

Morphological Comparisons Between *Xiphinema rivesi* Dalmasso and *X. americanum* Cobb Populations from the Eastern United States¹

MAREK R. WOJTOWICZ², A. MORGAN GOLDEN³, L. B. FORER⁴, AND R. F. STOUFFER⁵

Abstract: Though in the past *Xiphinema americanum* has been the most commonly reported dagger nematode in the eastern United States, our studies revealed the presence in Pennsylvania of a previously unrecognized and unreported species related to *X. americanum*. Morphometric data and photomicrographs establish the identity of this form as *X. rivesi* and show expected variations in populations of this species from various locations. Similar data and illustrations are given for *X. americanum* populations from Pennsylvania and other areas, showing variations and relationships. *Xiphinema rivesi* is widely distributed in the fruit producing area of south-central Pennsylvania and is also reported herein from raspberry in Vermont and apple in Maryland and New York. This species is frequently found in fruit growing areas of Pennsylvania associated with tomato ringspot virus-induced diseases and is also found associated with corn, bluegrass sod, and alfalfa. **Key words:** *Xiphinema americanum*, *X. rivesi*, morphology, occurrence, fruit orchards, virus transmission.

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A previously unrecognized, didelphic species of the nematode genus *Xiphinema* Cobb, 1913 was isolated by the senior author in 1977 from soil in a southcentral Pennsylvania (Adams County) apple orchard. Since the initial isolation, the species has been isolated frequently from peach and apple orchards, grape vineyards, and soft fruit plantings as well as alfalfa, corn, and bluegrass in this particular area of Pennsylvania and from fruit growing areas in nearby states. Many of the sites where this nematode has been found have a history of tomato ringspot virus (TmRSV) problems in the fruit crops. The possible association between this species of *Xiphinema* and TmRSV disorders is being in-

vestigated. Preliminary results indicate that this previously unidentified species of *Xiphinema* is able to transmit TmRSV (3), and its presence in fruit orchards, alone or in species mixtures, has complicated dagger nematode identifications, especially in virus transmission research. This report primarily provides morphological data and details of the newly isolated *Xiphinema* species identified herein and the related and commonly occurring species, *X. americanum* Cobb, 1913.

MATERIALS AND METHODS

Soil samples were taken with an Oakfield soil probe to a depth of approximately 23–30 cm, depending on soil condition and texture. Multiple probes were combined to give a composite sample of approximately 550 cm³. Each composite sample was thoroughly but gently mixed, a 100-cm³ subsample was taken, and the nematodes extracted by a modification of the decanting and sieving technique described by Flegg (2). The extracted nematodes were killed with a 3.4% hot formaldehyde solution, fixed in formalin/acetic acid fixative,

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²Visiting Scientist, Pennsylvania State University, Fruit Research Laboratory, Biglerville, PA 17307. Present address: Research Institute of Pomology and Floriculture, 96-100 Skierniewice, Poland.

³Nematologist, Nematology Laboratory, U.S. Department of Agriculture, ARS, BARC-West, Beltsville, MD 20705.

⁴Nematologist, Pennsylvania Department of Agriculture, Bureau of Plant Industry, Harrisburg, PA 17110.

⁵Professor, Department of Plant Pathology, Pennsylvania State University, Fruit Research Laboratory, Biglerville, PA 17307.

Table 1. Morphometric data of *Xiphinema rivesi* populations from the United States (5) and France (1).

Characteristics (♀ ♀)	Populations (origin and host)					
			Eureka, Kansas, USA	Victoria Springs, Nebraska	Bordeaux, France	
			Walnut et al. (after Lamberti et al., 1979)	Cottonwood (after Lamberti et al., 1979)	Grape (types) (after Dalmasso, 1969)	
	Adams Co., Pennsylvania, USA	Hyde Park, Vermont, USA				
	Peach	Apple	<i>Rubus</i> sp.			
L (mm)	1.8 (1.7–2.0)	1.8 (1.7–1.9)	2.1 (1.9–2.2)	1.7 (1.6–1.9)	1.9 (1.9–2)	1.96 (1.68–2.1)
a	50 (48–53)	47 (42–54)	40 (39–42)	41 (37–44)	45 (41–50)	41.8 (37–49)
b	6.4 (5.8–7.1)	6.7 (5.9–7.4)	7.1 (6.1–7.8)	6.4 (6.1–6.9)	6.6 (6.5–6.9)	6.28 (5.7–6.9)
c	56 (50–61)	56 (52–62)	64 (62–70)	51 (48–57)	59 (58–61)	55.5 (51–59)
V%	52 (50–53)	53 (51–54)	52 (51–53)	52 (50–53)	52	52.2 (51–54)
Total stylet length (μm)	140 (135–143)	145 (139–151)	149 (144–154)	135 (128–147)	133 (127–140)	147 (140–151)
Odontostyle (μm)	90 (86–92)	92 (85–97)	94 (90–98)	84 (80–92)	85 (83–90)	96 (90–101)
Odontophore (μm)	50 (48–51)	52 (49–55)	56 (51–62)	51 (48–55)	48 (44–50)	51 (48–57)
Guide ring from oral aperture (μm)	68 (65–71)	75 (74–78)	79 (62–88)	74 (70–78)	74 (73–77)	76 (71–79)
Tail (μm)	33 (31–34)	32 (30–34)	32 (30–34)	34 (32–36)	33	35 (30–40)
J (μm)	7.6 (6.9–8.2)	6 (4.3–8.2)	7.2 (5.6–8.6)	7 (6–8)	6.5 (6–7.5)	...
Body diameter at anus (μm)	24 (22–25)	24 (19–28)	30 (28–31)	25 (22–26)	24 (23–25)	26 (23–29)
Body diameter at beginning of J (μm)	10 (9–11)	11 (7.7–14)	14 (13–16)	11 (9.5–11.5)	12 (11–14)	...

and transferred to glycerol by the glycerol-ethanol procedure of Seinhorst (7). Specimens for comparison were collected from other locations and other hosts as indicated in Tables 1 and 2; in some cases, prepared specimens were obtained from colleagues. Common procedures were used in taking measurements and photomicrographs.

RESULTS

Morphometric data are given in Table 1 for two *Xiphinema* populations from Pennsylvania and one from Vermont; also for *X. rivesi* Dalmasso, 1969 (1) from Kansas and Nebraska (after Lamberti et al. [6]) and from France (from original description by Dalmasso [1]). The data on the Pennsylvania and Vermont populations are particularly close to that for *X. rivesi*, especially the population from France. Specifically, the stylet length, vulva percentage, and various tail measurements of these populations are well within the range of variation expected of *X. rivesi* from diverse hosts, areas, and countries. The photomicrographs of head and tail areas (Figs. 1–20) of populations from different hosts and localities provide additional information on this species.

A brief description and further details of the population from peach (Adams County, Pennsylvania) follows: Body tapering gradually, forming a closed "C." Lip region rounded, continuous with the rest of the body, 10 μm wide. Amphids stirrup-shaped. Amphid aperture slit-like, about 1/2 as wide as lip region; odontostyle robust, 90 μm long, with flanged odontophore 50 μm long. Guiding sheath 3–4 μm long with a double guiding ring. Basal ring situated 69 μm from the anterior extremity of the specimen. The basal bulb of oesophagus occupies about 1/4 of the total oesophageal length and measures 75–85 μm long and 16–25 μm wide. Nuclei difficult to see. Cardia bluntly conical, nearly as long as wide.

Vulva about equatorial. Vagina occupying 1/4 corresponding body diameter. Gonads paired, opposed, reflexed. Spermatheca and "Z" organ not observed. Pre-rectum 50–90 μm long. Rectum about 1/2 diameter of anus. Tail conoid, 33 μm long, usually with a small terminal bulge.

Males rare, body similar to that of female, with greater curvature in posterior part of body. Distance from anterior part of the body to the guide ring, 76 μm . Tail slightly more slender than in female, $c' = 1.3$. Spicules 49 μm long. An adanal pair of supplements present with six supplements.

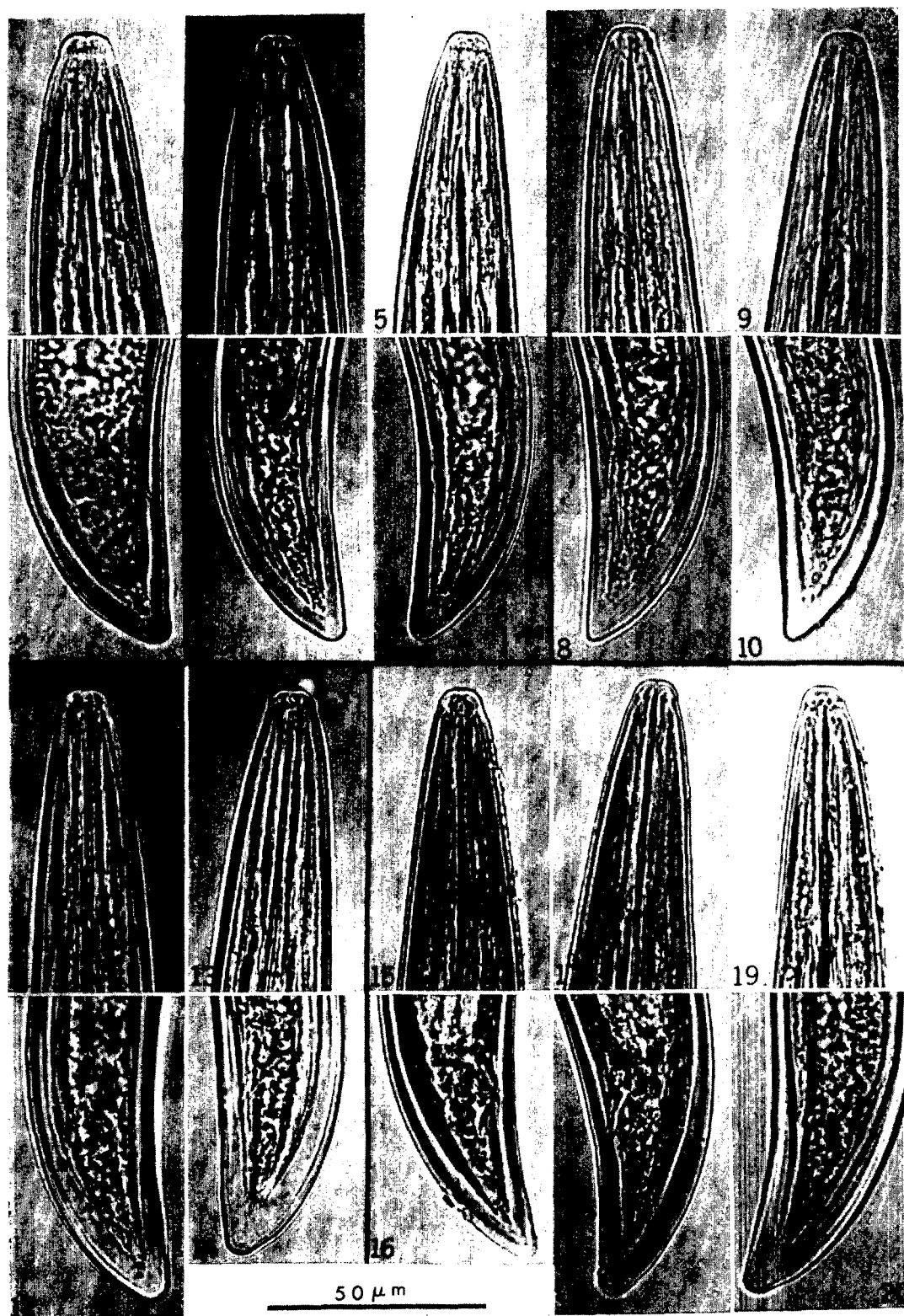
These details and data indicate that this *Xiphinema* from Pennsylvania and certain other areas is *X. rivesi*.

In Table 2 morphometric data on four populations of *X. americanum* are presented to facilitate identification and to show relationship and variations of this species. The data consist of our measurements of two populations, one each from Pennsylvania and New York, and details from Lamberti et al. (6) on a Maryland population and the type population from Rhode Island. These populations are essentially the same, although the stylet of the Maryland populations is a bit longer than the others. Photomicrographs (Figs. 22–39) show the characteristics of head and tail areas of females of populations of *X. americanum* on different hosts from Pennsylvania, New York, and Maryland. Unlike *X. rivesi*, the head of *X. americanum* is slightly offset, its stylet is shorter, and its tail is of a different shape, being especially more pointed. These characteristics in particular are very useful in separating *X. americanum* from *X. rivesi*.

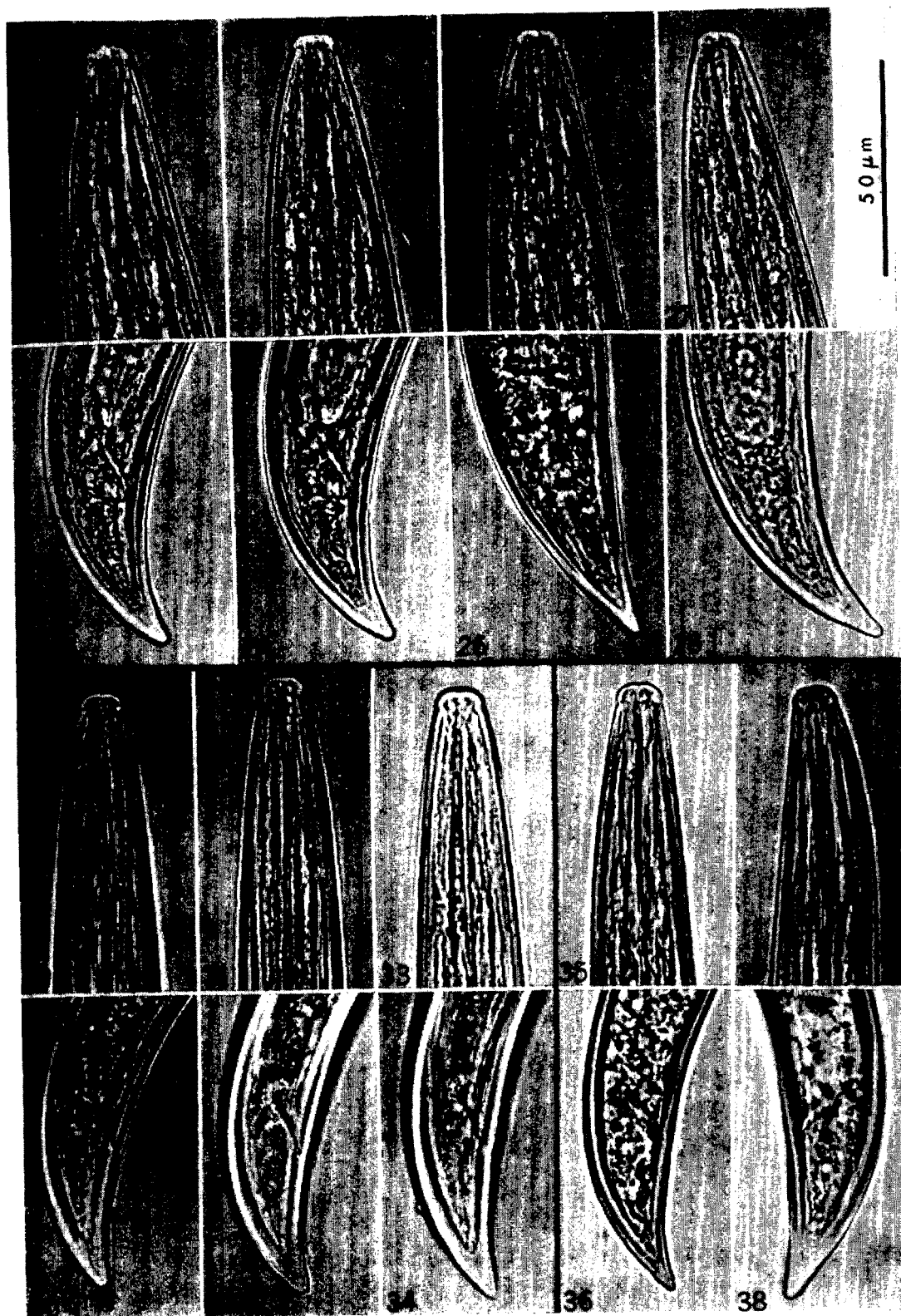
DISCUSSION

In the past the dagger nematode commonly reported from the eastern United States was identified as *X. americanum*. For example, the population of *X. rivesi* from Vermont, which was reexamined recently and is discussed here, was initially identified and reported in 1965 as *X. americanum* (5); however, another population of *Xiphinema*, recently found, was isolated repeatedly and was recognized to differ clearly from *X. americanum*. This population resembles *X. rivesi* more closely than *X. americanum*, and on the basis of the information presented here, this new population has been identified as *X. rivesi*, this being the first known occurrence of *X. rivesi* in the eastern United States.

Of even more significance, perhaps, than



Figs. 1-20. Photomicrographs of the head and tail areas of *Xiphinema rivesi* populations from different hosts and localities. 1-2) Raspberry from Vermont. 3-6) Walnut et al. from Kansas. 7-10) Peach from Adams County, Pennsylvania. 11-14) Apple from Adams County, Pennsylvania. 15-20) Grape from France.



Figs. 21-38. Photomicrographs of the head and tail areas of *Xiphinema americanum* populations from various hosts and locations. 21-28) Peach from Adams County, Pennsylvania. 29-34) Grape from Ithaca, New York. 35-38) Alfalfa from Beltsville, Maryland.

Table 2. Morphometric data of four populations of *Xiphinema americanum* from the United States.

Characteristics (♀ ♀)	Populations (origin and host)			
	Pennsylvania	Ithaca, N.Y.	Rhode Island	
			(Types) Grass (after Lamberti et al., 1979)	Beltsville, Md. Rose (after Lamberti et al., 1979)
	Peach	Grape		
L. (mm)	1.5 (1.4-1.7)	1.6 (1.5-1.6)	1.7 (1.6-1.8)	1.7 (1.6-1.8)
a	47 (45-49)	46 (44-48)	51 (43-59)	50 (48-53)
b	5.5 (5.2-5.6)	5.7 (5.3-6)	6.9 (5.8-8.1)	6.4 (5.8-6.9)
c	47 (45-51)	48 (44-52)	52 (39-59)	49 (45-55)
V%	51 (50-52)	51 (49-53)	51 (49-53)	52 (50-54)
Total stylet length (μm)	111 (107-117)	115 (112-118)	110 (101-123)	124 (116-131)
Odontostyle (μm)	71 (68-74)	71 (69-74)	68 (63-73)	79 (75-83)
Odontophore (μm)	40 (35-44)	44 (43-46)	42 (38-50)	45 (41-48)
Guide ring from oral aperature (μm)	54 (48-64)	59 (57-64)	58 (49-66)	67 (63-71)
Tail (μm)	31 (31-33)	33 (31-34)	32 (28-37)	34 (32-36)
J (μm)	10 (8.6-11)	9.4 (8.2-10)	8 (5-9.5)	9 (7.5-10)
Body diameter at anus (μm)	19 (18-20)	20 (19-21)	19 (17-22)	19 (17-21)
Body diameter at beginning of J (μm)	8.8 (7.7-10)	8.4 (7.7-9)	8 (6.5-9)	8 (7.5-8.5)

the isolation of this dagger nematode species not previously reported from Maryland, New York, and Pennsylvania, is the possible implication of this species as a vector of tomato ringspot virus (TmRSV). To the authors' knowledge, *X. rivesi* has not been reported as a vector of TmRSV. The prevalence of this species in orchards where there are severe TmRSV-induced diseases raises the possibility that it may be serving as a virus vector (4). In fact, the results of preliminary transmission tests indicate that this species is capable of transmitting TmRSV (3). Comparative tests are in progress to determine whether those nematodes we consider to be *X. americanum* are also able to transmit TmRSV and whether there is a significant difference in the efficacy. The complete results of these studies will be reported elsewhere.

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