146.0)	131.2 ± 6.1 (120.0-140.0)	133.3 ± 7.2 (122.0-144.0)	149.4 ± 20.8 (134.8-164.1)	152.7 ± 7.8 (144.0-159.0)	142.7 ± 9.1 (132.0-158.0)	139.8 ± 4.3 (136.0-145.0)
24.9 ± 1.1 (23.0-27.0)	35.7 ± 1.7 (33.0-38.0)	31.7 ± 1.7 (28.0-35.0)	25.2 ± 1.0 (24.0-26.0)	23.8 ± 1.7 (22.0-27.0)	26.0 ± 1.2 (25.0-27.0)	25.3 ± 1.5 (24.0-27.0)	24.3 ± 1.5 (23.0-26.0)	23.0 ± 1.1 (21.0-25.0)	23.0 ± 2.0 (18.0-25.0)	24.9 ± 0.6 (24.5-25.4)	29.7 ± 0.6 (29.0-30.0)	24.7 ± 1.1 (22.0-26.0)	25.6 ± 1.1 (24.0-27.0)
18.5 ± 0.6 (17.5-19.5)	15.0 ± 0.8 (14.0-16.0)	14.5 ± 0.6 (14.0-16.0)	17.9 ± 1.1 (16.0-18.0)	17.6 ± 0.5 (17.0-18.0)	18.0 ± 0.0 (18.0-18.0)	18.3 ± 0.6 (18.0-19.0)	17.7 ± 0.6 (17.0-18.0)	17.4 ± 0.7 (16.0-18.0)	17.0 ± 1.1 (15.0-19.0)	18.4 ± 1.2 (17.5-19.3)	15.7 ± 1.2 (15.0-17.0)	19.0 ± 1.2 (16.0-20.0)	19.6 ± 1.1 (18.0-21.0)
47.7 ± 3.8 (44.0-57.0)	58.0 ± 2.7 (52.0-64.0)	55.1 ± 3.3 (50.0-61.0)	57.7 ± 5.6 (52.0-65.0)	50.4 ± 3.0 (46.0-54.0)	45.8 ± 2.1 (43.0-48.0)	52.0 ± 5.3 (48.0-58.0)	49.0 ± 7.2 (43.0-57.0)	42.3 ± 1.4 (40.0-44.0)	41.0 ± 2.4 (37.0-44.0)	66.5 ± 4.9 (63.0-70.0)	64.7 ± 6.4 (60.0-72.0)	48.0 ± 5.7 (40.0-60.0)	57.6 ± 3.0 (55.0-62.0)
36.8 ± 2.7 (30.0-42.0)	50.6 ± 3.8 (46.0-60.0)	48.1 ± 2.4 (44.0-54.0)	38.0 ± 2.3 (36.0-41.0)	40.4 ± 2.7 (36.0-44.0)	38.3 ± 4.3 (34.0-44.0)	41.3 ± 7.6 (36.0-50.0)	41.0 ± 2.6 (37.0-44.0)	40.8 ± 3.2 (37.0-48.0)	40.8 ± 2.3 (38.0-46.0)	35.9 ± 7.4 (30.6-41.1)	54.0 ± 4.0 (50.0-58.0)	37.3 ± 3.3 (31.0-44.0)	43.2 ± 3.2 (39.0-47.0)
34.2 ± 1.7 (32.0-38.0)	39.8 ± 2.2 (37.0-45.0)	39.1 ± 1.7 (36.0-42.0)	36.4 ± 3.8 (32.0-42.0)	34.1 ± 1.7 (32.0-37.0)	33.0 ± 1.4 (32.0-35.0)	34.7 ± 1.5 (33.0-36.0)	33.7 ± 3.2 (30.0-36.0)	31.1 ± 3.3 (29.0-34.0)	30.6 ± 1.5 (28.0-33.0)	35.9 ± 6.2 (31.5-40.3)	52.7 ± 1.2 (52.0-54.0)	33.1 ± 3.7 (23.0-38.0)	37.6 ± 2.5 (35.0-40.0)
12.5 ± 1.2 (10.0-14.0)	11.3 ± 1.4 (9.0-14.0)	11.5 ± 1.2 (10.0-14.0)	13.0 ± 1.0 (12.0-14.0)	13.3 ± 0.8 (12.0-14.0)	12.0 ± 0.0 (12.0-12.0)	13.3 ± 1.5 (12.0-15.0)	13.3 ± 1.2 (12.0-14.0)	11.4 ± 1.6 (9.0-14.0)	10.5 ± 0.8 (9.0-12.0)	13.1 ± 3.7 (10.5-15.8)	9.3 ± 1.2 (8.0-10.0)	12.3 ± 1.4 (10.0-14.0)	11.6 ± 1.7 (10.0-14.0)

\* Measurement based on the original figure.

TABLE 5. Morphometrics of *Longidorus breviannulatus* males from New York (Long-39) and Nebraska (Long-160) populations.

Morphometrics	Long-39	Long-160
N	4	2
L (mm)	4.81 ± 0.38 (4.42–5.33)	4.50 ± 0.47 (4.17–4.83)
A	70.6 ± 5.8 (65.3–76.1)	115.7 ± 16.2 (104.3–127.1)
B	10.4 ± 0.8 (9.3–11.3)	13.3 ± 2.5 (11.6–15.1)
C	93.9 ± 9.4 (85.5–106.7)	109.8 ± 0.0 (109.7–109.8)
c'	1.0 ± 0.1 (1.0–1.1)	1.3 ± 0.1 (1.2–1.3)
H%	9.1 ± 1.8 (6.7–10.7)	27.0 ± 2.8 (25.0–28.9)
T%	46.6	42.3
Odontostyle	91.3 ± 2.1 (89.0–93.0)	79.5 ± 3.5 (77.0–82.0)
Odontophore	63.8 ± 7.1 (58.0–74.0)	50.5 ± 3.5 (48.0–53.0)
Total stylet	155.0 ± 8.3 (148.0–167.0)	130.0 ± 7.1 (125.0–135.0)
Guide ring from anterior end	32.0 ± 1.8 (30.0–34.0)	23.0 ± 1.4 (22.0–24.0)
Anterior end width	15.5 ± 0.6 (15.0–16.0)	17.0 ± 1.4 (16.0–18.0)
Body width	68.3 ± 3.5 (64.0–72.0)	39.0 ± 1.4 (38.0–40.0)
Spicules	69.5 ± 4.7 (66.0–76.0)	43.0 ± 1.4 (42.0–44.0)
Supplements	11.0 ± 1.0 (10.0–12.0)	11
Tail length	51.5 ± 5.1 (45.0–56.0)	41.0 ± 4.2 (38.0–44.0)
ABW	50.3 ± 2.9 (47.0–54.0)	32.0 ± 1.4 (31.0–33.0)
Hyaline tail tip	4.8 ± 1.3 (3.0–6.0)	11.0 ± 0.0 (11.0–11.0)

*Male:* Anterior part of the body in males similar to that in females. Body curled ventrally in “C” shape when relaxed and killed by heat. Spicules paired, arcuate, appear to be longer in the New York specimens (seen flattened, as opposed to being seen obliquely in the Nebraska specimens), but they were severely flattened, which accounts for much of the differences in morphometric values when compared to the Nebraska males. Supplements consist of an adanal pair and a ventromedian series of 9 to 11. Testes paired, opposed, anterior testis reaching almost to middle of body. Tail conoid. Males were not found in the Arkansas populations but were found in New York (Long-39) and Nebraska (Long-160) populations (Table 5; Fig. 3).

*Remarks:* *Longidorus breviannulatus* is reported herein for the first time from Arkansas, Kansas, and California. Eight populations were identified from Arkansas (Table 1), and 19 populations were identified from California, Illinois, Iowa, Kansas, Michigan, Nebraska, New Jersey, New York, and Wisconsin (Table 2). The morphometrics of the 27 populations (Table 4) conform closely to the original description of the species

(Norton and Hoffmann, 1975). Males are reported and described for the first time. Four juvenile stages were present as reported by Hoffmann and Norton (1975). Juvenile measurements are not reported in this study.

*Longidorus fragilis* Thorne, 1974  
(Figs. 4,5)

*Measurements:* See Tables 6,7.

*Description*

*Female:* This species is characterized by its medium body length, tapering narrow-rounded anterior end, very slender odontostyle, elongate-conoid arcuate tail with blunt rounded terminus and parthenogenetic reproduction. Cuticle with fine transverse striations as seen with SEM. Anal opening a crescent-shaped transverse slit about 4 µm in length. Photos are presented of two Arkansas and the Indiana populations (Fig. 4) and include the anterior region (including odontostyle and odontophore), vulval area (parts of the genital tract), and the posterior region (showing variation in tail shape). The polytomous key code of Chen et al. (1997) is modified in parentheses as follows: A(2)3(4)-B(1)2-C(2)3-D2-E?F(2)3-G2(3)-H2-I1.

*Male:* Not found.

*Juveniles:* Four juvenile stages are present (Fig. 5). Most specimens fall into a distinct stage; however, a few individuals expressed overlapping morphometric between stages. In assigning an individual to a stage L, odontostyle length, replacement odontostyle length, and ABW were given the greatest importance. Specimens with characteristics of more than one factor were assigned to a specific stage into which they were thought to best fit. Note that females of this population had a wide range in odontostyle length. General morphology similar to that of female, but smaller. Measurements are given in Table 7. A scatter plot of odontostyle length and replacement odontostyle length against body length of *L. fragilis* juveniles and females (Long-224) is given in Fig. 6.

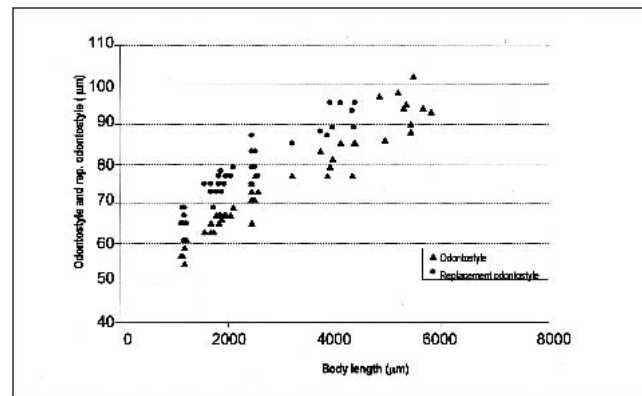


FIG. 6. Scatter plot of odontostyle length and replacement odontostyle length against body length of *L. fragilis* juveniles and females (Long-224).



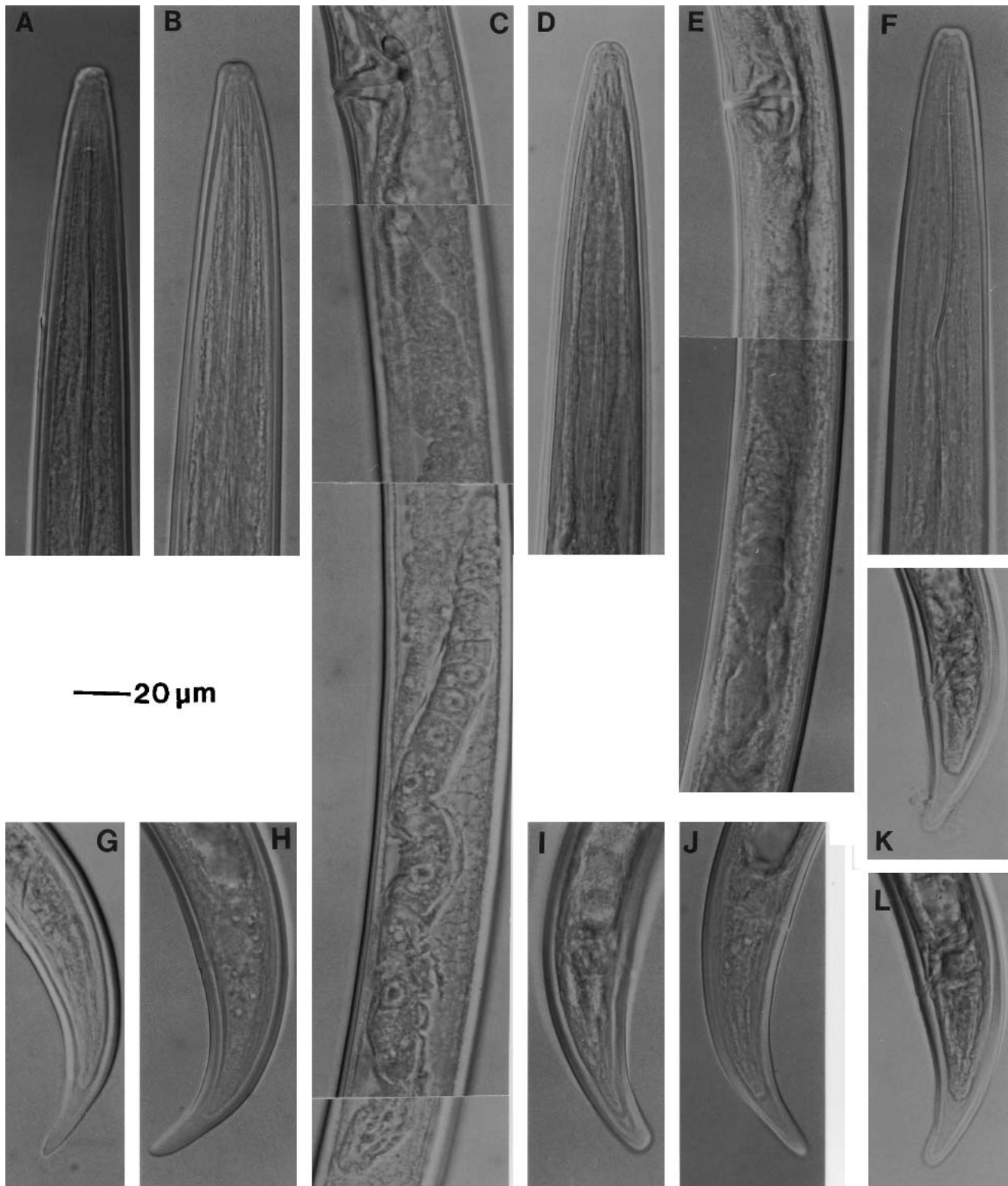


FIG. 4. Photographs of female *Longidorus fragilis* from Arkansas populations Long-224 (A-C, G-H), Long-97 (D-E, I-J), and Indiana population Long-59 (F, K-L). Anterior region showing head shape, odontostyle, odontophore, and guide ring (A-B, D-F). Vulval region showing vulval structures, uteri, spincter at distal ends of uteri, oviduct, and reflexed ovary (C, E). Posterior region showing variation in tail shape (G-H, I-L).

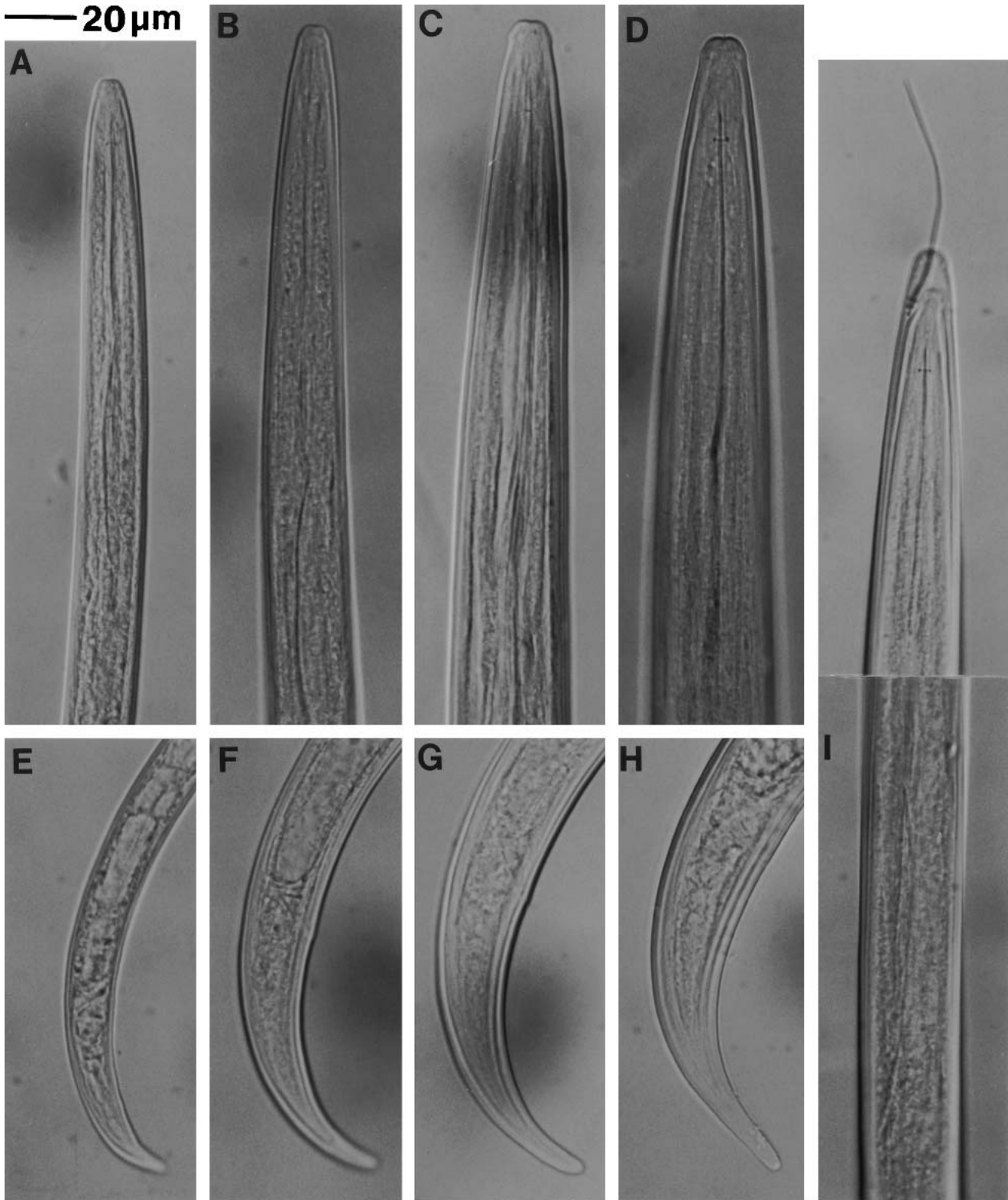


FIG. 5. Juveniles of *Longidorus fragilis* Arkansas population Long-224. Stage J1 (A, E), stage J2 (B, F), stage J3 (C, G), and J4 (D, H). Anterior region showing head shape, guide ring, odontostyle, odontophore (A–D), replacement odontostyle (A–B only). Posterior region showing tail shape (E–H). Molting J2–J3 showing the shed J2 odontostyle, the J3 odontostyle (normal position), and the replacement odontostyle (I).

TABLE 6. Morphometrics of *Longidorus fragilis* females from different localities and populations.

Morphometrics	<i>L. fragilis</i> Thorne, 1974	Lectotype (Robbins & Brown, 1995)	Paralectotype (Robbins & Brown, 1995)	Long-59 Indiana	Long-97 Arkansas	Long-127 Arkansas	Long-224 Arkansas	Long-225 Arkansas
N	1	1	1	2	17	4	10	5
L (mm)	5.30	5.55	5.94	4.99 ± 0.31 (4.76–5.21)	5.12 ± 0.58 (4.25–6.60)	5.48 ± 0.46 (4.89–5.91)	5.35 ± 0.29 (4.85–5.81)	5.32 ± 0.38 (4.83–5.70)
A	103	116	110	104.9 ± 1.9 (103.6–106.3)	128.4 ± 12.9 (106.3–157.1)	130.6 ± 11.5 (116.1–147.5)	122.0 ± 6.4 (115.2–131.9)	111.3 ± 5.5 (105.0–118.8)
B	13.2	14.5	14.9	16.9 ± 2.1 (15.4–18.3)	14.1 ± 3.2 (10.5–22.9)	15.0 ± 1.7 (12.1–16.4)	13.8 ± 0.8 (12.3–14.9)	14.4 ± 0.7 (13.7–15.1)
C	81.0	87.0	106.0	98.3 ± 7.5 (93.0–103.6)	70.1 ± 9.0 (57.4–84.0)	73.3 ± 8.2 (59.4–79.6)	68.1 ± 6.4 (58.9–80.7)	79.4 ± 5.5 (71.3–86.1)
c'	1.9	2.3	1.8	1.8 ± 0.2 (1.6–1.9)	2.6 ± 0.3 (2.1–3.2)	2.8 ± 0.4 (2.3–3.3)	2.7 ± 0.2 (2.4–3.0)	2.5 ± 0.3 (2.1–2.9)
G1%	7.0	7.0	6.4	6.2 ± 1.9 (4.9–7.6)	5.4 ± 2.0 (2.6–10.7)	5.6 ± 1.2 (3.8–7.2)	5.9 ± 2.2 (4.3–11.5)	6.6 ± 1.2 (5.8–7.5)
G2%	7.0	6.5	6.6	6.4 ± 1.3 (5.5–7.3)	4.8 ± 1.1 (2.4–6.1)	5.9 ± 1.7 (4.7–9.0)	6.1 ± 1.5 (4.3–9.7)	7.5 ± 1.8 (6.3–8.8)
V	49.0	45.9	44.8	49.1 ± 2.3 (47.5–50.7)	48.0 ± 2.7 (41.3–53.2)	47.3 ± 1.4 (45.8–49.2)	45.2 ± 1.1 (42.9–46.7)	46.9 ± 1.4 (45.6–48.5)
H%	37.0	34.4	35.7	45.3 ± 3.5 (42.9–47.8)	29.3 ± 3.6 (24.0–37.7)	29.7 ± 4.6 (23.1–33.9)	28.8 ± 2.0 (25.6–31.6)	31.2 ± 2.5 (27.4–33.3)
Odontostyle	94.0	96.0	94.0	89.0 ± 1.4 (88.0–90.0)	91.3 ± 4.7 (80.0–99.0)	94.8 ± 2.4 (93.0–99.0)	93.7 ± 4.8 (86.0–102.0)	88.6 ± 2.1 (87.0–92.0)
Odontophore		50.0	50.0	63.0 ± 4.2 (60.0–66.0)	58.2 ± 7.8 (50.0–83.0)	64.2 ± 10.3 (55.0–80.0)	58.9 ± 2.8 (54.0–63.0)	63.6 ± 6.7 (57.0–73.0)
Total stylet		146.0	144.0	152.0 ± 2.8 (150.0–154.0)	149.4 ± 9.3 (132.0–172.0)	159.0 ± 9.3 (149.0–173.0)	152.6 ± 4.7 (148.0–162.0)	152.2 ± 6.3 (144.0–160.0)
Guide ring from anterior end	31.8	30.0	28.0	30.0 ± 1.4 (29.0–31.0)	30.1 ± 1.2 (27.0–32.0)	29.8 ± 1.5 (28.0–32.0)	29.9 ± 1.5 (27.0–33.0)	30.8 ± 0.8 (30.0–32.0)
Anterior end width	11.3	13.0	13.0	13.5 ± 0.7 (13.0–14.0)	12.6 ± 1.0 (11.0–15.0)	12.6 ± 0.5 (12.0–13.0)	12.8 ± 0.4 (12.0–13.0)	13.0 ± 1.0 (12.0–14.0)
Body width	51.5	44.0	52.0	47.5 ± 2.1 (46.0–49.0)	39.9 ± 2.3 (37.0–44.0)	42.0 ± 2.8 (38.0–44.0)	43.9 ± 2.6 (40.0–48.0)	47.8 ± 2.3 (45.0–50.0)
Tail length	54.0	64.0	56.0	51.0 ± 7.1 (46.0–56.0)	73.5 ± 7.0 (62.0–84.0)	75.4 ± 9.5 (62.0–86.0)	78.8 ± 4.4 (72.0–84.0)	67.4 ± 7.9 (60.0–80.0)
ABW	31.3	28.0	32.0	29.0 ± 1.4 (28.0–30.0)	28.6 ± 1.2 (26.0–30.0)	27.0 ± 2.2 (24.0–30.0)	29.2 ± 1.1 (28.0–31.0)	27.2 ± 1.1 (26.0–28.0)
Hyaline tail tip	20.0	22.0	20.0	23.0 ± 1.4 (22.0–24.0)	21.6 ± 3.7 (16.0–29.0)	22.2 ± 2.9 (18.0–26.0)	22.7 ± 1.9 (19.0–25.0)	21.0 ± 2.6 (17.0–24.0)

*Remarks:* We identified seven populations in Arkansas (Table 5; Fig. 3) and one population from Indiana (Long-59). The Arkansas specimens fit the description given by Thorne (1974) and redescription by Robbins and Brown (1995), except that all Arkansas populations have a slightly longer tail (62–84 µm) than the type specimens (56, 64 µm); the specimens from Indiana have similar tail length (46–56 µm). This is the first report of this species in Arkansas and Indiana. Juveniles are reported for the first time.

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TABLE 7. Morphometrics of *Longidorus fragilis* juveniles from Arkansas population (Long-224).

Morphometrics	J1	J2	J3	J4
N	9	14	6	9
L	1.19 ± 0.33 (1.13–1.24)	1.89 ± 0.22 (1.58–2.45)	2.49 ± 0.48 (2.45–2.57)	4.00 ± 0.38 (3.21–4.40)
A	63.6 ± 4.3 (55.6–69.9)	73.5 ± 5.3 (67.5–86.3)	91.7 ± 6.1 (86.1–102.7)	10.3 ± 9.4 (97.0–127.4)
B	5.3 ± 0.3 (4.9–6.0)	6.7 ± 0.9 (4.9–8.1)	8.3 ± 0.8 (7.2–9.3)	11.9 ± 1.3 (10.5–14.7)
C	25.7 ± 1.2 (23.8–27.0)	30.9 ± 2.3 (26.8–34.0)	37.0 ± 2.9 (33.7–41.6)	52.0 ± 7.1 (39.5–63.3)
c'	3.3 ± 0.2 (3.0–3.7)	3.6 ± 0.3 (3.0–4.0)	3.4 ± 0.4 (2.9–3.8)	3.0 ± 0.3 (2.5–3.5)
Odontostyle length	58.0 ± 2.5 (54.8–60.9)	65.8 ± 1.9 (62.9–69.0)	73.4 ± 2.4 (71.1–77.1)	81.2 ± 3.7 (77.1–85.3)
Replacement odontostyle	66.3 ± 2.7 (60.9–69.0)	75.3 ± 2.3 (71.1–79.2)	81.5 ± 3.7 (77.1–87.3)	91.0 ± 3.9 (85.3–95.4)
Guide ring from anterior end	17.8 ± 0.7 (16.2–18.3)	21.4 ± 1.5 (19.3–24.4)	24.4 ± 0.6 (23.3–25.4)	25.9 ± 0.9 (24.4–27.4)
Anterior end width	8.1 ± 0.0 (8.1–8.1)	8.7 ± 0.5 (8.1–9.1)	10.3 ± 0.4 (10.2–11.2)	11.1 ± 0.9 (10.2–12.2)
Esophagus length	226.0 ± 15.3 (194.9–243.6)	283.6 ± 43.4 (211.1–373.5)	303.8 ± 27.3 (276.19–345.1)	334.4 ± 48.6 (263.9–401.9)
Body width	18.8 ± 1.0 (17.3–20.3)	25.7 ± 2.2 (22.3–29.4)	27.2 ± 1.6 (24.4–28.4)	37.0 ± 3.4 (30.5–42.6)
Tail length	46.4 ± 3.0 (42.6–50.8)	61.0 ± 5.3 (48.7–72.1)	67.7 ± 5.2 (58.9–73.1)	77.4 ± 7.1 (69.0–91.4)
ABW	14.0 ± 0.9 (12.2–15.2)	17.2 ± 0.9 (16.2–18.3)	19.8 ± 0.8 (18.3–20.3)	25.7 ± 1.1 (23.3–27.4)
Hyaline tail tip	5.7 ± 0.8 (4.1–6.1)	7.8 ± 2.6 (6.1–14.2)	12.0 ± 1.3 (10.2–14.2)	20.5 ± 1.8 (18.3–24.4)

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