

MORPHOMETRICS OF ADULTS AND JUVENILE STAGES OF THREE LONGIDORID NEMATODES (NEMATODA: DORYLAIMIDA) FROM VOJVODINA PROVINCE, NORTHERN SERBIA

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Summary. Populations of *Longidorus distinctus*, *L. euonymus* and *Xiphinema italiae* from Vojvodina Province, Northern Serbia are briefly described. Morphometrics and illustrations of females and juvenile stages are provided. Males of *L. euonymus* and *X. italiae* are reported for the first time. Further research on taxonomy and biology of *X. italiae* is suggested because of its high morphometric variability and existence of populations with either four or three juvenile stages.

Longidorus distinctus Lamberti, Choleva et Agostinelli, *L. euonymus* Mali et Hooper and *Xiphinema italiae* Meyl are known to occur in Vojvodina Province, Northern Serbia (Krnjaić, 1970, 1976; Barsi, 1989, 1993, 1994, 1996). However, reported data on their morphology and intraspecific variability are scanty (Barsi, 1989, 1994) and information on juvenile developmental stages of these species has never been recorded.

Morphometrics of adults and juvenile stages of several populations of these nematodes, found in some cultivated and natural habitats in Vojvodina Province, are reported here to provide additional information on their natural variability.

MATERIALS AND METHODS

Nematodes were extracted from soil samples by Cobb's wet sieving technique. Specimens were killed by hot FP 4:1 and processed and mounted on permanent slides in dehydrated glycerin. Measurements were made with an eyepiece graticule, except body length, which was determined with the aid of a drawing tube and map measurer.

MEASUREMENTS AND DESCRIPTIONS

LONGIDORUS DISTINCTUS Lamberti, Choleva et Agostinelli, 1983 (Tables I and II; Figs 1-4)

Female: body from open C to a single spiral, tapering gradually toward the extremities. Lip region slightly expanded, frontally almost flattened, laterally rounded and offset from the rest of the body by a slight depression. Amphidial pouch asymmetrically bilobed. Odontostyle, odontophore and guide ring typical of the genus. Oesophagus dorylaimoid, with the basal bulb occupying about 1/4 of the total oesophagus length and

measuring 85-106 µm long and 18-21 µm wide. Vulva pre-equatorial, slit like; vagina occupying about 1/2 of the corresponding body diameter. Reproductive system amphidelphic with equally developed genital branches; uterus consisting of two distinct parts of almost equal length. Glandular bodies are present in the lateral hypodermal cords. Prerectum as long as 10 to 21 times the anal body width; rectum about one anal body width long. Tail elongate-conoid, dorsally convex, ventrally slightly concave; bearing two caudal pores on each side.

Male: not found.

Juveniles: separated into four stages (Fig. 3). They resemble the adult except for smaller size. Tail elongate-conoid, dorsally convex, ventrally slightly concave in all stages. Odontostyle length in the first and second juvenile developmental stages is very similar (43.7-51.2 µm vs. 46.2-52.3 µm), with considerable overlapping. However, they are clearly distinguishable because of the unique position of the replacement odontostyle (ie. the tip of the replacement odontostyle overlapping the base of the odontophore).

The presence of four juvenile stages has already been reported from Bulgaria (Peneva and Choleva, 1992a; Lamberti *et al.*, 1997) and Eastern Serbia (Krnjaić *et al.*, 1999). Lamberti *et al.* (1997) emphasized that plotting body length versus odontostyle length did not separate the first two groups of juvenile stages in a population of *L. distinctus* from Kolarovo, Bulgaria. However, populations from Kolarovo, Bulgaria, Knjaževac (Krnjaić *et al.*, 1999) and Senta, Serbia (this study) basically show a very similar developmental pattern (Fig. 4), although it should be noted that the Kolarovo population possesses a longer odontostyle in all stages compared to the other two populations, which is clearly evident in the scatter diagram.

In a population from Knjaževac, Eastern Serbia (Krnjaić *et al.*, 1999) there was considerable overlapping of body length and the odontostyle length between the second and third, and the third and fourth juvenile stage, respectively. Also, there is a discrepancy between

Table I. Morphometric characters of a population of *Longidorus distinctus* from Vojvodina Province, Northern Serbia.

Locality: Host:	Senta Grapevine (<i>Vitis</i> sp.)					
	n	30 females	13 J1	17 J2	21 J3	20 J4
L (mm)		4.65±0.29 (4.09-5.35)	1.07±0.06 (0.97-1.17)	1.54±0.14 (1.23-1.72)	2.29±0.20 (1.89-2.66)	3.27±0.22 (2.89-3.66)
a		115.8±6.52 (102.6-130.7)	61.9±2.22 (57.8-65.0)	68.8±3.10 (62.9-74.0)	84.2±4.57 (71.5-90.0)	100.9±5.98 (83.9-110.3)
b		12.0±0.83 (10.7-13.8)	4.7±0.47 (3.9-5.3)	6.5±0.54 (5.8-7.6)	8.2±0.61 (6.7-9.1)	10.2±0.81 (8.9-12.2)
c		76.1±7.36 (62.4-94.1)	22.6±1.64 (20.8-26.1)	27.9±2.48 (23.6-31.8)	37.9±4.00 (31.2-48.9)	49.8±4.08 (43.0-55.9)
c'		2.18±0.15 (1.92-2.42)	3.81±0.23 (3.36-4.13)	3.53±0.19 (3.21-3.79)	3.08±0.20 (2.54-3.39)	2.65±0.19 (2.17-2.93)
d*		2.3±0.08 (2.1-2.4)	2.3±0.11 (2.1-2.5)	2.1±0.10 (1.9-2.3)	2.1±0.05 (2.0-2.2)	2.2±0.06 (2.0-2.3)
d'***		1.5±0.04 (1.4-1.5)	1.6±0.05 (1.5-1.7)	1.4±0.05 (1.3-1.6)	1.5±0.04 (1.4-1.5)	1.4±0.04 (1.4-1.5)
J'		1.4±0.14 (1.1-1.6)	1.0±0.14 (0.8-1.2)	1.0±0.11 (0.9-1.3)	1.1±0.16 (0.9-1.5)	1.4±0.18 (0.9-1.7)
V		46.5±1.15 (43.7-48.7)	–	–	–	–
Odontostyle µm		78.3±1.99 (74.4-83.7)	49.7±2.50 (43.7-51.2)	50.9±1.69 (46.2-52.5)	62.8±1.38 (60.0-65.0)	70.3±2.26 (65.0-73.1)
Odontophore µm		52.4±2.08 (47.5-56.3)	32.3±1.13 (30.0-33.8)	37.9±2.28 (33.8-42.5)	42.5±2.47 (33.8-45.0)	46.3±2.23 (41.3-50.0)
Total stylet µm		130.8±3.21 (124.4-137.5)	82.0±2.57 (77.5-85.0)	88.8±2.39 (85.0-92.5)	105.4±2.99 (95.0-108.7)	116.6±3.02 (111.2-120.7)
Replacement odontostyle µm		–	52.0±1.74 (48.7-55.0)	61.3±2.57 (57.5-66.2)	69.5±1.61 (67.5-72.5)	77.9±1.75 (75.0-81.2)
Oral aperture to guide ring µm		29.0±0.84 (26.9-30.6)	17.5±0.73 (16.3-18.8)	19.1±0.66 (17.5-20.0)	21.4±0.61 (20.0-22.5)	24.5±0.61 (23.1-25.6)
Tail µm		61.4±5.13 (52.1-69.3)	47.2±2.46 (43.6-51.4)	55.5±3.53 (50.5-61.4)	60.6±4.35 (50.0-68.5)	65.6±3.97 (58.5-71.4)
J (hyaline portion of tail) µm		13.9±1.89 (11.3-17.5)	3.7±0.50 (3.1-4.4)	4.6±0.62 (3.8-5.6)	6.3±0.70 (5.0-7.5)	9.1±1.23 (6.3-11.3)
Body diam. at lip region µm		12.5±0.29 (12.1-13.8)	7.6±0.24 (7.5-8.3)	9.1±0.25 (8.8-9.6)	10.1±0.21 (10.0-10.6)	11.2±0.19 (10.9-11.6)
Body diam. at guide ring µm		18.2±0.56 (17.5-19.1)	11.9±0.43 (11.3-12.5)	13.2±0.55 (12.5-13.8)	14.7±0.57 (13.8-16.3)	16.1±0.31 (15.3-16.3)
Body diam. at base of oesophagus µm		35.7±1.55 (32.5-38.8)	17.9±0.70 (17.2-19.7)	21.8±1.45 (18.8-23.8)	26.3±1.45 (23.8-29.7)	30.3±1.20 (28.4-32.9)
Body diam. at mid- body or vulva µm		40.2±2.06 (36.9-43.8)	17.2±1.19 (16.3-19.7)	22.3±1.48 (19.6-25.0)	27.2±1.94 (23.8-31.3)	32.4±2.20 (28.8-37.1)
Body diam. at anus µm		28.2±1.10 (26.6-30.4)	12.4±0.65 (11.3-13.8)	15.7±0.99 (13.8-17.2)	19.7±1.19 (17.5-21.9)	24.7±1.12 (23.1-26.9)
Body diam. at beginning of J µm		10.3±1.02 (8.8-12.5)	3.9±0.26 (3.4-4.4)	4.5±0.48 (3.8-5.0)	5.6±0.45 (5.0-6.3)	6.5±0.48 (5.4-7.2)

d* - anterior to guide-ring/body width at lip region, d'*** - body width at guide-ring/body width at lip region (Brown *et al.*, 1994); J' - length of the hyaline region of the tail/hyaline width (Lišková *et al.*, 1997).

the data presented in Table I and in the scatter diagram - Fig. 2 of Krnjaić *et al.* (1999). Possibly some of the juvenile specimens were wrongly categorized during identification.

L. distinctus is known to occur only in Bulgaria (Lamberti *et al.*, 1983; Peneva and Choleva, 1992a; Lamberti *et al.*, 1997) and Serbia (Barsi, 1989; Krnjaić *et al.*, 1999). The population of *L. distinctus* from Senta reported here originated from the same vineyard

from which Barsi (1989) described six females of the species for the first time from Serbia. Their morphometrics are in general agreement except for body length, and a and b ratios whose values are slightly higher in the population described here. Compared to the type population from north-west Bulgaria (Lamberti *et al.*, 1983) there are no relevant differences. Two other Bulgarian populations of *L. distinctus*, from Zlatarevo (Peneva and Choleva, 1992a) and from

Table II. Morphometrics of juvenile stages and females of *L. distinctus*.

Developmental stages and populations		Body length (mm) (mean)	Odontostyle (μm) (mean)	Odontophore (μm) (mean)	Replacement odontostyle (μm) (mean)
	J1				
Senta ¹		1.07	49.7	32.3	52.0
Knjaževac ²		1.0	46.3	31.3	51.6
Kolarovo ³		1.2	54.0	32.2	57.7
	J2				
Senta		1.54	50.9	37.9	61.3
Knjaževac		1.5	50.2	34.8	58.1
Kolarovo		1.8	56.9	36.3	63.9
	J3				
Senta		2.29	62.8	42.5	69.5
Knjaževac		2.1	57.4	42.7	65.3
Kolarovo		2.7	66.2	44.2	72.5
	J4				
Senta		3.27	70.3	46.3	77.9
Knjaževac		3.0	68.2	45.1	75.5
Kolarovo		3.5	81.6	47.8	91.2
	Females				
Senta		4.65	78.3	52.4	–
Knjaževac		4.1	74.8	46.8	–
Kolarovo		4.7	90.3	52.0	–

¹ Vojvodina Province, Northern Serbia (original); ² Eastern Serbia (Karnjaić *et al.*, 1999); ³ Bulgaria (Lamberti *et al.*, 1997).

Petrič (Lamberti *et al.*, 1997) appear to be biometricaly similar to the original description of the species. Two other populations, one from Kolarovo, Bulgaria and the other from Knjaževac, Eastern Serbia differ from all other populations in several respects. The Kolarovo population of *L. distinctus* has a longer odontostyle (84-103 μm *vs.* 70-86 μm) and shorter tail (51.4-53.7 μm *vs.* 47.3-69.3 μm) compared to all other populations; the Knjaževac population of this species is generally shorter (4.1 mm *vs.* 4.4, 4.6, 4.65, 4.7 mm) than all other populations.

LONGIDORUS EUONYMUS Mali et Hooper, 1974 (Tables III-V; Figs 5-8)

Female: *habitus* a more or less open C to a single spiral when killed by heat; body slender, cylindrical for almost its whole length, tapering very gradually toward the anterior extremity. Lip region slightly expanded, flat frontally and rounded laterally. Amphidial pouches more or less asymmetrically bilobed. Odontostyle, odontophore and guide ring typical of the genus. Oesophagus dorylaimoid; the basal bulb measures 106 to 138 μm long and 18 to 23 μm wide. Reproductive system amphidelphic, with both genital branches equally developed and reflexed; vulva slit like, situated more or less at mid-body. Prerectum is about 222 to 633 μm long; rectum shorter than the body diameter at anus.

Tail conical, dorsally convex with mostly bluntly rounded terminus, bearing two caudal pores on each side.

Male: generally similar to female with the posterior region of the body more coiled. Testes developed, apparently functional, filled with sperms. Spicules developed with guiding pieces about 11.5 μm long. One adanal pair and 6-8 ventromedian supplements present. Post-cloacal papilla developed. Tail conical, dorsally convex and ventrally almost straight with bluntly rounded terminus.

Juveniles: separated into four groups (Fig. 7). They resemble adults except for smaller size and tail shape, which is conical and about the same length in all juvenile stages, but it becomes progressively blunter and wider starting from the first stage.

All stages correspond well with juvenile stages described from Czechoslovakia by Mali and Hooper (1973) and show a very similar developmental pattern (Table V and Fig. 8). The original description of *L. euonymus* was based on specimens from the rhizosphere of spindle trees at Ivanka pri Dunaji in Czechoslovakia, now Slovakia (Mali and Hooper, 1974). The morphology of our populations were similar to those reported in the original description of the species. Compared to the type population (Mali and Hooper, 1974) *L. euonymus* from Vojvodina Province has greater variation of body length (5.08-8.87 mm *vs.* 6.0-7.63 mm) and a slightly

shorter distance from the oral aperture to guide ring (22.5-30 μm vs. 27-33 μm).

Lamberti *et al.* (1997) found adults and four juvenile stages of *L. euonymus* at Kostinbrod and Sandanski in south west Bulgaria and Lamberti *et al.* (1999) found females and specimens belonging to the fourth

juvenile stage in Syria. The population from Kostinbrod fits within the range of the original description, while the population from Sandanski has a shorter body (5.7 mm vs. 6.91 mm) and odontostyle (78.5 μm vs. 86 μm), smaller values of ratios a (123 vs. 153) and c (121.8 vs. 155) and slightly anterior guide ring (25



Fig. 1. Photomicrographs of *Longidorus distinctus*: A and B, female anterior region; C-F female posterior region; G, vulva region and posterior uterus; H, glandular bodies in the hypodermal cord.

μm vs. $30 \mu\text{m}$), as compared to the original one. Population from Syria compared to the type population has an anterior vulva ($V = 48$ vs. $V = 51$), a shorter odontostyle ($80.6 \mu\text{m}$ vs. $86 \mu\text{m}$) and a shorter tail ($35.7 \mu\text{m}$ vs. $45 \mu\text{m}$).

Average values of the body, odontostyle, odontophore and replacement odontostyle lengths of females and juveniles of five populations of *L. euonymus* were compared (Table V and Fig. 8). They show a similar developmental pattern with the exception of the Sandans-

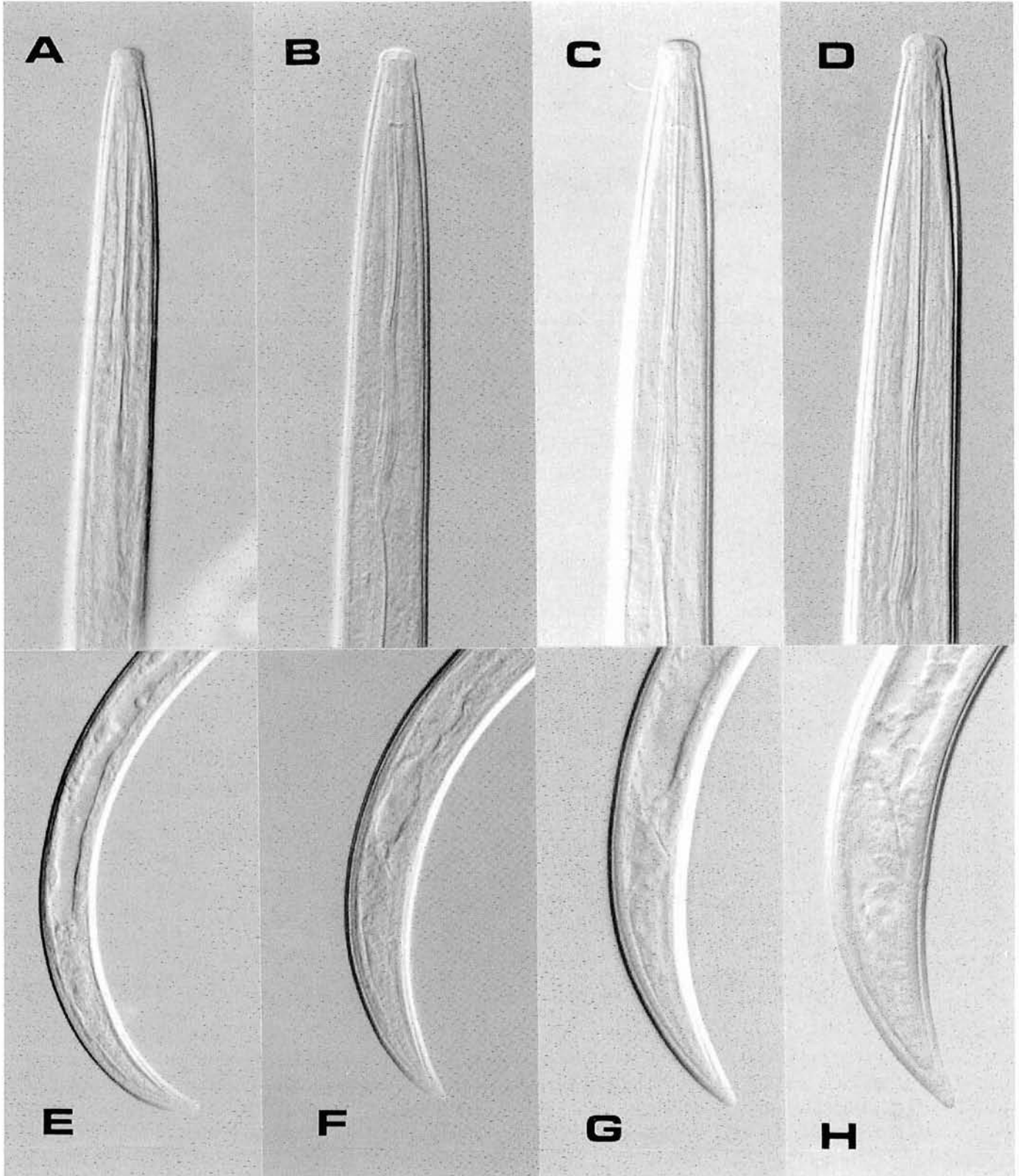


Fig. 2. Photomicrographs of juveniles of *L. distinctus*: A-D, anterior region of J1, J2, J3 and J4 stage, respectively; E-H, tail of J1, J2, J3 and J4 stage, respectively.

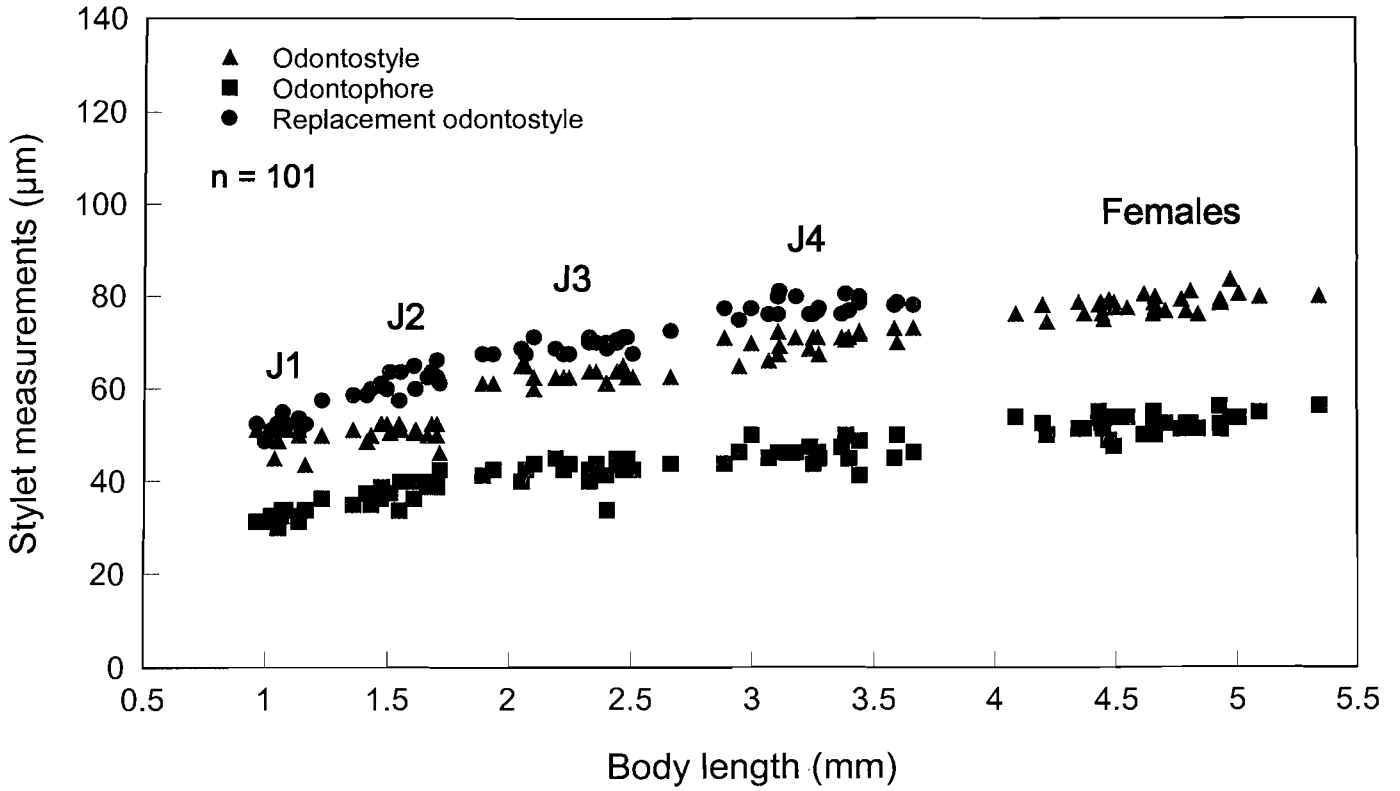


Fig. 3. Scatter diagram separating juveniles and females of *L. distinctus*.

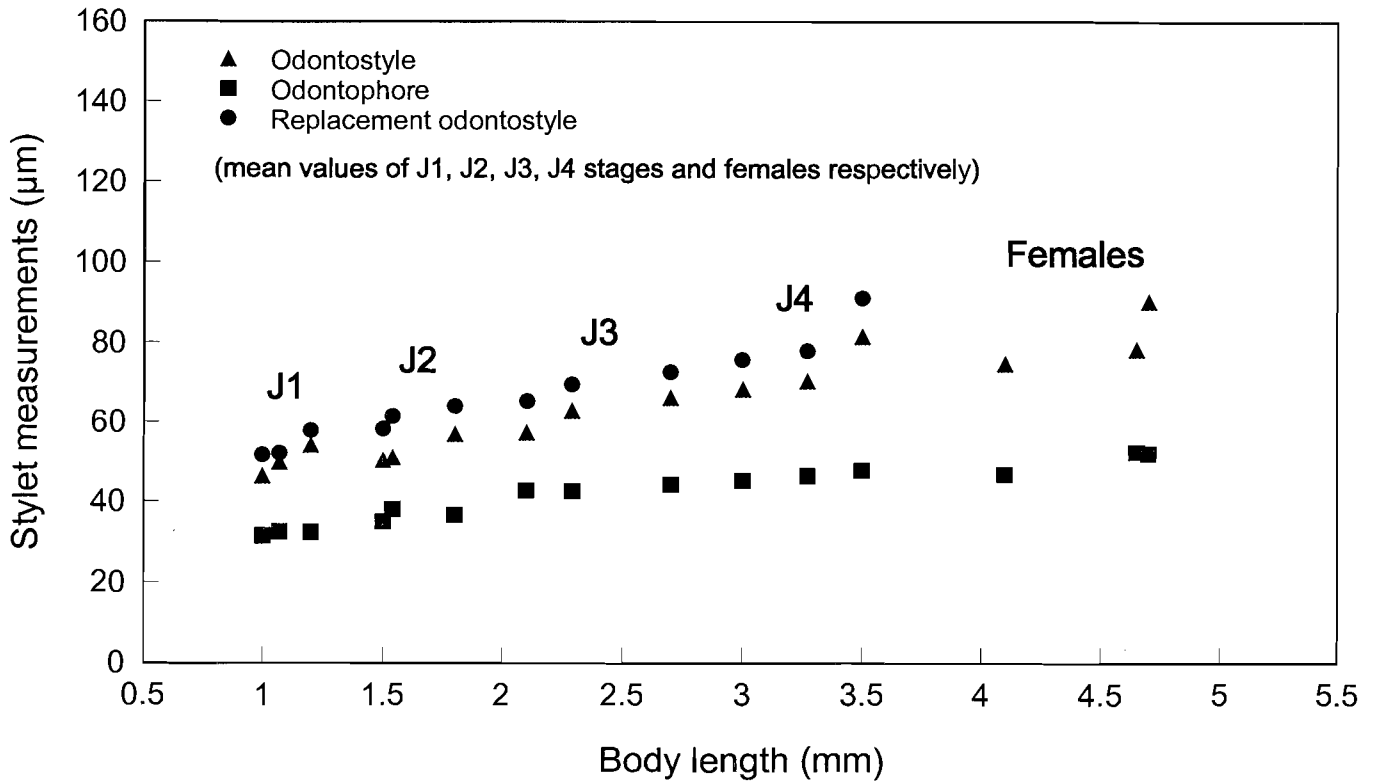


Fig. 4. Scatter diagram separating juveniles and females of *L. distinctus* from populations from Bulgaria and Serbia (for details see Table II).

Table III. Morphometric characters of a population of *Longidorus euonymus* from Vojvodina Province, Northern Serbia.

Locality: Host:	Novi Bečej Poplar (<i>Populus</i> sp.)					
	n	25 females	16 J1	12 J2	10 J3	12 J4
L (mm)		6.80±0.62 (5.08-8.21)	1.37±0.07 (1.29-1.52)	2.06±0.20 (1.77-2.43)	3.36±0.30 (2.97-3.89)	4.89±0.38 (4.41-5.53)
a		160.3±11.42 (133.4-186.0)	68.1±2.10 (63.3-71.7)	85.7±5.74 (72.2-93.9)	110.7±7.08 (102.7-122.8)	140.5±7.33 (130.4-152.4)
b		15.4±1.50 (12.4-18.1)	5.3±0.25 (4.9-5.8)	6.8±0.49 (6.1-7.6)	9.3±0.80 (8.1-10.3)	12.1±0.79 (1.11-13.3)
c		151.0±19.64 (114.5-191.9)	27.6±1.66 (24.7-30.9)	39.2±3.18 (32.4-45.7)	61.5±5.35 (54.9-69.1)	97.4±9.72 (85.5-120.3)
c'		1.32±0.14 (1.10-1.67)	3.29±0.23 (2.87-3.72)	2.81±0.13 (2.50-3.03)	2.21±0.12 (2.04-2.41)	1.70±0.11 (1.47-1.86)
d		1.7±0.08 (1.5-1.8)	1.7±0.08 (1.6-1.9)	1.7±0.07 (1.5-1.8)	1.7±0.09 (1.6-1.9)	1.7±0.13 (1.7-2.1)
d'		1.2±0.03 (1.2-1.3)	1.3±0.05 (1.2-1.4)	1.3±0.06 (1.1-1.4)	1.2±0.05 (1.2-1.3)	1.3±0.08 (1.2-1.5)
J'		0.5±0.07 (0.4-0.8)	1.4±0.10 (1.3-1.7)	1.1±0.13 (0.8-1.3)	0.9±0.11 (0.8-1.1)	0.7±0.05 (0.6-0.8)
V		52.0±2.10 (48.8-56.7)	-	-	-	-
Odontostyle µm		86.6±2.41 (80.6-91.2)	51.0±1.12 (48.7-52.5)	58.8±1.98 (56.2-61.9)	69.3±1.03 (67.5-70.6)	77.3±3.48 (70.6-82.5)
Odontophore µm		58.1±2.84 (50.0-63.8)	33.9±2.16 (28.8-36.3)	41.4±2.43 (37.5-46.3)	48.0±2.45 (43.8-52.5)	53.3±2.07 (50.0-56.3)
Total stylet µm		144.7±3.70 (135.0-148.8)	84.9±2.89 (77.5-87.5)	100.2±2.41 (96.2-104.4)	117.3±2.98 (113.8-123.1)	130.6±3.75 (121.9-133.8)
Replacement odontostyle µm		-	59.4±1.36 (57.5-61.3)	68.1±3.12 (62.5-72.5)	78.6±1.99 (76.3-81.9)	88.7±3.29 (84.2-94.2)
Oral aperture to guide ring µm		25.4±1.00 (23.8-27.5)	15.8±0.51 (15.0-16.3)	18.3±0.48 (17.5-18.8)	21.4±1.11 (20.0-23.8)	23.6±1.23 (21.3-26.3)
Tail µm		45.4±4.30 (37.8-55.0)	49.8±2.54 (44.3-52.8)	52.5±2.99 (47.5-57.8)	54.8±4.93 (49.6-65.7)	50.4±3.33 (46.0-56.8)
J (hyaline portion of tail) µm		9.3±0.97 (7.1-12.2)	7.4±0.69 (6.3-8.4)	7.2±1.02 (5.6-8.8)	9.3±0.80 (8.1-10.6)	8.7±0.78 (7.5-10.0)
Body diam. at lip region µm		15.2±0.41 (14.7-16.3)	9.2±0.29 (8.8-9.7)	10.9±0.34 (10.0-11.3)	12.6±0.31 (12.2-13.4)	13.6±0.53 (12.5-14.2)
Body diam. at guide ring µm		18.3±0.56 (17.5-19.4)	12.2±0.34 (11.3-12.5)	13.9±0.54 (12.9-15.0)	15.5±0.60 (15.0-16.6)	17.3±0.63 (16.3-18.8)
Body diam. at base of oesophagus µm		35.9±1.43 (32.1-38.8)	19.9±0.82 (18.8-21.3)	23.8±1.50 (21.3-26.9)	28.6±1.48 (26.3-30.9)	32.4±1.30 (30.6-34.4)
Body diam. at mid-body or vulva µm		42.4±2.65 (37.5-48.8)	20.2±1.28 (18.8-22.8)	24.1±1.90 (21.3-28.4)	30.4±2.16 (26.3-32.9)	34.8±2.24 (31.3-38.1)
Body diam. at anus µm		34.3±1.52 (31.3-38.1)	15.2±0.91 (13.8-16.3)	18.7±1.27 (16.7-21.3)	24.8±1.28 (23.8-27.9)	29.7±1.38 (27.8-31.3)
Body diam. at beginning of J µm		17.9±1.74 (13.8-21.9)	5.2±0.33 (4.4-5.6)	6.6±0.74 (5.0-7.5)	9.8±0.84 (8.4-11.3)	12.5±1.11 (10.3-13.8)

ki population, which is somewhat different in having a greater average body length in the first and second juvenile stages and noticeably smaller average body length in the fourth juvenile stage and in the females. It should be noted that in spite of the fact that the first, second and third juvenile stages are missing from the Syrian population, the fourth juvenile stage and the females fit well with the fourth juvenile stages and the females of the other three populations.

Two males found in the rhizosphere of elder at Novi Sad are morphologically similar to the only known male of *L. euonymus*, which was described from the rhizosphere of grapevine at Avellino, southern Italy (Roca, 1991). Compared to this male they have a longer body (5.74, 6.96 mm *vs.* 5.5 mm), shorter odontostyle (77.5, 81.2 µm *vs.* 88.8 µm), shorter and longer tail, respectively (38.6, 48.6 µm *vs.* 43 µm) and shorter spicules (50.0, 50.7 µm *vs.* 56.5 µm).

Table IV. Morphometric characters of adult populations of *L. euonymus* from Vojvodina Province, Northern Serbia.

Locality: Host:	Novi Sad Elder (<i>Sambucus nigra</i> L.)		Novi Sad Poplar	Kanjiza <i>Amorpha fruticosa</i> L.
n	6 females	2 males	10 females	3 females
L (mm)	6.98±0.32 (6.60-7.38)	5.74, 6.96	8.33±0.53 (7.17-8.87)	7.43±0.61 (6.88-8.08)
a	159.4±4.99 (150.7-164.0)	158.2, 170.1	179.4±9.72 (157.6-188.7)	169.0±20.7 (157.1-192.2)
b	16.3±0.79 (15.2-17.4)	15.0, 16.1	18.1±1.03 (16.4-19.7)	16.2±1.50 (14.6-17.4)
c	172.7±19.08 (140.1-191.2)	148.8, 143.2	190.2±16.51 (161.7-218.9)	155.1±29.5 (133.9-188.8)
c'	1.18±0.12 (1.08-1.39)	1.3, 1.49	1.17±0.09 (1.00-1.28)	1.36±0.08 (1.28-1.44)
d	1.9±0.09 (1.7-2.0)	1.9, 2.0	1.9±0.07 (1.8-1.9)	2.0±0.12 (1.8-2.0)
d'	1.3±0.05 (1.2-1.4)	1.3, 1.3	1.3±0.03 (1.2-1.3)	1.4±0.01 (1.3-1.4)
J	0.5±0.06 (0.5-0.6)	0.8, 0.7	0.5±0.03 (0.4-0.5)	0.5±0.07 (0.4-0.5)
V	49.5±2.99 (46.2-54.3)	-	51.9±0.62 (50.7-52.7)	50.9±3.07 (48.0-54.1)
Odontostyle µm	84.8±3.32 (81.2-90.6)	81.2, 77.5	85.0±2.60 (81.2-90.0)	88.1±3.82 (83.7-90.6)
Odontophore µm	61.3±3.72 (55.0-66.3)	60.0, 66.3	62.0±3.45 (56.3-66.3)	55.8±1.44 (55.0-57.5)
Total stylet µm	146.1±4.28 (139.4-151.9)	141.2, 143.8	147.0±3.58 (142.5-151.3)	143.9±4.63 (138.7-147.5)
Oral aperture to guide ring µm	27.5±1.11 (26.3-29.4)	27.5, 29.4	26.4±1.53 (22.5-28.1)	28.6±1.56 (26.9-30.0)
Tail µm	40.7±3.60 (37.1-47.1)	38.6, 48.6	43.9±2.47 (40.0-48.6)	48.5±4.97 (42.8-51.4)
J (hyaline portion of tail) µm	10.7±1.43 (8.8-13.1)	12.2, 10.9	10.2±0.80 (8.8-11.3)	9.3±1.17 (8.4-10.6)
Body diam. at lip region µm	14.8±0.88 (13.8-16.3)	14.4, 15.0	14.3±0.70 (12.8-15.0)	14.5±0.29 (14.2-14.7)
Body diam. at guide ring µm	19.5±0.74 (18.1-20.0)	18.8, 20.0	18.3±1.06 (16.3-20.0)	19.7±0.52 (19.1-20.0)
Body diam. at base of oesophagus µm	37.3±1.60 (34.7-38.8)	35.0, 37.2	38.1±1.54 (35.0-39.7)	36.7±0.35 (36.3-36.9)
Body diam. at mid- body or vulva µm	43.8±1.12 (42.5-45.0)	36.3, 40.9	46.5±2.70 (41.3-51.3)	44.1±2.42 (41.9-46.7)
Body diam. at anus µm	34.6±0.83 (33.8-35.6)	2 9.7, 32.5	37.8±1.48 (35.6-40.9)	35.6±2.25 (33.4-37.9)
Body diam. at beginning of J µm	20.6±1.33 (18.8-22.5)	15.3, 15.0	21.8±2.29 (16.9-25.9)	19.8±2.26 (17.2-21.3)
Spicules µm	-	50.0, 50.7	-	-

***XIPHINEMA ITALIAE* Meyl, 1953**
(Tables VI-IX; Figs 9-14)

Female: body ventrally curved after fixation with the greatest curvature in the posterior third of the body. Lip region gently rounded, 3.8-5 µm high, expanded with respect to the adjoining body. Odontostyle, odontophore and guide sheath typical of the genus. Oesophagus dorylaimoid with the basal bulb measuring 95-123 µm long and 13-19 µm wide. A small 2-3 µm long "mu-

cro" is usually present in the tubular part of the oesophagus. Reproductive system amphidelphic, with both genital branches equally developed; vulva anterior to mid-body, slit like; vagina occupying about 60-70% of the corresponding body diameter. Prerectum 420-672 µm long; rectum longer than the anal body width. Tail ventrally curved, from elongate bluntly conoid to almost subdigitate, most commonly with dorsal and ventral constrictions towards the terminus; three caudal papillae on each side.

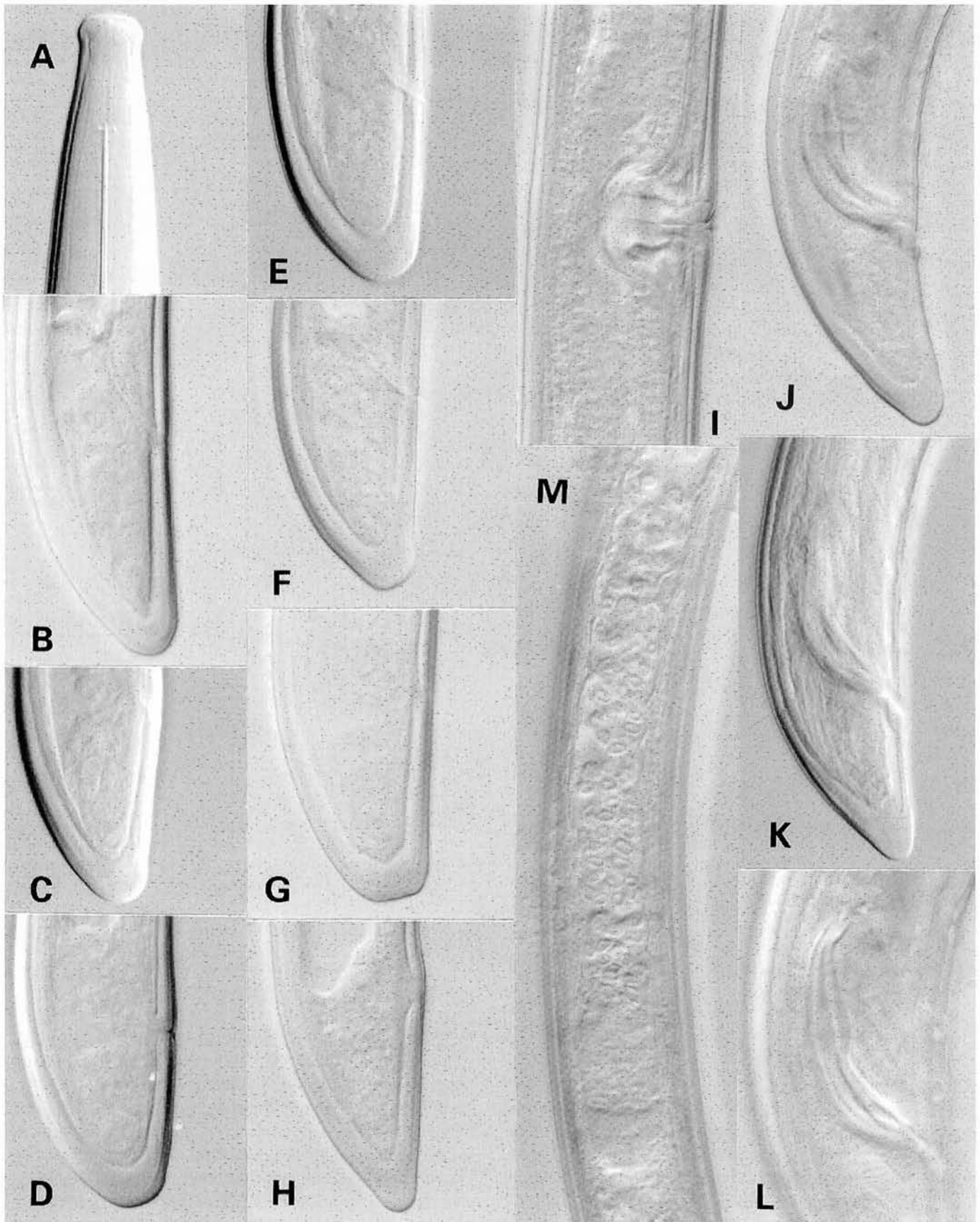


Fig. 5. Photomicrographs of *Longidorus euonymus*: A, female anterior region; B-H, female tail; I, vulva region; J-K, male tail; L, spicule and lateral guiding piece; M, part of the posterior testis.

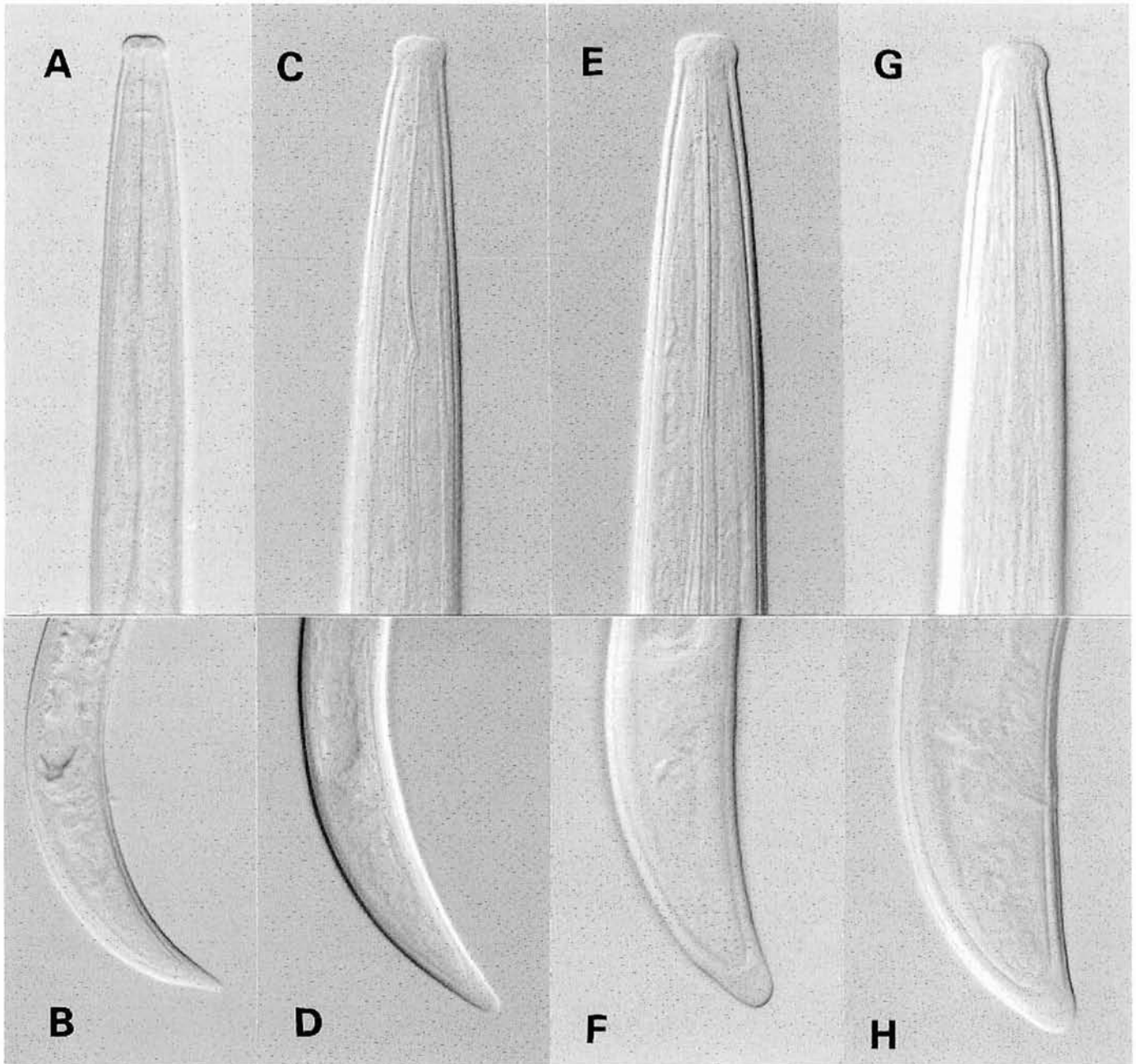


Fig. 6. Photomicrographs of juveniles of *L. euonymus*: A, C, E, G, anterior region of J1, J2, J3 and J4 stage, respectively; B, D, F, H, tail of J1, J2, J3 and J4 stage, respectively.

Male: generally similar to female with the posterior region of the body more coiled, but with a different tail shape. Tail shorter than in the female, conoid with a dorsal curvature more expressed and with a digitate projection ventrally. Testes scarcely visible, no sperms evident inside. Spicules moderately developed with guiding pieces about 11.3 μm long. One adanal pair and four ventromedian supplements present.

Juveniles: similar to adults, clearly separated into four developmental stages (Fig. 12).

X. italiae is reported with either four (Martelli *et al.*, 1966; Lamberti *et al.*, 1997) or three juvenile stages (Lamberti *et al.*, 1996a; Avgelis and Tzortzakakis, 1997). Populations from Bulgaria (Lamberti *et al.*, 1997) and

Northern Serbia (this study) have a very similar developmental pattern with four juvenile stages (Fig. 13), but a population from Egypt (Lamberti *et al.*, 1996a) has a different developmental pattern with only three stages. The scatter diagram (Fig. 14) with morphometric data of three juvenile stages of the Egyptian population and four juvenile stages of the Bulgarian and Serbian populations shows that the first, second and third juvenile stages of the Egyptian population fit with the second, third and fourth juvenile stages from Bulgaria and Serbia. Females show only the usual intraspecific variability present between various populations of the species. If we accept that "The number of juvenile stages for a species is a discrete and unambiguous character..."

Table V. Morphometrics of juvenile stages and females of *L. euonymus*.

Developmental stages and populations	Body length (mm) (mean)	Odontostyle (µm) (mean)	Odontophore (µm) (mean)	Replacement odontostyle (µm) (mean)
J1				
Ivanka pri Dunaji ¹	1.51	47.0	37.0	57.0
Kostinbrod ²	1.40	49.7	35.2	56.3
Sandaski ²	1.70	46.9	34.3	58.9
Novi Bečej ³	1.37	51.0	33.9	59.4
Idleb ⁴	–	–	–	–
J2				
Ivanka pri Dunaji	2.18	58.0	49.0	66.0
Kostinbrod	2.20	55.7	42.8	65.0
Sandaski ²	2.60	61.5	39.0	69.5
Novi Bečej	2.06	58.8	41.4	68.1
Idleb	–	–	–	–
J3				
Ivanka pri Dunaji	3.25	67.0	57.0	78.0
Kostinbrod	3.50	63.6	47.0	71.8
Sandaski ²	3.50	67.8	45.6	74.9
Novi Bečej	3.36	69.3	48.0	78.6
Idleb	–	–	–	–
J4				
Ivanka pri Dunaji	4.90	78.0	60.0	87.0
Kostinbrod	4.90*	73.4*	50.5*	84.0*
Sandaski ²	4.20	70.7	49.0	81.4
Novi Bečej	4.89	77.3	53.3	88.7
Idleb	4.80	75.4	55.3	86.5
Females				
Ivanka pri Dunaji	6.91	86.0	59.0	–
Kostinbrod	6.50**	82.6**	55.2**	–
Sandaski ²	5.70	78.5	51.0	–
Novi Bečej	6.80	86.6	58.1	–
Idleb	6.80	80.6	57.9	–

¹ Czechoslovakia – now Slovak Republic (Mali *et Hooper*, 1974); ² Bulgaria (Lamberti *et al.*, 1997); ³ Vojvodina Province, Northern Serbia (original); ⁴ Syria (Lamberti *et al.*, 1999).

* average of two fourth stage juveniles; **average of two females.

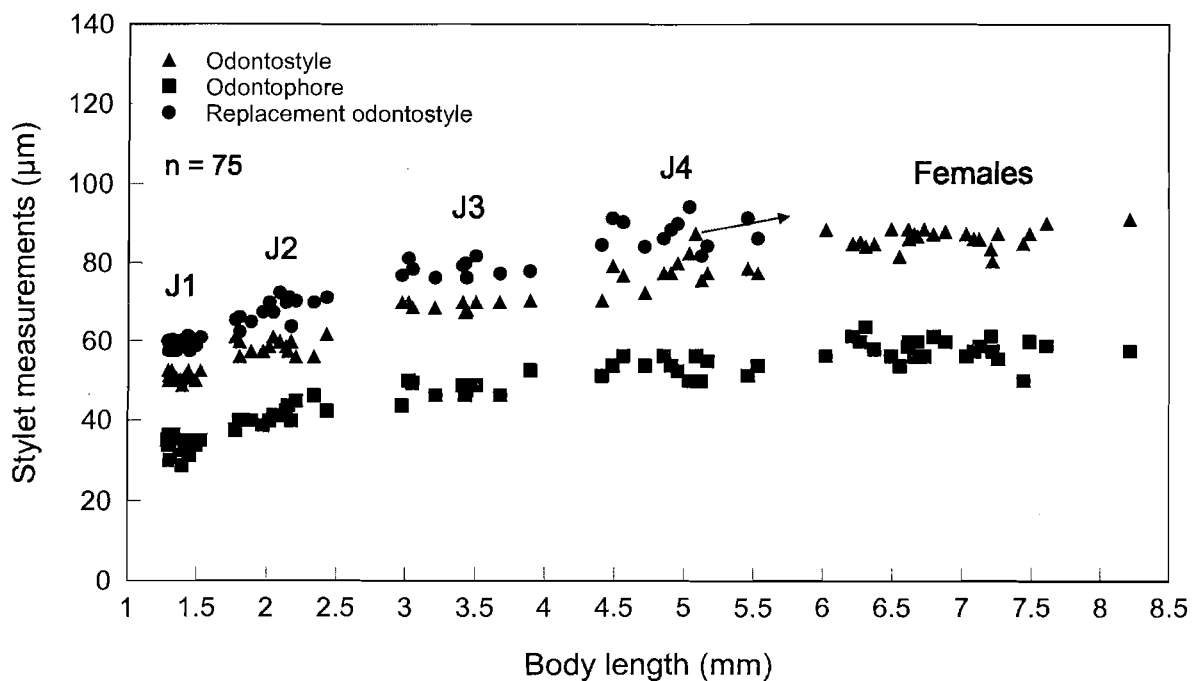


Fig. 7. Scatter diagram separating juveniles and females of *L. euonymus*.

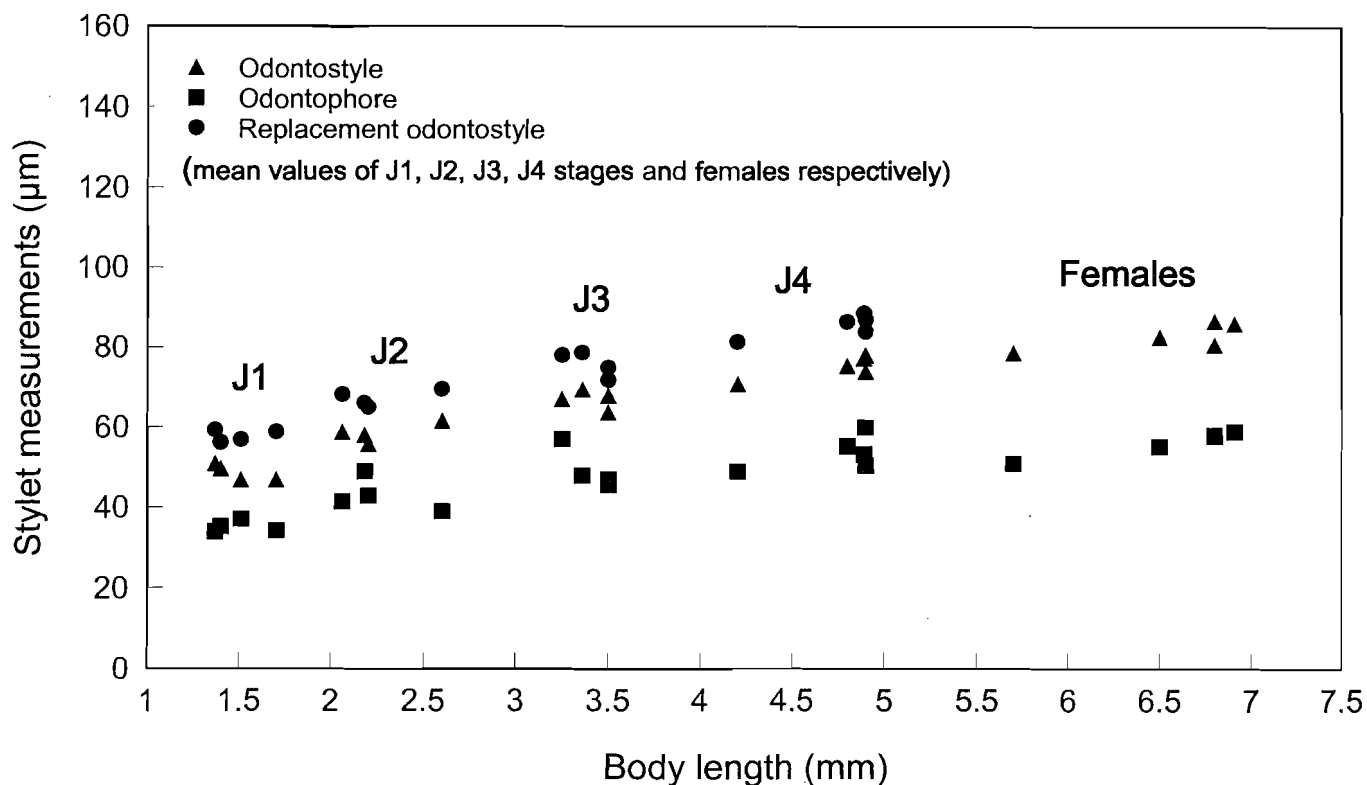


Fig. 8. Scatter diagram separating juveniles and females of *L. euonymus* from populations from Slovakia, Bulgaria, Serbia and Syria (for details see Table V).

(Halbrendt and Brown, 1993), then the presence of two developmental patterns with either three or four juvenile stages in the same species (*X. italiae* in this case) leads us to the question: do these populations represent the same species or are we dealing with at least two morphologically and morphometrically very similar species? Although there are many published data on *X. italiae* it seems that this question will not soon be answered.

Halbrendt *et al.* (1997) listed *X. italiae* with *Xiphinema* species having only three juvenile stages. They did this on the basis of the Egyptian population of *X. italiae* (Lamberti *et al.*, 1996a) and on the fact that measurements of the functional odontostyles in the third and fourth juvenile stages overlap in a population from Bari, Italy, reported in the species redescription (Table III in Martelli *et al.*, 1966), which suggests that only three juvenile stages may occur in this species. Surprisingly the fact that the replacement odontostyles in the third juvenile stage are noticeably longer (92-99 µm) than the functional odontostyles in the fourth juvenile stage (82-87 µm) and the replacement odontostyles in third and fourth juvenile stages make a continuum (92-99 and 99-104 µm) was overlooked by Cohn (1977) and also by Halbrendt *et al.* (1997). At the same time females of *X. italiae* from Bari (Table I in Martelli *et al.*, 1966) have odontostyles 92-104 µm long. Speculatively, data presented in Table III of Martelli *et al.* (1966) make sense only if the morphometrics of the third and fourth juvenile stages are combined. So, in that way a new develop-

mental pattern is emerging with three juvenile stages, very similar (Table IX) to the Egyptian population (Lamberti *et al.*, 1996a). Morphometric data of *X. italiae* from the Greek island Samos, based only on twelve specimens (three females, two first, one second and six third juvenile stages, respectively) presented by Avgelis and Tzortzakakis (1997) also suggest the presence of three juvenile stages (Table IX).

Coomans *et al.* (2001) in their monograph of the genus *Xiphinema* treated *X. italiae* as having four juvenile stages.

Based on numerous publications (Martelli *et al.*, 1966; Martelli and Lamberti, 1967; Prota *et al.*, 1971; Heyns, 1974; Lamberti and D'Errico, 1980; Lamberti *et al.*, 1983, 1985, 1996a, 1996b, 1997, 1999a, 1999b; Luc and Aubert, 1985; Roca *et al.*, 1985, 1987a, 1987b, 1988, 1989, 1990, 1991; Hutsebaut *et al.*, 1987; Barsi, 1989; Peneva and Choleva, 1992b; Lišková *et al.*, 1993) morphometrics of *X. italiae* populations show a wide range of variability (min-max) as follows:

L = 2.29-3.8 mm, a = 59.9-114, b = 6.1-12.7, c = 28.3-64.9, c' = 1.9-5.3, V = 40.8-50, odontostyle = 80-112 µm, odontophore = 49-68 µm, oral aperture to basal guide ring = 64-108 µm, tail = 49-102.5 µm, J (hyaline portion of tail) = 7.5-19 µm, body diam. at lip region = 9.4-14 µm, body diam. at guide ring = 18.8-30 µm, body diam. at base of oesophagus = 23.8-38 µm, body diam. at vulva = 25.5-42.5 µm, body diam. at anus = 16.5-27 µm, body diam. at beginning of J = 5-12 µm.

A wide range of variability is especially true for the

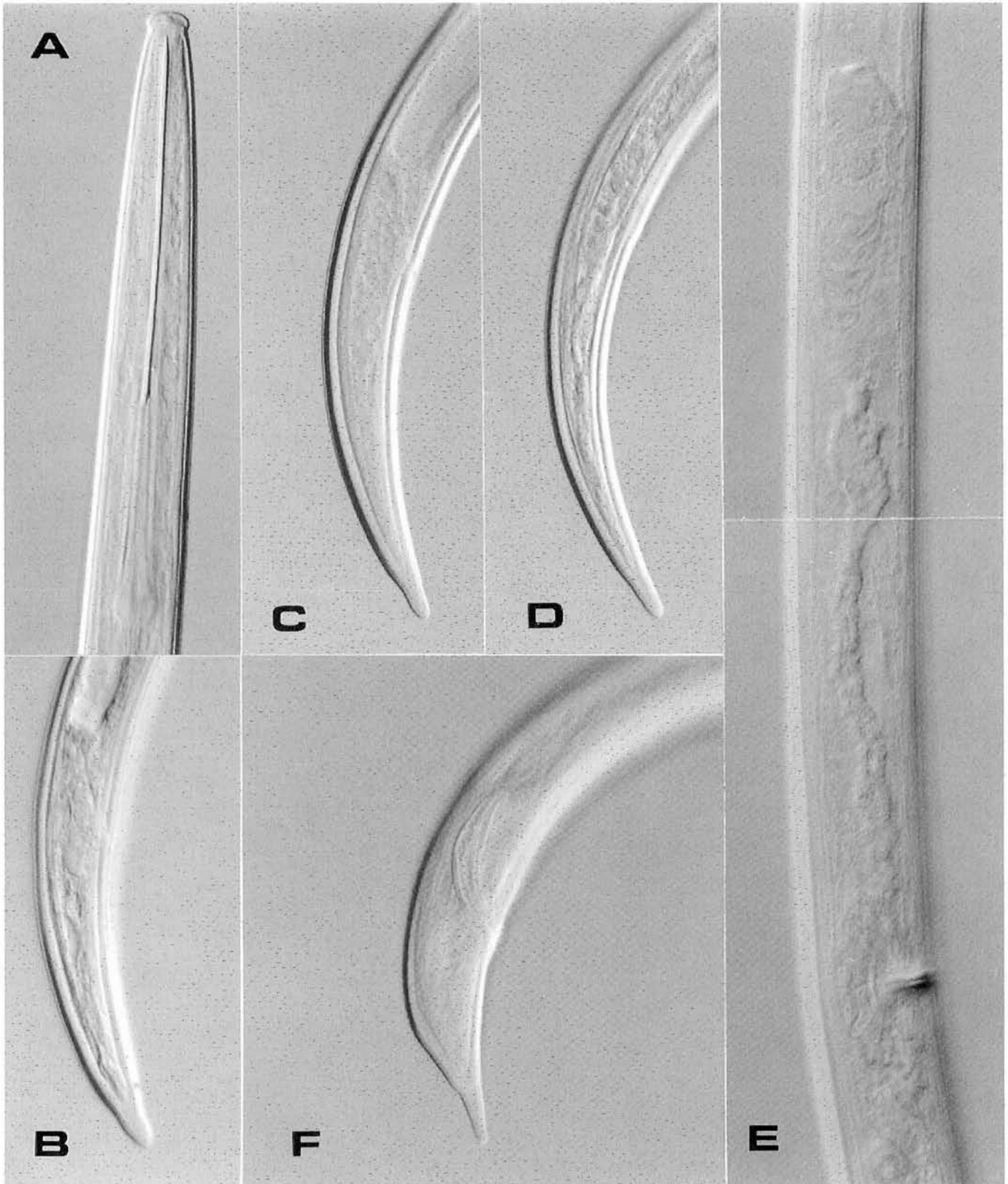


Fig. 9. Photomicrographs of *Xiphinema italiae*: A, female anterior region; B-D, female tail; E, anterior genital branch; F, male tail.

tail length and the related ratios (c and c'). It seems that the tail morphology is the most variable character of this species illustrated in several publications (Martelli *et al.*, 1966; Cohn and Sher, 1972; Heyns, 1974; Hutsebaut *et al.*, 1987; Peneva and Choleva, 1992b; Lišková *et al.*,

1993; Lamberti *et al.*, 1996a, 1997).

Morphometrically, populations of *X. italiae* from Vojvodina Province are similar except for slight differences in their body length, length of the odontostyle, distance of oral aperture to guide ring, tail length and values of

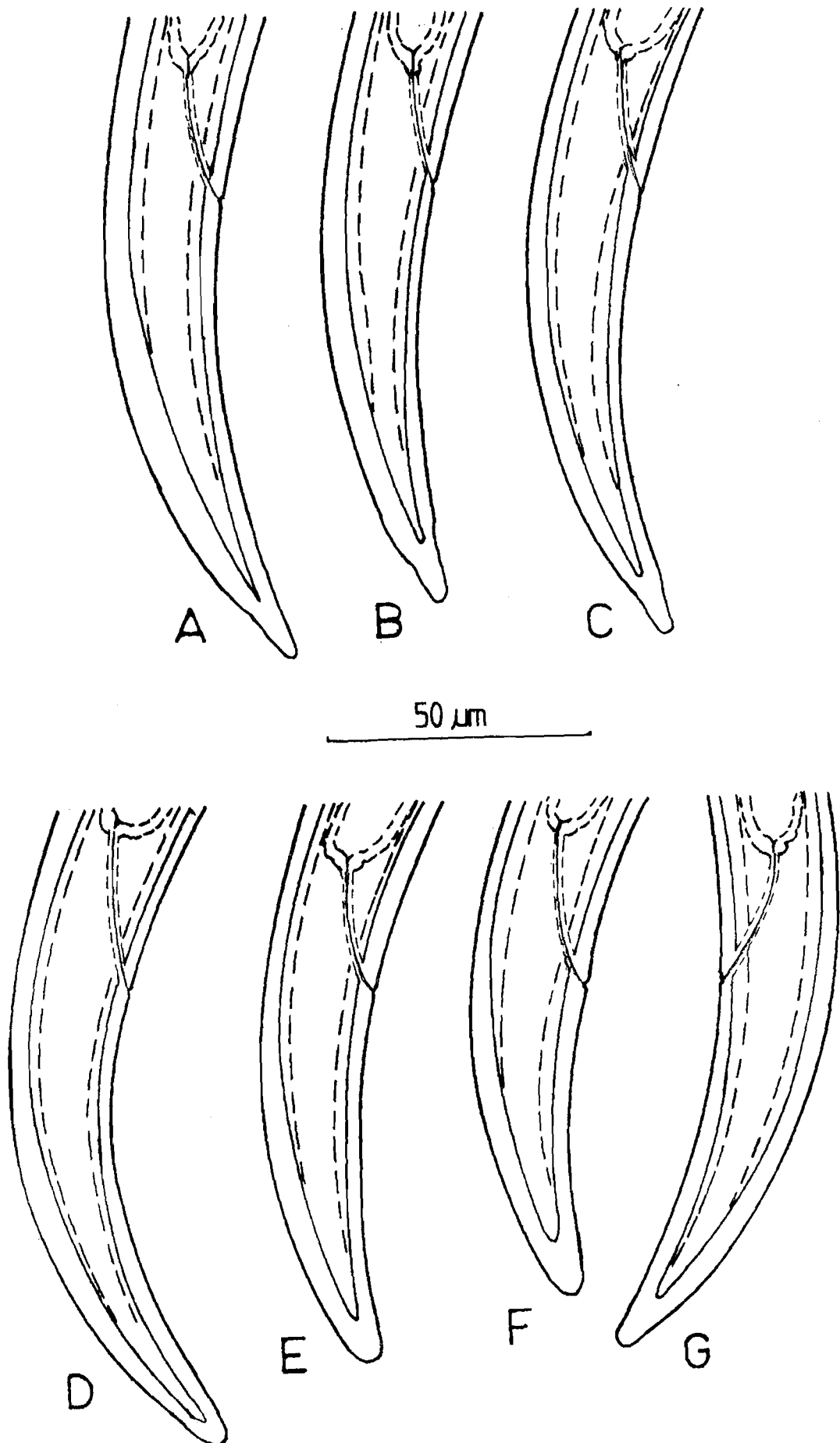


Fig. 10. *X. italiae*: A-G, female tails.

Table VI. Morphometric characters of a population of *Xiphinema italiae* from Vojvodina Province, Northern Serbia.

Locality: Host:	Novi Sad Elder (<i>S. nigra</i>)						
	n	75 females	1 male	14 J1	13 J2	14 J3	14 J4
L (mm)		2.88±0.11 (2.64-3.18)	2.89	0.84±0.03 (0.79-0.89)	1.21±0.05 (1.12-1.33)	1.60±0.09 (1.45-1.77)	2.12±0.12 (1.94-2.39)
a		89.1±3.88 (80.9-99.7)	95.2	53.1±2.46 (49.1-55.9)	61.7±3.11 (55.0-66.4)	70.3±3.07 (65.2-77.1)	80.6±2.27 (77.7-84.6)
b		7.2±0.34 (6.4-8.4)	6.9	3.5±0.19 (3.2-3.9)	4.3±0.14 (4.2-4.7)	5.0±0.33 (4.4-5.7)	5.8±0.44 (5.2-6.8)
c		30.4±2.22 (26.0-35.7)	50.2	14.9±0.80 (13.2-16.2)	18.1±0.94 (16.7-20.0)	19.8±1.23 (17.6-21.7)	23.3±2.04 (19.9-26.4)
c'		4.65±0.36 (3.90-5.32)	2.42	4.94±0.22 (4.53-5.37)	4.96±0.33 (4.07-5.40)	5.14±0.36 (4.69-5.87)	4.80±0.42 (4.20-5.56)
V		44.5±1.11 (42.3-47.1)	–	–	–	–	–
Odontostyle µm		95.0±2.08 (90.0-101.2)	97.5	44.2±1.06 (41.8-46.2)	53.5±1.00 (51.2-55.0)	68.6±1.59 (66.2-71.2)	81.7±2.80 (77.5-86.9)
Odontophore µm		55.4±1.67 (52.5-58.8)	56.3	30.5±1.44 (27.5-32.5)	37.5±1.62 (35.0-41.3)	43.2±1.21 (41.3-45.0)	49.0±1.46 (45.0-51.3)
Total stylet µm		150.4±2.68 (145.6-156.9)	153.8	74.7±1.81 (70.6-77.5)	91.1±1.83 (88.7-95.0)	111.8±2.18 (108.7-115.0)	130.7±3.56 (122.5-135.7)
Replacement odontostyle µm		–	–	52.1±1.58 (48.7-53.7)	68.8±2.02 (66.2-73.1)	81.2±2.07 (77.5-83.7)	95.6±2.31 (90.0-100.0)
Oral aperture to basal guide ring µm		93.1±2.17 (88.7-98.1)	91.3	37.3±0.88 (35.6-38.8)	50.4±1.38 (46.9-51.3)	62.9±1.41 (61.3-66.3)	76.8±2.56 (73.8-82.5)
Tail µm		95.3±6.09 (78.5-108.5)	57.5	56.2±2.72 (50.3-60.7)	66.5±2.94 (61.0-71.0)	80.5±3.38 (73.2-85.0)	91.4±6.52 (80.7-98.9)
J (hyaline portion of tail) µm		13.5±1.37 (10.0-17.2)	17.2	6.6±0.46 (6.3-7.5)	5.8±1.01 (3.4-7.5)	7.2±1.02 (5.6-10.0)	9.4±0.95 (8.1-11.3)
Body diam. at lip region µm		10.7±0.33 (10.0-11.3)	10.9	7.8±0.32 (7.5-8.4)	8.5±0.28 (8.1-8.8)	9.2±0.20 (8.8-9.6)	10.0±0.08 (10.0-10.3)
Body diam. at basal guide ring µm		23.0±0.54 (21.9-24.2)	22.8	13.7±0.22 (13.1-13.8)	15.8±0.59 (15.0-17.2)	18.1±0.57 (17.5-19.4)	20.5±0.65 (19.7-21.9)
Body diam. at base of oesophagus µm		29.0±1.16 (26.6-32.2)	29.1	16.1±0.68 (15.0-17.2)	19.5±1.18 (17.9-22.2)	22.3±1.51 (20.0-24.7)	25.6±1.01 (23.8-27.9)
Body diam. at mid-body or vulva µm		32.4±1.34 (30.0-35.8)	30.3	15.8±0.93 (15.0-17.5)	19.6±1.43 (17.5-22.5)	22.8±1.71 (20.0-25.0)	26.4±1.13 (25.0-28.4)
Body diam. at anus µm		20.5±0.93 (18.7-23.8)	23.8	11.4±0.38 (10.6-12.2)	13.4±0.80 (12.5-15.0)	15.7±0.72 (14.1-16.9)	19.1±0.74 (17.8-20.3)
Body diam. at beginning of J µm		7.3±0.59 (5.6-8.4)	8.4	4.5±0.28 (3.8-5.0)	4.6±0.51 (3.8-5.0)	5.2±0.54 (4.4-6.3)	6.0±0.54 (5.0-7.2)
Spicules µm		–	40.3	–	–	–	–

b, c and c' ratios. A single female from Čoka shows a high similarity compared to the neotype (Martelli *et al.*, 1966), except slightly posterior vulva ($V = 47.1$ vs. $V = 46$), slightly shorter odontostyle ($85.5 \mu\text{m}$ vs. $89 \mu\text{m}$) and odontophore ($55.3 \mu\text{m}$ vs. $64 \mu\text{m}$). Other three populations compared to the topotypes (Martelli *et al.*, 1966), have a longer body (2.64-3.40 mm vs. 2.3-2.8 mm), higher value of ratio a (80.9-100.3 vs. 75-84), ratio b (6.4-8.6 vs. 6.4-7.3), ratio c' (3.40-5.32 vs. 3.2-4.3), shorter odontostyle (85.5 - $91.8 \mu\text{m}$ vs. 87 - $96 \mu\text{m}$), except a population from Novi Sad (90 - $101.2 \mu\text{m}$ vs. 87 - $96 \mu\text{m}$) and slightly posterior guide ring (76.7 - $101.2 \mu\text{m}$ vs. 76 - $87 \mu\text{m}$). The population from Novi Sad is somewhat different from two other populations from the locality Male Pijace-Horgoš in having a longer tail (78.5 - $108.5 \mu\text{m}$ vs. 75 - $98.5 \mu\text{m}$) and higher value of ratio c' (3.90 -

5.32 vs. 3.40 - 4.67). Generally the morphometrics of *X. italiae* from Vojvodina Province are within the range of those reported for populations of different geographical origin from Europe, Asia and Africa with one exception. Tail length is between 102.8 - $108.5 \mu\text{m}$ in eight females out of 75 in a population found at Novi Sad and the maximum tail length already reported was $102.5 \mu\text{m}$.

Males of *X. italiae* are very rare. They have been reported from France, Israel, Italy, South Africa and recently from Slovakia (Martelli *et al.*, 1966, Prota *et al.*, 1971; Heyns, 1974; Lamberti and D'Errico, 1980; Roca *et al.*, 1991; Lišková, 1996). The morphometrics of a single male found in the rhizosphere of elder at Novi Sad is within the range reported for other males, except for the length of spicules, which is slightly shorter (40.3

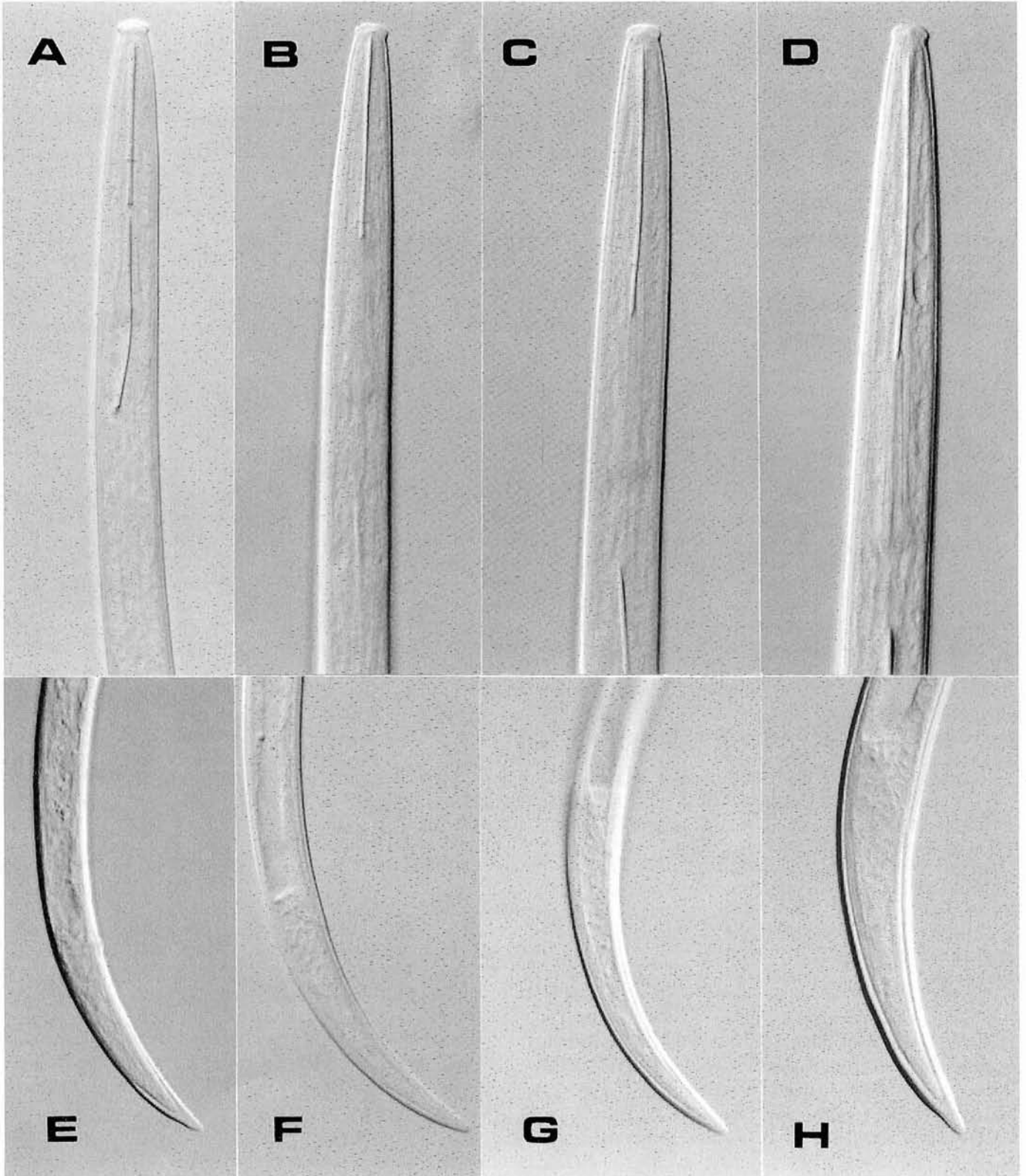


Fig. 11. Photomicrographs of juveniles of *X. italiae*: A-D, anterior region of J1, J2, J3 and J4 stage, respectively; E-H, tail of J1, J2, J3 and J4 stage, respectively.

μm vs. 42-52 μm) and tail length which is slightly longer (57.5 μm vs. 47-53 μm) compared to other males. Dorsal projections on lateral guiding pieces present in males from South Africa (Heyns, 1974) were not observed in one male from Vojvodina Province.

The existence of high morphometric variability of *X. italiae* and populations with either four or three juvenile developmental stages indicates a requirement for further research on taxonomy and biology of this species.

Table VII. Morphometric characters of adults from populations of *X. italiae* from Vojvodina Province, Northern Serbia.

Locality: Host:	Male Pijace-Horgoš Grapevine	Male Pijace-Horgoš Grapevine	Čoka Grapevine
n	9 females	6 females	1 female
L (mm)	3.07±0.17 (2.73-3.40)	2.91±0.17 (2.66-3.15)	2.49
a	93.9±4.0 (88.5-100.3)	87.6±2.8 (84.8-92.7)	84.3
b	7.8±0.5 (6.9-8.6)	7.9±0.4 (7.0-8.2)	6.8
c	34.5±1.1 (32.9-36.4)	36.4±3.2 (32.5-41.9)	32.3
c'	4.17±0.30 (3.57-4.67)	3.83±0.26 (3.40-4.26)	3.95
V	45.8±1.4 (43.9-48.1)	45.6±0.8 (44.4-46.8)	47.1
Odontostyle µm	89.8±1.1 (88.0-91.8)	86.7±1.0 (85.5-88.0)	85.5
Odontophore µm	58.1±2.1 (55.3-62.8)	55.1±1.3 (52.8-56.5)	55.3
Total stylet µm	147.9±2.9 (144.5-154.6)	141.8±1.7 (139.5-144.5)	140.8
Oral aperture to basal guide ring µm	86.2±3.6 (76.7-89.2)	82.4±2.4 (77.9-85.5)	79.2
Tail µm	89.2±6.9 (75.0-98.5)	80.0±4.0 (74.9-85.6)	77.0
J (hyaline portion of tail) µm	11.1±1.8 (8.2-14.4)	11.9±0.7 (10.7-12.5)	11.3
Body diam. at lip region µm	10.8±0.1 (10.7-11.0)	10.5±0.4 (10.0-11.0)	10.0
Body diam. at basal guide ring µm	23.8±0.6 (22.6-24.8)	23.5±0.6 (22.6-24.3)	23.0
Body diam. at base of oesophagus µm	29.4±0.6 (28.6-30.1)	29.6±0.9 (28.3-30.6)	26.4
Body diam. at vulva µm	32.8±1.0 (31.4-33.9)	33.2±1.4 (31.4-35.2)	29.5
Body diam. at anus µm	21.4±0.6 (20.1-22.6)	20.9±0.7 (20.1-22.0)	19.5
Body diam. at beginning of J µm	7.5±0.6 (6.3-8.5)	7.2±0.4 (6.3-7.5)	6.7

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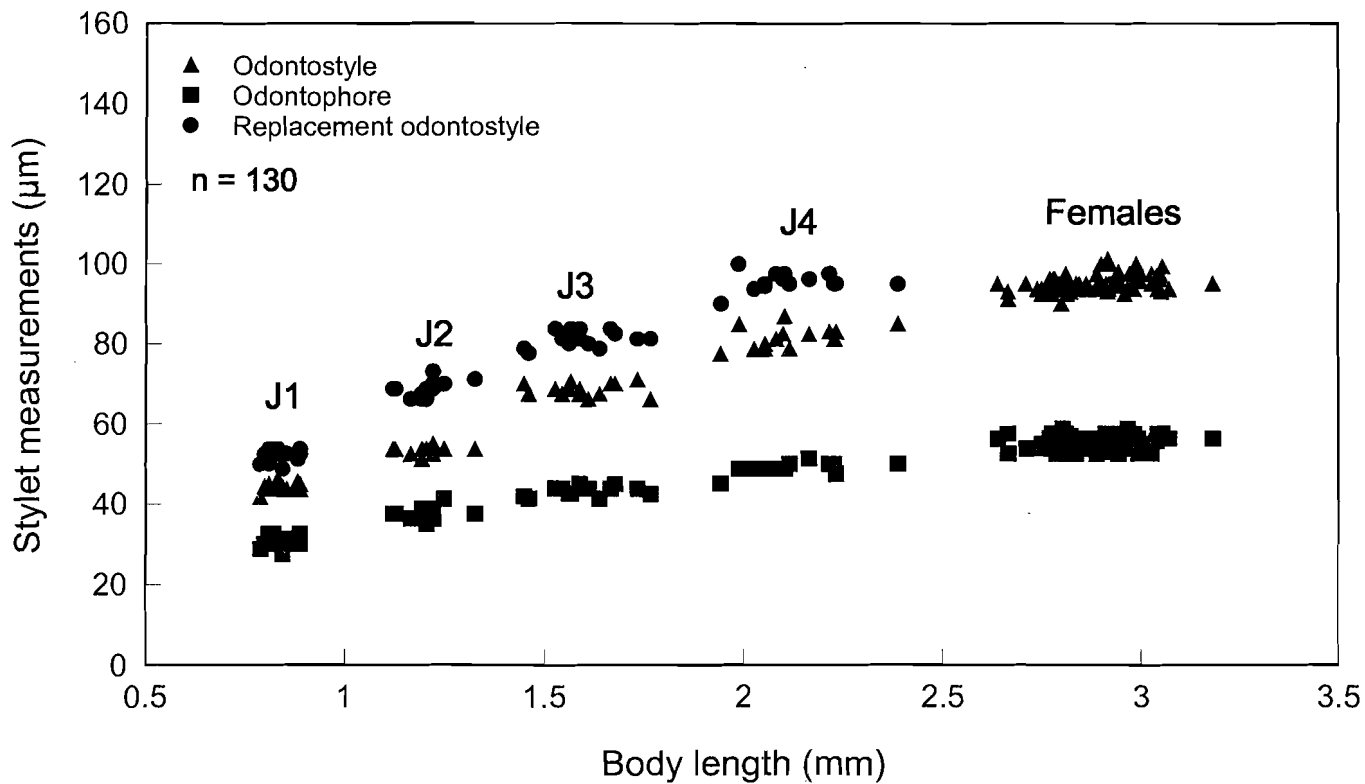


Fig. 12. Scatter diagram separating juveniles and females of *X. italiae*.

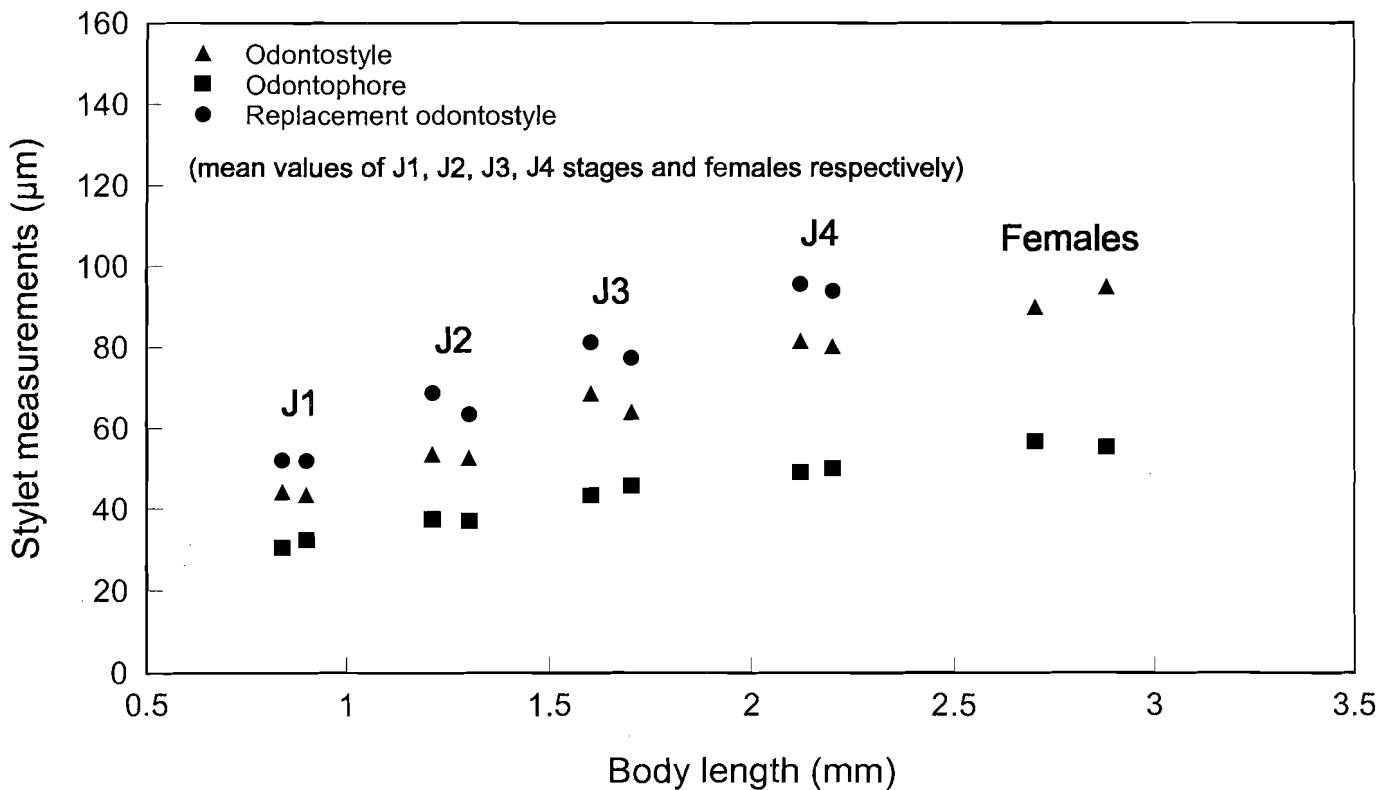


Fig. 13. Scatter diagram separating juveniles and females of *X. italiae* from populations from Serbia and Bulgaria (for details see Table VIII).

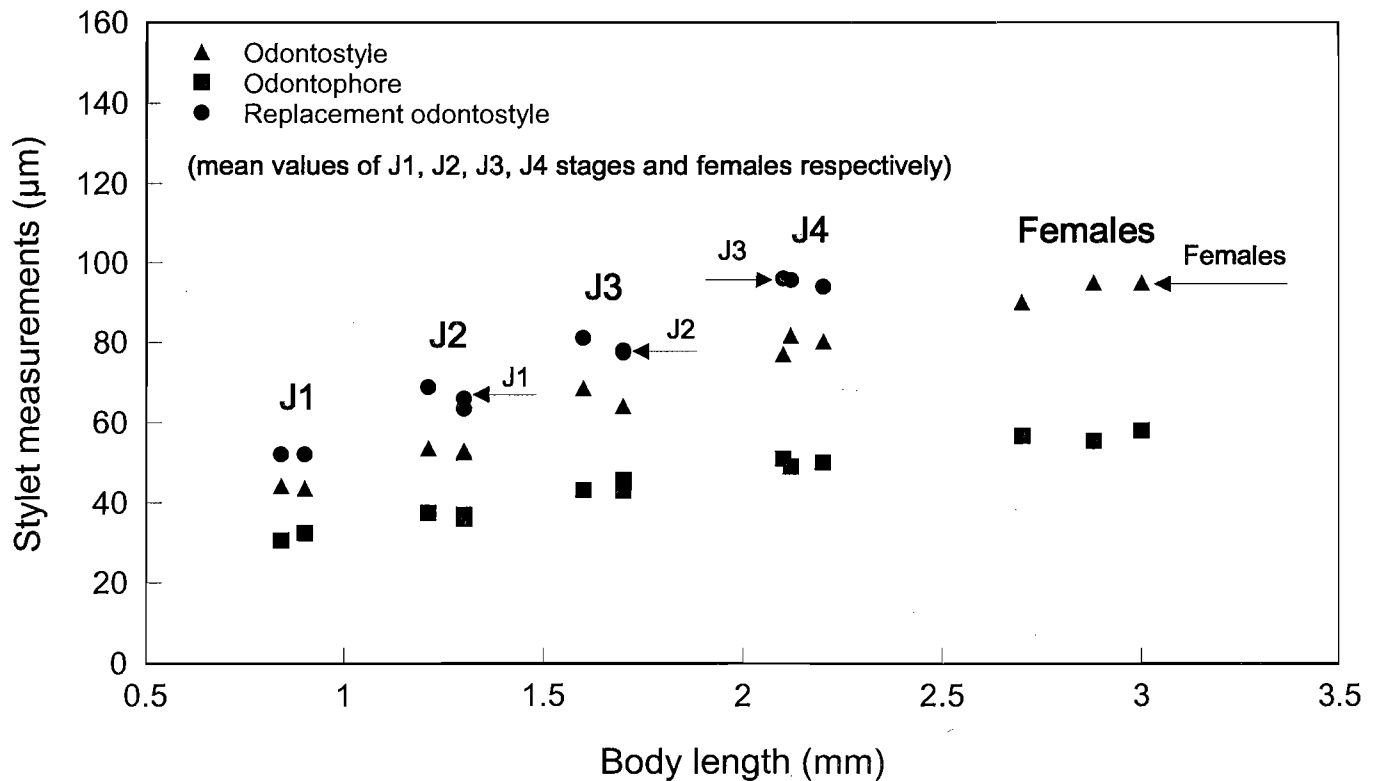


Fig. 14. Scatter diagram separating juveniles and females of *X. italiae* from populations from Serbia, Bulgaria and Egypt (marked with arrows) (for details see Table VIII).

Table VIII. Morphometrics of juvenile stages and females of *X. italiae*.

Developmental stages and populations		Body length (mm) (mean)	Odontostyle (µm) (mean)	Odontophore (µm) (mean)	Replacement odontostyle (µm) (mean)
	J1				
Novi Sad ¹		0.84	44.2	30.5	52.1
Sandanski ²		0.9	43.5	32.4	52
Nubaria ³		1.3	53	36	66
	J2				
Novi Sad		1.21	53.5	37.5	68.8
Sandanski		1.3	52.6	37	63.5
Nubaria		1.7	64	43	78
	J3				
Novi Sad		1.60	68.6	43.2	81.2
Sandanski		1.7	64	45.7	77.5
Nubaria		2.1	77	51	96
	J4				
Novi Sad		2.12	81.7	49.0	95.6
Sandanski		2.2	80.3	50	94
Nubaria		–	–	–	–
	Females				
Novi Sad		2.88	95.0	55.4	–
Sandanski		2.7	90	54.5	–
Nubaria		3.0	95	58	–

¹ Vojvodina Province, Northern Serbia (original); ² Bulgaria (Lamberti *et al.*, 1997); ³ Egypt (Lamberti *et al.*, 1996).

Table IX. Morphometrics of juvenile stages and females of *X. italiae*.

	J1	J2	J3	Females
L (mm) (mean)				
Nubaria ¹	1.3	1.7	2.1	3.0
Bari ²	1.44	1.86	2.39*	3.05
Island of Samos ³	–	–	–	2.78
a (mean)				
Nubaria	51	61	70.5	86.5
Bari	66	72	84*	97
Island of Samos	–	–	–	–
b (mean)				
Nubaria	5.1	5.9	6.1	8.0
Bari	5.1	5.5	6.2*	8.1
Island of Samos	–	–	–	–
c (mean)				
Nubaria	23	25	32	45
Bari	21	25	30*	44
Island of Samos	–	–	–	–
c' (mean)				
Nubaria	4.1	3.9	3.4	3.1
Bari	4.35	4.08	3.85*	3.3
Island of Samos	–	–	–	–
Odontostyle µm (mean)				
Nubaria	53	64	77	95
Bari	62.1	70.6	83.9*	98
Island of Samos	60	67.5	80.5	96.5
Replacement odontostyle µm (mean)				
Nubaria	66	78	96	–
Bari	74.7	86.2	99.1*	–
Island of Samos	74.2	84	97.2	–

¹ Egypt (Lamberti *et al.*, 1996); ² Italy (Martelli *et al.*, 1966); ³ Greece (Avgelis and Tzortzakakis, 1997).

* Combined data of J3 and J4 from Table III in Martelli *et al.*, 1966.

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