

Longidorus bififormis n. sp. and *L. glycines* n. sp. (Nematoda: Longidoridae): Two Amphimictic Species from Arkansas¹

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Abstract: Two new amphimictic species of *Longidorus* were found in Arkansas. *Longidorus bififormis* n. sp., found in the rhizosphere of hardwood trees along streams in sandy soil in 14 Arkansas locations, is characterized by its long body (5.42–9.50 mm), wide expanded flattened head end, head width 20.0 to 26.0 µm, odontostyle 96 to 125 µm, guide ring 29 to 38 µm posterior to the anterior end, elongate conoid tail, and $c' = 0.9$ – 2.1 . Females with 2 to 11 vetromedian supplement-like structures were found in 2 of 14 populations of this new species. *Longidorus bififormis* n. sp. is closest to *L. seinhorsti* Peneva, Loof & Brown, 1998 and *L. closelongatus* Stoyanov, 1964. Among North American species it is closest to *L. glycines* n. sp. A distinguishing feature of *L. bififormis* n. sp. is the presence of supplement-like organs in some females. *Longidorus glycines* n. sp., found in soybean microplots at the Main Research Station, Fayetteville, Arkansas, is characterized by its long body (6.14–8.31 mm), wide offset flattened head end, head width 20.3 to 23.3 µm, odontostyle 87.3 to 99.5 µm, guide ring 22.3 to 26.4 µm posterior to the anterior end, short conoid tail with rounded terminus, and $c' = 0.9$ – 1.4 . *Longidorus glycines* n. sp. is closest to *L. lusitanicus* Macara, 1985. Among North American species it is close to *L. bififormis* n. sp., *L. breviannulatus* Norton and Hoffman, 1975, and *L. crassus* Thorne, 1964. Both new species are believed to have four juvenile stages; the first stage was not found for *L. bififormis* n. sp.

Key words: hierarchical cluster analysis, *Longidorus*, morphology, species, SEM, taxonomy.

In a survey and study of longidorids in Arkansas from 1999 to 2002, two amphimictic species were collected that had not been described previously. The first, *Longidorus bififormis* n. sp., was collected from the rhizosphere of hardwood trees in 14 locations in Arkansas, and the second, *L. glycines* n. sp., was found in soybean microplots at the Arkansas Research and Extension Center, Fayetteville.

MATERIALS AND METHODS

Sampling: The soil samples were collected from a depth of 10 to 40 cm either from the sandy soil of

stream banks (Table 1) or from the rhizosphere of soybean growing in sandy soil in microplots.

Nematode extraction, fixing, and mounting: Soil was suspended in water and the suspension was poured through an 850-µm-pore sieve to remove plant debris and a 75-µm-pore sieve to extract the nematodes. Nematodes caught on the 75-µm-pore sieve were separated from soil and other debris by sucrose (specific gravity = 1.167; 568 g sucrose in 1 liter water) centrifugation-flotation technique (Jenkins, 1964). Nematodes were killed and fixed by slowly adding boiling water until the volume of solution containing the nematodes was doubled, and then formalin (37%) was added to make a 2% final concentration. The nematodes were processed to glycerin by a modification of Seinhorst's rapid method (1959) and permanently mounted on 25 × 75-mm microscope slides.

Morphometrics: Specimens were examined with a Nikon Optiphot II compound microscope with Nomarski interference contrast at powers up to 1,000× magnification. Drawings and measurements were made using a Nikon drawing tube. Tail measurements followed the

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TABLE 1. Population numbers, associated plants, and source locations of *Longidorus bififormis* n. sp. from Arkansas.

Population number	Associated plant	Location
Long-4	Elm, hackberry, maple, scrub	Middle Fork of the White River, near Elkins, Washington Co.
Long-76	Birch, sweet gum, sycamore	Little Red River, South Fork, Clinton, Van Buren Co.
Long-85	Elm, sycamore	White River, Highway 45 Bridge, near Goshen, Washington Co.
Long-105	Elm, hackberry	Crooked Creek, Yellville, Marion Co.
Long-131	Grape, oak	County Road 62 Bridge, Illinois River, Washington Co.
Long-133	Box elder, cottonwood, locust, maple	War Eagle Mill, near Rogers, Benton Co.
Long-136	Box elder, hackberry, maple, pine	Little Missouri River by Highway 195, Hempstead Co.
Long-149	Elm, Osage orange, sycamore, willow	Osage Creek, Highway 412, Carrol Co.
Long-158	Birch, black cherry, river cane	Big Piney Creek Access Area, Highway 164, Pope Co.
Long-221	Elm	Kings River, Highway 412, Marble, Madison Co.
Long-222	Oak	Bridge on Robinson Road, Illinois River, Washington Co.
Long-227	Hackberry	Haroldton Access, Arkansas River, near Van Buren, Crawford Co.
Long-263	Birch, box elder, persimmon	Buffalo River, Newton Co.
Long-264	Birch, black walnut, hickory, maple, sycamore, tree of heaven	Frog Bayou, Highway 162, south of Alma, Crawford Co.

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 as 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 scanning electron microscopy (SEM) were fixed in Karnovsky's fixative for 2 hours after being killed by heat relaxation, washed in two changes of 0.05M cacodylate buffer (pH 7.2) for 20 minutes each, rinsed with distilled water twice, fixed with equal volume of 0.1M 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 then 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 an ISI-60 SEM at 15 kv.

Hierarchical cluster analysis: Nine morphometric characters used in hierarchical cluster analysis are L, distance of vulva from anterior end, head width, odontostyle length, guide ring position from anterior end, esophagus length, body width, tail length, and anal body width. Hierarchical cluster analysis was performed using the JMP 4.02 program (SAS Institute, Cary, NC). The populations and their measurements of *L. bififormis* n. sp. and *L. glycines* n. sp. used for this study are listed in Tables 2, 3, and 6. The morphometric measurements of 131 *Longidorus* species are from published resources whose values were obtained from the means of paratypes or holotype of the original species descriptions.

SYSTEMATICS

Longidorus bififormis n. sp. (Figs. (1–4))

Measurements: See Tables 2–5.

Description

Females (Paratypes): Body spiral upon heat relaxation, tapering toward both ends, cuticle appears smooth as seen by light microscopy, with fine transverse striae as observed under SEM. The glandular, lateral, hypodermal fields occupy about one-third of the body width. Head region wider anteriorly, almost ovate with anterior flattened, separated from the rest of the body by a short narrow region. Amphidial pouches deeply bilobed, extend about 90% of the distance from the anterior end to the guide ring. Odontostyle long and slender, odontophore base not flanged. Guide ring 6 μ m wide. Nerve ring close to the odontophore base. Esophagus dorylaimoid with esophageal bulb cylindri-

TABLE 2. Morphometrics of the holotype female, allotype male, and female and male paratypes of *Longidorus bififormis* n. sp. from Arkansas (population Long-4).

Character ¹	Holotype	Allotype	Female paratypes	Male paratypes
<i>n</i>	1	1	25	20
L (mm)	5.57	5.54	5.90 \pm 0.57 (5.29–7.43)	5.73 \pm 0.41 (5.00–6.49)
a	112	124	116 \pm 10.5 (104–143)	121 \pm 12.5 (96–138)
b	12.6	13.8	14.0 \pm 1.7 (11.9–17.9)	13.6 \pm 1.6 (10.3–15.2)
c	112	105	105.8 \pm 11.1 (87.0–136)	101 \pm 8.9 (85–118)
c'	1.32	1.37	1.5 \pm 0.2 (1.3–1.9)	1.4 \pm 0.1 (1.2–1.5)
G1%	9.7	—	9.4 \pm 1.5 (6.8–13.7)	—
G2%	10.3	—	9.1 \pm 1.5 (6.8–11.8)	—
V	50.3	—	49.9 \pm 1.6 (46.4–53.1)	—
T%	—	36.1	—	37.8 \pm 5.0 (27.0–46.0)
H%	38.8	19.2	37.1 \pm 4.0 (29.0–44.0)	27.7 \pm 3.5 (18.5–33.3)
Spicules	—	59.0	—	59.2 \pm 2.9 (52.8–62.9)
Supplement like or Supplements	8	13	4.5 (0–13)	13.6 \pm 1.6 (11–18)
Odontostyle	108.0	108.0	105.8 \pm 3.6 (98.5–111.7)	103.8 \pm 4.6 (91.4–111.7)
Odontophore	67.0	60.9	66.1 \pm 3.2 (58.9–71.1)	66.5 \pm 2.8 (60.9–73.1)
Total stylet	174.6	168.5	171.9 \pm 4.4 (164.4–182.7)	170.3 \pm 5.2 (158.3–182.7)
Guide ring from anterior end	30.5	28.4	32.0 \pm 1.8 (28.4–36.5)	32.7 \pm 1.1 (31.5–35.5)
Head width	23.3	20.3	22.9 \pm 0.8 (22.3–24.4)	23.1 \pm 0.8 (22.3–24.4)
Body width	49.7	44.7	50.5 \pm 3.0 (44.7–56.8)	48.0 \pm 4.8 (40.6–56.8)
Tail length	49.7	52.8	56.1 \pm 4.3 (50.8–67.0)	57.1 \pm 4.3 (52.8–67.0)
ABW	37.6	38.6	38.5 \pm 2.0 (34.5–42.6)	41.7 \pm 2.1 (38.6–45.7)
Hyaline tail tip	19.3	10.2	20.4 \pm 1.8 (16.2–22.3)	15.8 \pm 2.5 (10.2–20.3)

¹ All measurements except length in micrometers. Means \pm SD, range in parentheses.

cal. Basal esophageal bulb in paratypes 101.5–121.8 μ m long, 22.3–26.4 μ m wide, with the normal arrangement of one dorsal gland nuclei (24%–31%) of the basal esophageal bulb length and two subventral nuclei (SV1 61%–67%, SV2 63%–69%). Cardia conoid at the junction of the esophageal bulb with the intestine. Reproductive system amphidelphic, didelphic, with reflexed ovaries. Anterior reproductive system 420–684 μ m long, posterior reproductive system 416–684 μ m long in paratypes. Vulva a transverse slit as seen obliquely. Vagina perpendicular to body axis with a thick cuticular lining, extending to half the body width. Anterior uterus of paratypes 126–300 μ m long, posterior uterus 136–290

TABLE 3. Morphometrics of *Longidorus bififormis* n. sp. females from 12 different Arkansas locations.

Character	Long-76	Long-85	Long-105	Long-131	Long-133	Long-136	Long-149	Long-158	Long-221	Long-227	Long-263	Long-264
<i>n</i>	4	2	8	6	3	8	7	10	2	2	2	3
L (mm)	7.46 ± 0.45 (6.90–8.08)	5.73 ± 0.11 (5.66–5.80)	6.52 ± 0.47 (5.83–7.08)	7.63 ± 1.11 (6.06–9.50)	7.13 ± 0.31 (6.80–7.42)	5.90 ± 0.42 (5.42–6.55)	7.11 ± 0.80 (5.64–8.25)	7.33 ± 0.54 (6.59–7.97)	6.59 ± 0.60 (6.55–6.63)	7.60 ± 1.10 (6.82–8.37)	7.74 ± 0.85 (7.68–7.80)	6.28 ± 0.20 (6.05–6.40)
a	146.8 ± 17.3 (128.8–173.8)	113.4 ± 0.5 (113.0–113.7)	135.1 ± 12.2 (116.6–160.9)	146.9 ± 21.7 (116.5–181.8)	155.3 ± 10.9 (144.7–166.5)	132.0 ± 7.6 (124.4–144.7)	133.6 ± 12.4 (117.5–149.0)	131.5 ± 11.7 (112.0–147.6)	140.2 ± 13.4 (130.7–149.7)	166.5 ± 16.3 (155.0–178.1)	137.0 ± 0.2 (136.8–137.1)	149.6 ± 4.8 (144.0–152.4)
b	17.3 ± 2.0 (15.1–20.3)	16.9 ± 5.1 (13.8–20.5)	19.2 ± 3.2 (13.8–23.1)	20.0 ± 4.0 (13.9–24.3)	17.9 ± 0.7 (17.2–18.6)	15.3 ± 2.1 (13.4–19.5)	19.2 ± 1.4 (16.8–21.2)	17.4 ± 4.7 (10.5–24.3)	17.9 ± 0.8 (17.4–18.4)	17.1 ± 2.1 (15.7–18.6)	14.5 ± 0.6 (14.1–14.9)	18.3 ± 3.3 (14.5–20.4)
c	137.3 ± 12.2 (123.9–155.4)	99.6 ± 12.7 (90.6–108.7)	104.5 ± 20.9 (72.0–141.6)	127.6 ± 17.1 (101.0–152.4)	126.7 ± 3.7 (123.7–130.8)	104.4 ± 9.4 (94.4–118.6)	116.6 ± 19.2 (82.9–140.6)	133.9 ± 16.4 (98.8–152.6)	107.7 ± 5.3 (103.9–111.5)	135.5 ± 2.5 (133.7–137.2)	149.4 ± 13.8 (139.6–159.2)	101.7 ± 8.7 (91.7–106.7)
<i>c'</i>	1.5 ± 0.1 (1.2–1.6)	1.5 ± 0.2 (1.4–1.6)	1.8 ± 0.2 (1.4–2.3)	1.6 ± 0.3 (1.3–2.1)	1.5 ± 0.1 (1.3–1.6)	1.7 ± 0.1 (1.5–1.9)	1.6 ± 0.2 (1.3–2.1)	1.3 ± 0.1 (1.2–1.6)	1.6 ± 0.1 (1.6–1.7)	1.6 ± 0.1 (1.5–1.6)	1.3 ± 0.1 (1.2–1.3)	1.8 ± 0.1 (1.7–1.9)
G1%	6.8 ± 1.2 (5.9–7.6)	6.5 ± 1.5 (5.9–7.6)	7.8 ± 2.3 (5.9–11.9)	6.7 ± 1.5 (5.1–8.9)	5.5 ± 2.4 (4.1–8.2)	9.2 ± 1.1 (7.9–10.6)	6.5 ± 2.2 (2.4–8.3)	9.5 ± 2.8 (6.0–14.1)	8.4 ± 1.2 (7.6–9.3)	3.6 ± 2.3 (1.9–5.2)	7.1 ± 2.0 (5.7–8.6)	14.2 ± 0.5 (13.9–14.5)
G2%	6.5 ± 1.5 (5.4–7.6)	6.5 ± 1.5 (5.4–7.6)	8.9 ± 3.3 (5.9–16.2)	7.3 ± 1.0 (5.7–8.1)	7.4 ± 0.9 (6.3–8.1)	8.7 ± 1.8 (6.3–10.5)	7.7 ± 1.3 (5.8–9.2)	8.9 ± 2.8 (5.9–13.7)	5.0 ± 1.1 (4.3–5.8)	5.8 ± 0.4 (5.5–6.1)	8.6 ± 0.8 (8.0–9.1)	8.7 ± 4.0 (5.9–11.6)
V	45.7 ± 2.9 (42.2–50.0)	46.5 ± 1.8 (45.2–47.8)	46.5 ± 1.1 (45.1–48.4)	49.2 ± 2.4 (46.2–52.1)	48.4 ± 1.3 (47.1–49.7)	48.4 ± 2.1 (44.1–50.9)	48.3 ± 0.9 (47.1–50.0)	47.3 ± 3.4 (40.5–51.6)	46.0 ± 1.0 (45.3–46.8)	48.4 ± 0.8 (47.8–49.0)	48.8 ± 0.1 (48.7–48.8)	46.4 ± 1.0 (45.3–47.1)
H%	32.9 ± 4.4 (27.6–38.5)	23.9 ± 3.8 (21.2–26.6)	29.6 ± 6.2 (22.2–42.0)	28.4 ± 9.6 (11.1–38.0)	32.1 ± 6.1 (26.3–38.5)	27.8 ± 2.5 (24.1–30.8)	32.5 ± 2.9 (29.4–37.1)	36.0 ± 4.2 (28.3–43.1)	30.1 ± 7.3 (25.0–35.3)	21.8 ± 8.6 (15.7–27.9)	34.8 ± 5.6 (30.9–38.8)	31.1 ± 1.9 (30.0–33.3)
Odontostyle	107.2 ± 4.1 (101.0–110.0)	98.0 ± 0.0 (98.0–98.0)	103.6 ± 4.6 (96.0–108.0)	108.2 ± 5.2 (100.0–115.0)	108.3 ± 6.7 (101.0–114.0)	100.8 ± 4.1 (97.0–109.0)	107.1 ± 4.4 (102.0–115.0)	113.5 ± 5.7 (106.0–121.0)	106.8 ± 2.5 (105.0–108.5)	108.5 ± 2.1 (107.0–110.0)	117.0 ± 11.3 (109.0–125.0)	104.3 ± 0.6 (104.0–105.0)
Odontophore	67.5 ± 5.0 (59.0–74.0)	68.5 ± 12.0 (60.0–77.0)	59.1 ± 3.4 (55.0–66.0)	70.8 ± 6.6 (62.0–77.0)	65.7 ± 6.1 (59.0–71.0)	65.0 ± 4.4 (60.0–72.0)	67.3 ± 4.0 (60.0–72.0)	69.9 ± 7.0 (57.0–80.0)	63.4 ± 0.6 (63.0–63.0)	72.0 ± 2.8 (70.0–74.0)	66.5 ± 2.1 (65.0–68.0)	65.7 ± 7.5 (57.0–70.0)
Total stylet	174.7 ± 6.7 (167.0–184.0)	166.5 ± 12.0 (158.0–175.0)	162.8 ± 6.9 (151.0–173.0)	179.0 ± 9.0 (168.0–192.0)	174.0 ± 2.6 (172.0–177.0)	164.6 ± 3.8 (158.0–169.0)	174.4 ± 6.1 (162.0–180.0)	183.4 ± 11.4 (165.0–201.0)	170.2 ± 3.1 (168.0–172.4)	180.5 ± 0.7 (180.0–181.0)	183.5 ± 13.4 (174.0–193.0)	170.0 ± 7.8 (161.0–175.0)
Guide ring from anterior end	31.2 ± 1.8 (29.0–34.0)	30.5 ± 2.1 (29.0–32.0)	31.5 ± 1.1 (30.0–33.0)	32.2 ± 2.1 (30.0–35.0)	30.7 ± 1.2 (30.0–32.0)	32.8 ± 2.3 (30.0–37.0)	34.8 ± 1.7 (32.0–37.0)	34.2 ± 2.5 (29.0–38.0)	32.4 ± 1.2 (31.5–33.3)	32.5 ± 3.5 (30.0–35.0)	36.5 ± 6.4 (32.0–41.0)	30.3 ± 0.6 (30.0–31.0)
Head width	23.7 ± 1.4 (22.0–26.0)	23.0 ± 0.0 (23.0–23.0)	22.9 ± 0.6 (22.0–24.0)	23.3 ± 1.6 (21.0–25.0)	22.3 ± 0.6 (20.0–23.0)	20.6 ± 0.7 (20.0–22.0)	23.5 ± 1.6 (20.0–25.0)	23.9 ± 1.4 (22.0–26.0)	23.6 ± 0.0 (23.6–23.6)	23.0 ± 0.0 (23.0–23.0)	26.5 ± 0.7 (26.0–27.0)	22.0 ± 0.0 (22.0–22.0)
Body width	51.2 ± 4.8 (45.0–59.0)	50.5 ± 0.7 (50.0–51.0)	48.4 ± 3.2 (43.0–52.0)	52.3 ± 6.7 (40.0–60.0)	46.0 ± 2.6 (43.0–48.0)	44.3 ± 3.3 (38.0–47.0)	53.3 ± 3.7 (48.0–57.0)	56.0 ± 4.7 (51.0–64.0)	47.3 ± 4.9 (43.8–50.8)	45.5 ± 2.1 (44.0–47.0)	56.5 ± 0.7 (56.0–57.0)	42.0 ± 0.0 (42.0–42.0)
Tail length	54.3 ± 2.7 (52.0–58.0)	58.0 ± 8.5 (52.0–64.0)	63.9 ± 9.0 (50.0–81.0)	60.5 ± 10.9 (50.0–76.0)	56.3 ± 4.0 (52.0–60.0)	56.9 ± 4.7 (50.0–64.0)	61.8 ± 6.6 (50.0–68.0)	55.3 ± 6.8 (50.0–68.0)	61.3 ± 2.5 (59.5–63.0)	56.0 ± 7.1 (51.0–61.0)	52.0 ± 3.5 (49.0–55.0)	62.0 ± 3.5 (60.0–66.0)
ABW	37.3 ± 2.5 (35.0–42.0)	39.0 ± 1.4 (38.0–40.0)	38.5 ± 1.1 (33.0–36.0)	38.5 ± 3.7 (33.0–43.0)	37.7 ± 1.2 (37.0–39.0)	33.9 ± 1.0 (32.0–35.0)	38.0 ± 2.4 (38.0–40.0)	41.3 ± 2.5 (37.0–45.0)	37.2 ± 0.6 (36.8–37.6)	36.0 ± 2.8 (34.0–38.0)	41.0 ± 1.4 (40.0–42.0)	34.7 ± 0.6 (34.0–35.0)
Hyaline tail tip	17.8 ± 2.4 (15.0–20.0)	14.0 ± 4.2 (11.0–17.0)	18.5 ± 2.1 (15.0–21.0)	16.5 ± 4.4 (8.0–20.0)	18.0 ± 2.6 (15.0–20.0)	15.5 ± 0.8 (14.0–16.0)	20.0 ± 1.9 (16.0–23.0)	19.9 ± 3.0 (15.0–24.0)	18.4 ± 3.7 (15.8–21.0)	12.5 ± 6.4 (8.0–17.0)	18.0 ± 1.4 (17.0–19.0)	19.3 ± 2.3 (18.0–22.0)

¹ All measurements except length in micrometers. Means + SD, range in parentheses.

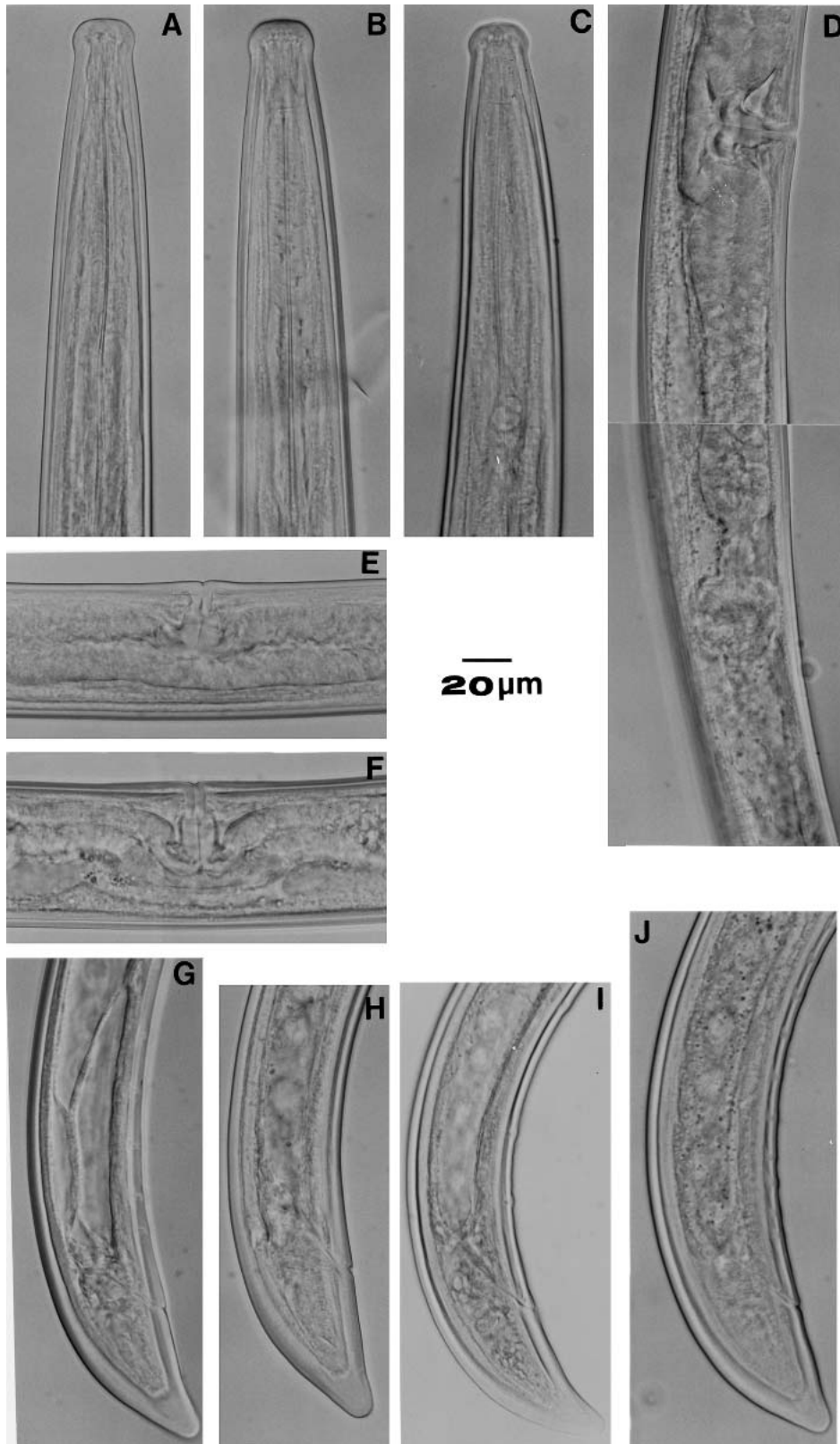


FIG. 1. A–J) Photographs of female *Longidorus biformis* n. sp. (type population Long-4). A, E, G) Holotype female. A–C) Head region showing entire stylet. D) Vulval region showing posterior uterus, sphincter between uterus and oviduct, base of oviduct. E–F) Vulval region. G–J) Female tail region variations in shape with G,I,J showing supplement-like structures.



FIG. 2. A–C) Photographs of *Longidorus biformis* n. sp. (type population Long-4) entire reproductive system with slight overlap of oviducts. A) Anterior region shows reflexed ovary and oviduct. B) Central region showing vulva, vaginal region, both uteri, and both uterine-oviduct sphincters. C) Posterior region shows reflexed ovary and oviduct.

μm long. Densely packed oval sperm, in genital tract in females, sperm about 3 μm long, 1.5 μm wide. Tail elongate conoid, ventrally bent, about one and one-half ABW long. Hyaline region 16–22 μm long. Ventromedian supplement-like structures anterior to the anus varying from zero to 13, morphologically similar with male supplements but less developed, only one adanal pore instead of a pair as in males. Twenty-nine of 36 females have supplement-like structures (Figs. 1G, I–J; 4H–J) in the type location; three of seven females in population Long-264 have supplement-like structures (2, 5, 8 in number). These structures were not observed in any other populations examined. This unique character has not previously been reported in *Longidorus*.

Males: Morphologically similar to female, more strongly curved tail. Spicules well developed, arcuate. Supplements, an adanal pair, a ventromedian series of nine to fifteen. Tail about one and one-half anal body

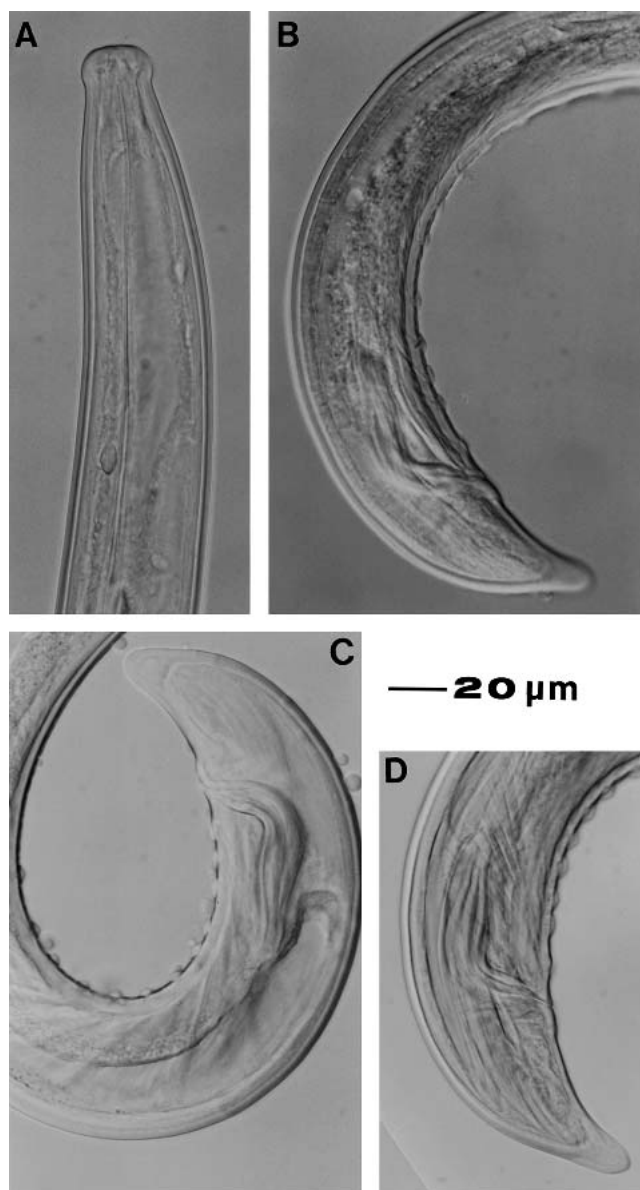


FIG. 3. A–D) Photographs of *Longidorus biformis* n. sp. (type population Long-4) males. A) Head region showing entire stylet. B–D) Variation of tail morphology and spicule shape.

width in length, dorsally convex, bluntly rounded terminus.

Juveniles: Morphologically similar to adults, but smaller. The presence of four juvenile stages is assumed although the first-stage juvenile (with the replacement odontostyle embedded in the base of the odontophore) was not found (Fig. 5). Replacement odontostyle present in the three juvenile stages observed were well posterior to the odontophore base. Juvenile measurements of two populations are given (Table 5).

Type locality and habitat

Sandy soil around a mixture of American elm (*Ulmus americana* L.), Hackberry (*Celtis occidentalis* L.), and Maple (*Acer* sp. L.) scrub (small hardwood trees) by

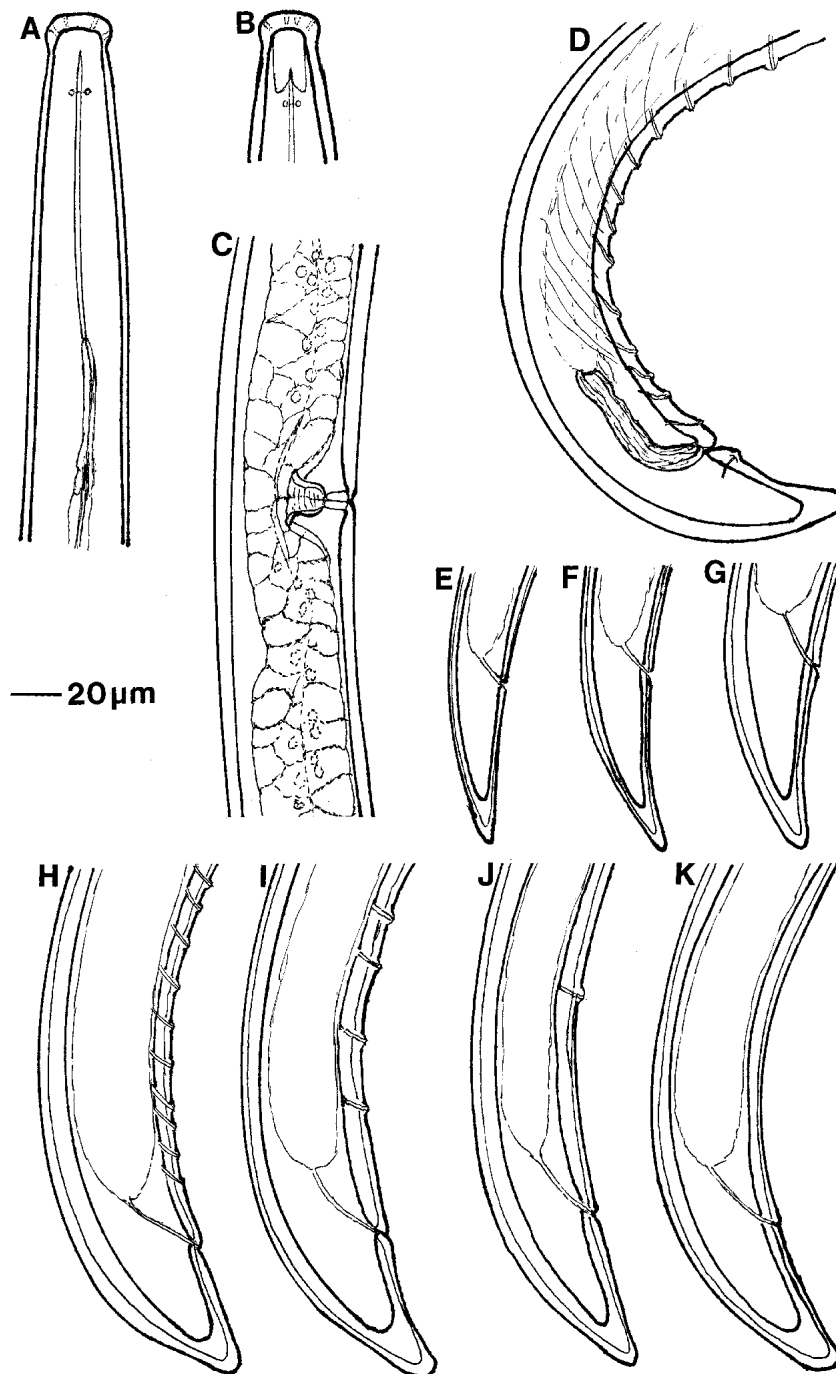


FIG. 4. A–J) Drawings of *Longidorus biformis* n. sp. paratypes (population Long-4). A) Anterior region. B) Amphid region. C) Vulval region. D) Male posterior region. E) Second-stage juvenile tail. F) Third-stage juvenile tail. G) Fourth-stage juvenile tail. H–K) Variation in female tail.

the bank of Middle Fork of the White River, Elkins, Washington County, Arkansas, collected by R. T. Robbins on 12 October 1982 and by R. T. Robbins and Weimin Ye on 4 November 1999 and 20 September 2001. Global positional coordinates N 35°; 59.732 minutes; W 094° 04.301 minutes.

Type specimens

The holotype female (slide T571t) and allotype male (T572t) are deposited in the Nematology Laboratory

Collection, USDA, ARS, Beltsville, Maryland. Two paratype females and two paratype males are deposited in the following collections: Department of Nematology Collection, University of California, Riverside, California; Department of Nematology Collection, University of California, Davis, California; CABI Bioscience Collection, UK Centre, Surrey, United Kingdom; Department of Nematology Collection, Agricultural University, Wageningen, Netherlands; and the Institute of Parasitology Collection, Moscow, Russia. All remaining

TABLE 4. Morphometrics of *Longidorus bififormis* n. sp. males from 11 different Arkansas locations.

Character ¹	Long-76	Long-105	Long-131	Long-133	Long-136	Long-149	Long-158	Long-222	Long-227	Long-263	Long-264
<i>n</i>	5	3	1	8	1	3	7	1	1	2	3
L (mm)	5.99 ± 0.72 (5.13-7.02)	6.89 ± 0.31 (6.60-7.22)	6.300	6.43 ± 0.75 (5.37-7.30)	4.95	6.03 ± 0.11 (5.90-6.10)	6.63 ± 0.54 (5.97-7.43)	5.90	5.86	6.39 ± 0.51 (6.03-6.75)	6.50 ± 1.17 (5.70-7.85)
a	134.9 ± 14.3 (124.4-156.0)	144.0 ± 10.7 (131.7-150.4)	157.5	142.6 ± 15.8 (119.3-169.5)	112.5	124.1 ± 15.5 (111.3-141.4)	138.4 ± 13.5 (114.8-154.8)	111.3	146.5	125.3 ± 0.4 (125.0-125.6)	134.4 ± 22.5 (118.8-160.2)
b	18.4 ± 2.3 (16.4-20.9)	19.0 ± 5.4 (14.3-24.8)	16.0	16.8 ± 2.5 (13.5-20.6)	10.7	20.6 ± 2.7 (17.4-22.3)	19.2 ± 3.8 (13.3-23.7)	15.5	13.2	15.7 ± 0.8 (15.2-16.3)	15.5 ± 2.9 (12.5-18.3)
c	110.4 ± 8.7 (101.6-121.5)	164.0 ± 44.6 (112.8-194.1)	95.5	106.2 ± 15.4 (79.0-121.7)	85.3	89.7 ± 8.6 (81.1-98.3)	157.8 ± 28.0 (117.1-198.5)	98.3	127.4	137.6 ± 3.7 (135.0-140.2)	105.2 ± 20.2 (86.4-126.6)
c'	1.6 ± 0.2 (1.4-1.9)	1.1 ± 0.3 (0.9-1.5)	1.7	1.5 ± 0.2 (1.3-1.7)	1.4	1.6 ± 0.3 (1.4-1.9)	1.1 ± 0.1 (0.9-1.3)	1.4	1.2	1.2 ± 0.0 (1.2-1.2)	1.6 ± 0.2 (1.5-1.8)
H%	24.0 ± 4.8 (20.0-29.7)	36.6 ± 7.4 (28.1-41.2)	27.3	24.8 ± 2.8 (20.3-27.9)	17.2	26.4 ± 2.5 (25.0-29.3)	36.1 ± 9.8 (25.0-52.9)	23.3	28.3	31.0 ± 4.3 (27.9-34.0)	25.9 ± 1.7 (24.2-27.6)
T%	44.0 ± 9.8 (34.0-53.5)	46.8 ± 1.7 (45.4-48.7)	59.9	33.6 ± 5.7 (24.4-41.6)	22.0	41.5 ± 4.1 (37.4-45.6)	53.4 ± 7.4 (33.3-63.8)	34.7	22.8	43.6 ± 15.5 (32.6-54.6)	42.6 ± 14.7 (32.6-59.4)
Odontostyle	100.6 ± 9.6 (90.0-113.0)	98.3 ± 10.4 (90.0-110.0)	112.0	109.5 ± 6.0 (104.0-120.0)	96.0	108.0 ± 5.3 (104.0-114.0)	96.1 ± 8.6 (88.0-113.0)	112.0	112.0	103.0 ± 15.6 (92.0-114.0)	101.7 ± 2.1 (100.0-104.0)
Odontophore	64.6 ± 15.2 (49.0-88.0)	56.7 ± 1.2 (56.0-58.0)	60.0	70.3 ± 7.7 (56.0-80.0)	56.0	69.0 ± 3.6 (65.0-72.0)	68.4 ± 6.6 (59.0-80.0)		60.0	71.0 ± 12.7 (62.0-80.0)	65.3 ± 6.7 (58.0-71.0)
Total stylet	165.2 ± 20.4 (139.0-194.0)	155.0 ± 10.1 (146.0-166.0)	172.0	179.8 ± 9.4 (163.0-188.0)	153.0	177.0 ± 1.7 (176.0-179.0)	164.6 ± 10.8 (152.0-185.0)		172.0	174.0 ± 28.3 (154.0-194.0)	167.0 ± 6.9 (159.0-171.0)
Guide ring from anterior end	29.4 ± 2.4 (26.0-32.0)	29.7 ± 3.8 (27.0-34.0)	32.0	30.8 ± 2.0 (29.0-35.0)	28.0	33.0 ± 0.0 (33.0-33.0)	28.9 ± 3.1 (25.0-35.0)	32.0	26.0	34.0 ± 4.2 (31.0-37.0)	31.3 ± 1.2 (30.0-32.0)
Head width	20.6 ± 3.4 (17.0-24.0)	25.7 ± 3.1 (23.0-29.0)	26.0	22.3 ± 1.3 (21.0-24.0)	20.0	22.0 ± 1.0 (21.0-23.0)	26.0 ± 1.5 (24.0-28.0)	24.0	20.0	24.5 ± 0.7 (24.0-25.0)	21.7 ± 1.5 (20.0-23.0)
Body width	44.4 ± 2.2 (41.0-47.0)	48.0 ± 4.0 (44.0-52.0)	40.0	45.1 ± 2.4 (42.0-49.0)	40.0	49.0 ± 5.3 (43.0-53.0)	48.0 ± 2.2 (45.0-52.0)	53.0	40.0	51.0 ± 4.2 (48.0-54.0)	48.3 ± 0.6 (48.0-49.0)
Spicules	67.2 ± 9.8 (55.0-78.0)	65.0 ± 5.0 (60.0-70.0)	70.0	66.4 ± 1.8 (64.0-68.0)	59.0	61.3 ± 5.8 (58.0-76.0)	65.4 ± 6.3 (58.0-76.0)	72.0	68.0	70.5 ± 3.5 (68.0-73.0)	59.3 ± 3.1 (56.0-62.0)
Supplements	11.4 ± 1.1 (10.0-13.0)	13.7 ± 1.5 (12.0-15.0)	13.0	11.5 ± 1.6 (9.0-13.0)	9.0	12.3 ± 2.3 (11-15)	12.9 ± 1.5 (11-15)	9.0	13	14	12.0
Tail length	54.4 ± 6.5 (48.0-64.0)	45.0 ± 16.5 (34.0-64.0)	66.0	61.1 ± 6.5 (48.0-68.0)	52.0	67.7 ± 7.5 (60.0-75.0)	42.9 ± 6.2 (34.0-51.0)	60.0	46.0	46.5 ± 4.9 (43.0-50.0)	62.0 ± 4.0 (58.0-66.0)
ABW	35.0 ± 5.4 (27.0-40.0)	39.3 ± 3.1 (36.0-42.0)	40.0	41.0 ± 2.4 (38.0-45.0)	34.0	41.7 ± 2.1 (40.0-44.0)	38.3 ± 2.9 (33.0-42.0)	44.0	38.0	39.0 ± 2.8 (37.0-41.0)	38.7 ± 3.1 (36.0-42.0)
Hyaline tail tip	13.2 ± 3.8 (10.0-19.0)	15.7 ± 2.1 (14.0-18.0)	18.0	15.1 ± 2.4 (13.0-19.0)	11.0	18.0 ± 3.6 (15.0-22.0)	15.0 ± 2.2 (12.0-18.0)	14.0	13.0	14.5 ± 3.5 (12.0-17.0)	16.0 ± 0.0 (16.0-16.0)

¹ All measurements except length in micrometers. Means ± SD, range in parentheses.

TABLE 5. Morphometrics of *Longidorus biformis* n. sp. juvenile populations Long-4 and Long-136.

Character	Long-4 J2	Long-4 J3	Long-4 J4	Long-136 J2	Long-136 J3	Long-136 J4
<i>n</i>	4	6	10	1	9	5
L (mm)	2.46 ± 0.49 (1.84–3.03)	3.16 ± 0.95 (3.05–3.29)	4.47 ± 0.37 (3.80–4.95)	1.57	3.39 ± 0.84 (2.34–4.64)	4.63 ± 0.60 (3.98–5.52)
<i>a</i>	64.5 ± 7.9 (56.5–73.9)	69.4 ± 8.8 (60.1–81.4)	88.9 ± 11.4 (73.6–107.9)	64.3	96.0 ± 15.5 (73.6–126.9)	113.9 ± 4.9 (108.6–120.0)
<i>b</i>	8.3 ± 2.2 (6.3–10.8)	10.8 ± 1.6 (8.8–12.8)	11.8 ± 0.6 (10.9–12.9)	5.7	10.7 ± 2.2 (6.8–13.5)	13.8 ± 1.6 (11.1–15.1)
<i>c</i>	41.6 ± 10.6 (29.2–53.4)	48.7 ± 4.2 (41.6–52.9)	74.8 ± 9.5 (57.6–89.6)	30.9	59.4 ± 17.1 (42.6–84.6)	82.5 ± 9.0 (75.5–97.1)
<i>c'</i>	2.3 ± 0.4 (1.8–2.7)	2.1 ± 0.2 (1.9–2.5)	1.7 ± 0.1 (1.4–1.9)	2.8	2.2 ± 0.4 (1.6–2.6)	1.8 ± 0.1 (1.6–1.9)
Odontostyle length	66.5 ± 3.0 (65.0–71.1)	81.4 ± 0.4 (81.2–82.2)	98.9 ± 4.0 (91.4–103.5)	69.0	83.5 ± 2.9 (79.2–87.3)	94.6 ± 2.7 (91.4–97.4)
Replacement odontostyle	76.1 ± 3.5 (71.1–79.2)	94.9 ± 4.1 (90.3–101.5)	109.5 ± 4.8 (101.5–115.7)	81.2	97.7 ± 2.1 (93.4–99.5)	105.2 ± 2.6 (101.5–107.6)
Guide ring from anterior end	23.9 ± 3.5 (20.3–28.4)	24.0 ± 1.0 (22.3–25.4)	28.7 ± 2.0 (25.4–31.5)	20.3	25.7 ± 2.1 (23.3–28.4)	29.2 ± 1.8 (26.4–30.5)
Head width	15.2 ± 1.2 (14.2–16.2)	17.4 ± 1.0 (16.2–18.3)	20.8 ± 1.4 (18.3–22.3)	12.2	15.7 ± 1.8 (14.2–18.3)	17.9 ± 0.6 (17.3–18.3)
Esophagus length	304.5 ± 54.2 (276.1–385.7)	298.4 ± 45.1 (243.6–365.4)	378.0 ± 25.7 (324.8–401.9)	276.1	318.0 ± 37.9 (243.6–365.4)	337.8 ± 33.7 (296.4–377.6)
Body weight	38.1 ± 5.6 (32.5–44.7)	46.2 ± 5.9 (39.6–54.8)	51.0 ± 7.5 (42.6–65.0)	24.4	35.2 ± 5.6 (27.4–42.6)	40.6 ± 4.4 (36.5–47.7)
Tail length	59.9 ± 4.8 (54.8–65.0)	65.3 ± 5.4 (60.9–75.1)	60.2 ± 4.9 (50.8–70.0)	50.8	57.7 ± 3.8 (50.8–62.9)	56.0 ± 2.3 (52.8–58.9)
ABW	26.9 ± 3.4 (23.3–31.5)	31.0 ± 2.7 (28.4–35.5)	35.5 ± 2.3 (32.5–40.6)	18.3	27.3 ± 4.3 (22.3–34.5)	31.5 ± 1.8 (30.5–34.5)
Hyaline tail tip	15.2 ± 2.0 (12.2–16.2)	17.3 ± 0.9 (16.2–18.3)	18.6 ± 1.9 (16.2–22.3)	8.1	12.4 ± 2.6 (8.1–16.2)	12.8 ± 2.0 (10.2–15.2)

¹ All measurements except length in micrometers. Means + SD, range in parentheses.

paratype females, males, and juveniles not deposited in the above collections are deposited in the USDA Nematology Laboratory Collection in Beltsville, Maryland.

Etymology

The Latin adjective “biformis” refers to the distinct ventral median supplement-like structures found anterior to the anus in some females and not found in others.

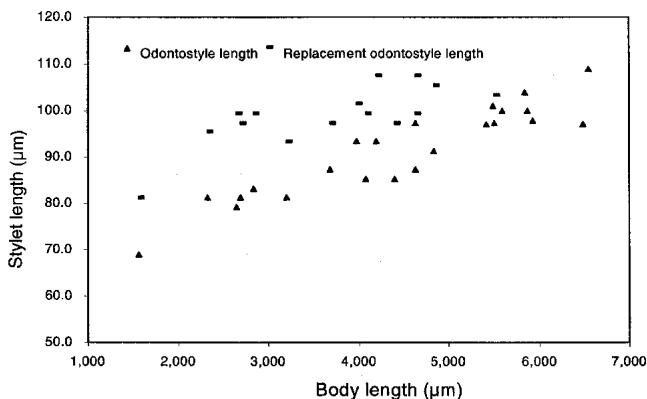


FIG. 5. Scatter plot of *Longidorus biformis* n. sp. (type population Long-4) paratypes odontostyle length and replacement odontostyle length against body length of juveniles (J2–J4) and females.

Diagnosis

Longidorus biformis n. sp. is an amphimictic species with approximately equal number of females and males. Females are characterized by body length (5.29–9.50 mm); expanded, wide, and flattened head end; head width 20–27 µm; odontostyle 96–125 µm; guide ring 29–41 µm posterior to the anterior end; elongate, conoid tail; *c'* = 1.2–2.3; and females with 0–13 ventromedian supplement-like structures in type females. The code for identifying the new species according to the polytomous key of Chen et al. (1997) is: A345-B45-C234-D4-E2-F345-G234-H456-I2.

Relationships

Longidorus biformis n. sp. most closely resembles *L. seinhorsti* Peneva, Loof & Brown, 1998 described from the Netherlands, from which it differs mainly in having longer body (5.29–9.50 mm vs. 4.60–6.20 mm), longer tail (49–81 µm vs. 41–46 µm), and the presence of ventromedian supplement-like structure in some females vs. none. It differs from *L. closelongatus* Stoyanov, 1964 by its elongated conical tail vs. rounded tail and the presence of ventromedian supplement-like structure in some females vs. none. Of North American species *Longidorus biformis* n. sp. is closest to *L. glycinis* n. sp.; both are amphimictic but differ in tail shape (elongate vs. short conoid), tail length (49–81 µm vs. 32–43 µm),

c' (1.2–2.3 vs. 0.9–1.4), a longer odontostyle (96–125 μm vs. 87–100 μm), a more posteriorly located guide ring (29–41 μm vs. 22–26 μm), and the presence of ventromedian supplement-like structure in some females. Phylogenetic analysis based on ITS1 and 18S gene DNA sequencing revealed that *L. biformis* n. sp. is a distinct species compared with other *Longidorus* species from North America (unpubl. data).

Distribution

Fourteen populations of *L. biformis* n. sp. were found associated with hardwood trees at various locations in Arkansas (Table 1).

Hierarchical cluster analysis

The dendrogram obtained from the hierarchical cluster analysis by average method (JMP program) showed

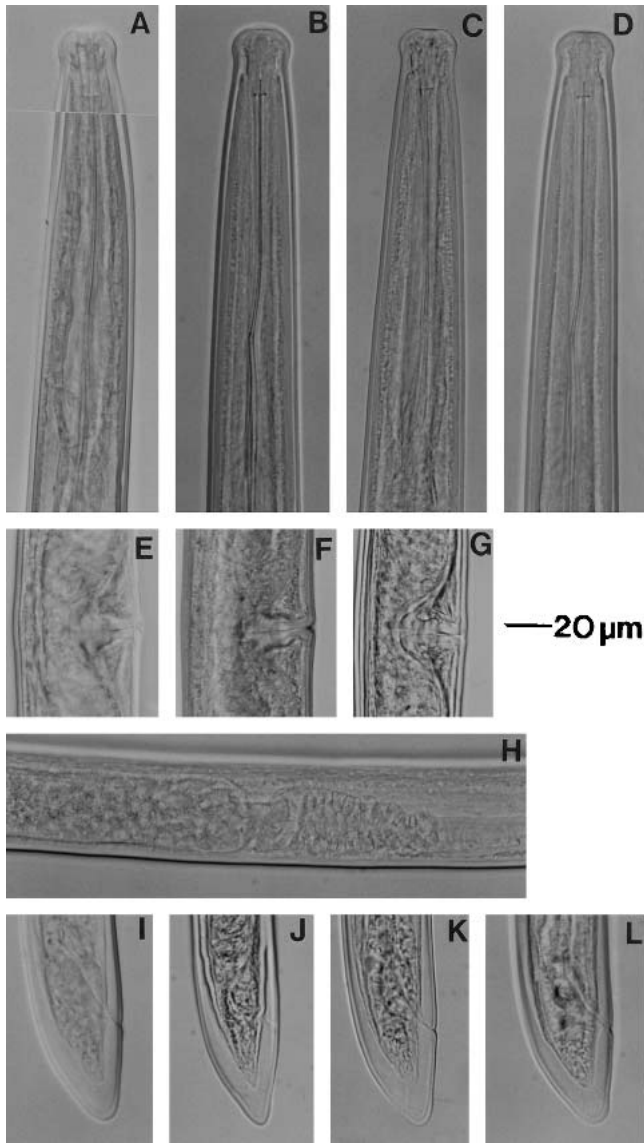


FIG. 7. Photographs of female *Longidorus glycines* n. sp. (type population Long-9). A, E, I) Holotype female. A–D) Variation of head regions showing entire stylets. E–G) Vulva region. H) Sphincter between uterus (left) and oviduct (right). I–L) Female tail region showing variations in shape.

that nine populations of *L. biformis* n. sp. from Arkansas are in one cluster and are morphologically closely related with *L. closelongatus* (Stoyanov, 1964) and *L. seinhorsti* (Peneva et al, 1998) (Fig. 6).

Longidorus glycines n. sp. (Fig. 7–9)

Measurements: See Tables 6 and 7.

Description

Females: Body long, spiral upon heat relaxation, tapering toward both ends, cuticle smooth as seen by light microscopy, with fine transverse striae as seen by SEM. Head region wider anteriorly, almost spherical with the anterior flattened, separated from the rest of the body by a short narrow region. Amphidial pouches shallowly bilobed, extend about 70% of the distance from the anterior end to the guide ring. Odontostyle long and slender, odontophore base not flanged. Guide ring about 4 μm wide. Nerve ring close to the odontophore base. Esophagus with cylindrical esophageal basal bulb 93–114 μm long, 18–24 μm wide in paratypes. The normal arrangement of one dorsal gland nuclei (24%–28%) of the basal esophageal bulb length and two subventral nuclei (SV1 55–63%, SV2 56–65%). Cardia conoid nuclei. Reproductive system amphidelphic, didelphic, with reflexed ovaries. Ante-

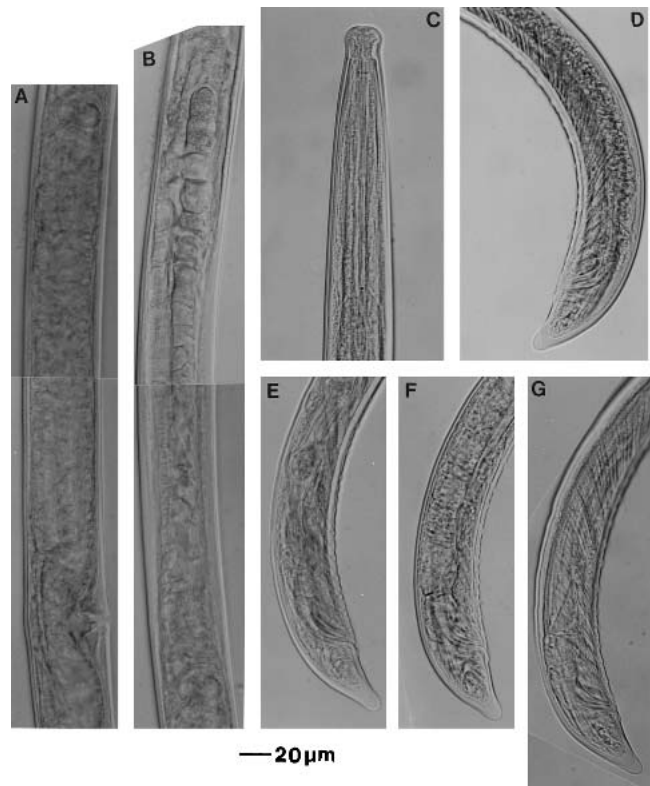


FIG. 8. Photographs of *Longidorus glycines* n. sp. (type population Long-9). A–B) Female anterior genital tract with A showing vulval region, uterus, and sphincter; B shows sphincter, oviduct, and reflexed ovary. C) Male head region showing entire stylet. D–G) Male tail region showing variation in shape.

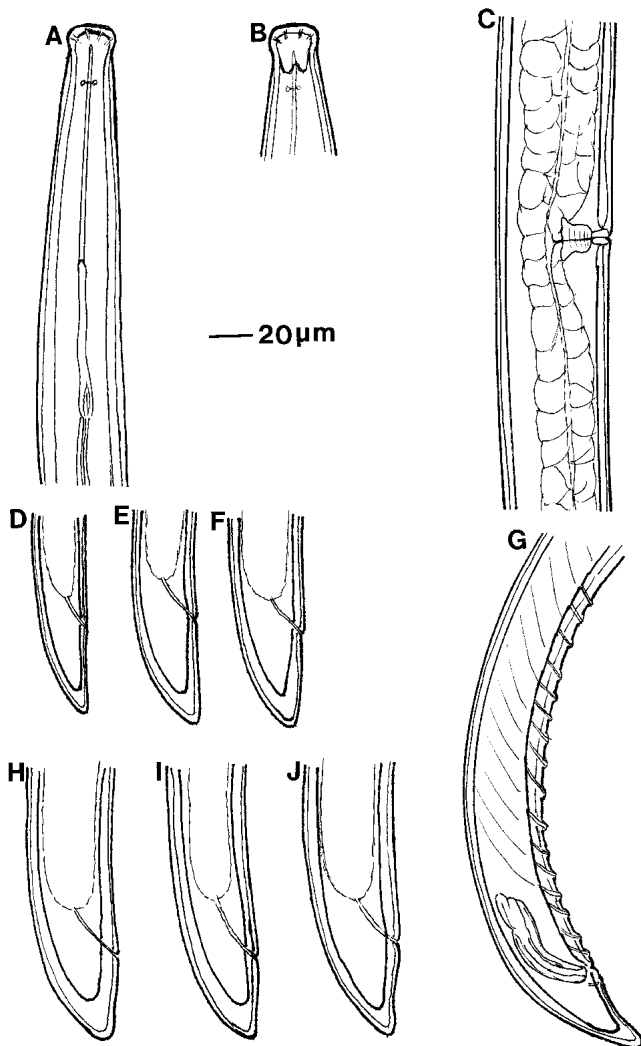


FIG. 9. A–J) Drawings of *Longidorus glycinis* n. sp. (paratype population Long-9). A) Anterior region. B) Amphid region. C) Vulval region. D) Second-stage juvenile tail. E) Third-stage juvenile tail. F) Fourth-stage juvenile tail. G) Male posterior region. H–J) Variation in female tail.

rior genital branch 378–808 μm long, posterior genital branch 422–954 μm long. Vulva a transverse slit 4 μm long as seen by SEM. Vagina perpendicular to body axis with a thick cuticular lining, extending to half the body width. Anterior uterus of paratypes 171–402 μm long, posterior uterus 179–453 μm long. Sperms oval about 5 μm long, 2.5 μm wide, often densely packed in female uteri and posterior oviduct. Tail short conoid with bluntly rounded terminus, 0.9–1.4 times anal body width long. Hyaline area 11–17 μm long.

Males: Morphologically similar to female, more strongly ventrally curved tail end. Spicules well developed, arcuate. Supplements, an adanal pair and a series of 10 to 16 ventromedian. Tail greater than 1 anal body width in length, slightly convex dorsally with bluntly rounded terminus.

Juveniles: Morphologically similar to adult but smaller (Table 7; Fig. 7). Four juvenile stages have been iden-

TABLE 6. Morphometrics of the holotype, allotype, female paratypes, and male paratypes of *Longidorus glycinis* n. sp. from Arkansas (Long-9).

Character	Holotype	Allotype	Female paratypes	Male paratypes
<i>n</i>	1	1	25	24
L (mm)	7.71	6.89	7.14 \pm 0.45 (6.14–8.31)	6.65 \pm 0.53 (5.79–8.00)
a	165.2	147.5	151.0 \pm 12.4 (113.4–188.2)	161.4 \pm 18.4 (121.7–187.0)
b	22.1	18.2	19.2 \pm 1.9 (15.9–23.0)	19.3 \pm 2.2 (16.3–23.2)
c	211.1	188.4	197.7 \pm 10.4 (151.3–240.9)	180.2 \pm 17.2 (154.8–219.9)
c'	1.2	1.1	1.1 \pm 0.1 (0.9–1.4)	1.1 \pm 0.1 (0.9–1.3)
G1%	8.6	—	8.2 \pm 1.7 (5.3–12.0)	—
G2%	9.4	—	8.7 \pm 2.0 (5.7–13.9)	—
V	50.2	—	52.2 \pm 2.0 (43.8–55.7)	—
T%	—	25.9	—	33.2 \pm 4.6 (22.1–40.2)
H%	36.9	27.8	39.0 \pm 3.7 (30.6–47.2)	34.3 \pm 4.7 (26.3–41.7)
Spicules	—	49.0	—	49.5 \pm 2.5 (44.7–52.8)
Supplements	—	13	—	(11–17)
Odontostyle	91.4	97.4	91.5 \pm 3.4 (87.3–99.5)	92.2 \pm 3.9 (85.3–97.4)
Odontophore	52.8	48.7	56.4 \pm 2.3 (50.8–60.9)	52.6 \pm 3.4 (48.7–60.9)
Total stylet	144.1	146.2	147.9 \pm 3.9 (142.1–158.3)	144.8 \pm 3.1 (136.0–150.2)
Guide ring from anterior end	24.4	25.4	23.5 \pm 1.2 (22.3–26.4)	24.4 \pm 1.3 (22.3–26.4)
Head width	22.3	21.3	22.0 \pm 0.7 (20.3–23.3)	22.1 \pm 1.2 (20.3–24.4)
Body width	46.7	46.7	48.1 \pm 4.6 (38.6–56.8)	41.6 \pm 3.4 (36.5–50.8)
Tail length	36.5	36.5	36.5 \pm 2.9 (32.5–42.6)	37.0 \pm 2.6 (32.5–42.6)
ABW	31.5	32.5	32.8 \pm 3.0 (28.4–42.6)	32.6 \pm 2.3 (28.4–38.6)
Hyaline tail tip	14.2	10.2	14.2 \pm 1.5 (11.2–17.3)	12.6 \pm 1.5 (9.1–15.2)

¹ All measurements except length in micrometers. Means \pm SD, range in parentheses.

tified (Figs. 9, 10). Replacement odontostyle present in all juvenile stages. Replacement odontostyle tip located within the odontophore in the first stage.

Type locality and habitat

Sandy soil in soybean (*Glycines max* (L.) Merr.) microplots at the Arkansas Research and Extension Center, Fayetteville. Collected by R.T. Robbins on 1 June 1983. Global positional coordinates N 36°; 05.989 minutes; W 094° 10.804 minutes.

Type specimens

The holotype female (slide T569t) and allotype male (slide T570t) are deposited in the Nematology Labora-

TABLE 7. Morphometrics of *L. glycines* n. sp. juveniles (Long-9).

Character	J1	J2	J3	J4
<i>n</i>	3	5	8	5
L	1.09 ± 0.79 (1.01–1.17)	190 ± 0.10 (1.80–2.03)	3.30 ± 0.92 (1.97–5.15)	4.56 ± 0.77 (3.22–5.19)
a	35.1 ± 1.7 (33.2–36.1)	59.9 ± 14.0 (45.2–75.5)	68.0 ± 13.7 (46.2 ± 93.9)	85.1 ± 12.9 (63.4 ± 96.5)
b	5.3 ± 0.3 (5.1–5.6)	7.9 ± 1.1 (6.3–8.9)	11.3 ± 1.9 (8.7–14.1)	14.2 ± 1.9 (11.0–16.0)
c	37.6 ± 1.3 (36.1–38.4)	48.5 ± 4.3 (43.0–54.6)	83.3 ± 19.3 (57.1–120.8)	111.2 ± 15.8 (83.4–121.8)
<i>c'</i>	1.5 ± 0.0 (1.4–1.5)	1.6 ± 0.3 (1.3–1.9)	1.2 ± 0.1 (1.0–1.3)	1.0 ± 0.1 (1.0–1.2)
Odontostyle length	53.5 ± 1.2 (52.8–54.8)	60.9 ± 0.0 (60.9–60.9)	70.3 ± 4.1 (65.0–75.1)	81.6 ± 2.6 (77.1–83.2)
Replacement odontostyle	62.9 ± 2.0 (60.9–65.0)	76.3 ± 5.1 (71.1–81.2)	80.7 ± 3.9 (75.1–85.3)	93.4 ± 2.0 (91.4–95.4)
Guide ring from anterior end	15.6 ± 0.6 (15.2–16.2)	18.3 ± 1.0 (17.3–19.3)	21.2 ± 1.8 (18.3–23.3)	21.7 ± 0.9 (20.3–22.3)
Head width	15.2 ± 1.0 (14.2–16.2)	17.1 ± 1.1 (16.2–18.3)	20.7 ± 1.7 (18.3–22.3)	22.1 ± 1.7 (20.3–24.4)
Esophagus length	207.1 ± 17.7 (194.9–227.4)	241.6 ± 29.2 (219.2–284.2)	289.8 ± 52.3 (203.0–365.4)	319.1 ± 23.6 (292.3–341.0)
Mid-body width	31.1 ± 1.2 (30.5–32.5)	33.3 ± 8.7 (26.4–44.7)	48.0 ± 4.7 (42.6–54.8)	53.4 ± 2.2 (50.8–56.8)
Tail length	29.1 ± 2.3 (26.4–30.5)	39.4 ± 3.1 (36.5–42.6)	40.6 ± 3.7 (34.5–44.7)	40.8 ± 1.5 (38.6–42.6)
ABW	20.0 ± 1.6 (18.3–21.3)	25.6 ± 5.7 (20.3–32.5)	34.5 ± 4.7 (28.4–42.6)	39.4 ± 4.4 (32.5–44.7)
Hyaline tail tip	9.1 ± 1.0 (8.1–10.2)	8.5 ± 1.2 (7.1–10.2)	10.0 ± 1.3 (8.1–12.2)	11.0 ± 1.1 (10.2–12.2)

¹ All measurements except length in micrometers. Means ± SD, range in parentheses.

tory, USDA, ARS, Beltsville, Maryland. Two paratype females and two paratype males deposited in the following collections: Department of Nematology Collection, University of California, Riverside, California; Department of Nematology Collection, University of Cali-

fornia, Davis, California; CABI Bioscience Collection, UK Centre, Surrey, United Kingdom; Department of Nematology Collection, Agricultural University, Wageningen, Netherlands; and Institute of Parasitology Collection, Moscow, Russia. All remaining paratype fe-

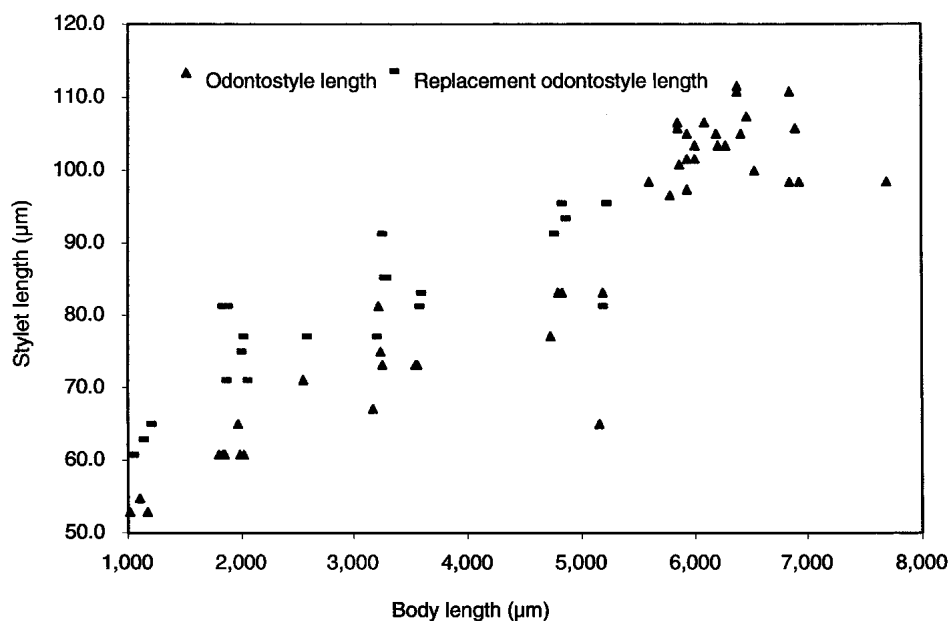


FIG. 10. Scatter plot of odontostyle length and replacement odontostyle length against body length of *Longidorus glycines* n. sp. juveniles and females paratypes (population Long-9).

males, males, and juveniles not deposited in the above collections are deposited in the USDA Nematology Laboratory Collection in Beltsville, Maryland.

Etymology

The latin adjective "glycines" refers to the scientific name of host plant soybean: *Glycine max* (L.) Merrill.

Diagnosis

Longidorus glycines n. sp. is an amphimictic species with approximately equal number of females and males. It is characterized by its long body (6.14–8.31 mm); wide (almost spherical), anteriorly flattened head with short narrower region just posterior; head width 20–23 µm; odontostyle 87–100 µm long; guide ring 22–26 µm posterior to the anterior end; short, conoid tail with rounded terminus; and $c' = 0.9–1.4$. The code for identifying the new species according to the polytomous key of Chen et al. (1997) is: A3-B4-C2-D3-E2-F34-G234-H12-12.

Relationships

Longidorus glycines n. sp. is most similar to *L. lusitanicus* Macara, 1985 from Bulgaria but can be distinguished by its more anterior guide ring (22–26 µm vs. 27–33 µm); wider head end (20–23 µm vs. 12–22 µm); longer tail (33–43 µm vs. 27–36 µm); and higher c' value (0.9–1.4 vs. 0.7–1.0).

Among Arkansas *Longidorus* species *Longidorus glycines* n. sp. is similar to *L. grandis* Ye & Robbins 2003 but can be distinguished by its almost spherical, anteriorly flattened head end with a short narrow region just posterior vs. expanded head with a longer narrow region just posterior, and amphimictic vs. parthenogenetic reproduction. *Longidorus glycines* n. sp. is also similar to *L. biformis* n. sp., with both being amphimictic species, but differs in tail shape (short conoid vs. elongate), tail length (33–43 µm vs. 50–81 µm), c' (0.9–1.4 vs. 1.2–2.3), shorter odontostyle (88–100 µm vs. 96–125 µm), more anterior guide ring (22–26 µm vs. 29–41 µm), and the absence of ventromedian supplements in females. Two other similar North American *Longidorus* species found in this study from Arkansas are *L. crassus* Thorne, 1964 and *L. breviannulatus* Norton and Hoffman, 1975. *Longidorus glycines* n. sp. can be distinguished from *L. crassus* by a shorter odontostyle (87–

100 µm vs. 104–115 µm), more anterior guide ring (22–26 µm vs. 29–36 µm), larger a ratio (113–188 vs. 73–110), and amphimictic vs. parthenogenetic reproduction. *Longidorus glycines* n. sp. can be distinguished from *L. breviannulatus* by a longer odontostyle (87–100 µm vs. 81–88 µm), longer body (6.14–8.31 mm vs. 4.76–5.15 mm), larger a ratio (113–188 vs. 86–114), larger c ratio (151–241 vs. 111–143), and amphimictic vs. parthenogenetic reproduction.

Distribution

Found only in microplots at the Arkansas Research and Extension Center, Fayetteville, Arkansas. The sandy soil in the microplots was commercially obtained from the Arkansas River valley near Van Buren, Arkansas.

Hierarchical cluster analysis

The dendrogram obtained from the hierarchical cluster analysis by the average method (JMP program) showed that *L. glycines* is most closely related with *L. lusitanicus* (Macara, 1985) (Fig. 6). Using hierarchical cluster analysis by Average method (JMP program) for an aid in species separation will be discussed in a subsequent paper.

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FIG. 6. Hierarchical clustering dendrogram (based on average method) of all published *Longidorus* species with *Longidorus biformis* n. sp. and *Longidorus glycines* n. sp.

