

NEMATODES ASSOCIATED WITH FLOWERING ORNAMENTAL PLANTS IN MAHALLAT, IRAN

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Summary. In a survey conducted in June 2005 through May 2006, twenty-one nematode species were found associated with ten flowering ornamental plant species cultivated in Mahallat, Iran. *Aphelenchus avenae*, *Aphelenchoides subtenuis*, *Boleodorus thylacutus*, *Ditylenchus kbeirii*, *D. myceliophagus*, *Filenchus sandneri*, *Irantylenchus vicinus*, *Helicotylenchus crassatus*, *H. crenacauda*, *H. digonicus*, *H. pseudodigonicus*, *H. pseudorobustus*, *H. vulgaris*, *Merlinius brevidens*, *Paratylenchus similis*, *Pratylenchus neglectus*, *P. penetrans*, *P. thornei*, *Tylenchorhynchus dubius* and *Zygotylenchus guevarai* varied in their frequency of distribution amongst the ten plant species. This is the first report of nematodes found associated with ornamental plants in Mahallat, Iran, and the first detection of six nematode species in Iran. Morphological and morphometric variations that typified the Mahallat populations are given and discussed for certain nematode species. Similarities to *Tylenchorhynchus dubius* and *T. canalis* were observed in a population of *Tylenchorhynchus* and, consequently, *T. canalis* is herein proposed as a junior synonym of *T. dubius*.

Key words: Identification, morphology, survey.

Iran is one of the world's largest producers of ornamental cut flowers with an estimated export value of \$100 million (Anon., 2006). The city of Mahallat in Markazi province houses one of four cut flower export terminals recently constructed in a country that annually exports more than one billion cut flowers cultivated on 4,700 hectares (Anon., 2007).

Cost-effective production and operations of the cut-flower industry can be adversely affected by the presence of plant parasitic microfauna. For this reason, from June 2005 through May 2006, a survey was conducted to detect nematodes associated with flowering ornamental plants cultivated in Mahallat. This survey also documents a first report of all detected nematode species found associated with selected ornamental plants in Mahallat, Iran.

MATERIALS AND METHODS

Seventy-six root (including corms and bulbs) and rhizosphere soil samples were collected from ten plant species, namely, Calla lily (*Zantedeschia aethiopica* (L.) K. Spreng.), carnation (*Dianthus caryophyllus* L.), chrysanthemum (*Dendranthema grandiflorum* Kitam. cv.

Puja), iris (*Iris versicolor* L.), gladiolus (*Gladiolus grandiflorus* L.), rose (*Rosa foetida* J. Herrm. AUSTRIAN B.), snapdragon (*Antirrhinum majus* L.), stock (*Matthiola incana* L.R. Br), tuberose (*Polianthes tuberosa* L.) and tulip (*Tulipa gesneriana* L.). For each sample, about 200 g soil and roots were collected in a zig-zag pattern from 27-32 sampling points in a 1-2 ha field. Additionally, samples were collected from plants exhibiting distinct symptoms of abnormal growth (stunting, chlorosis, and necrosis). A final, well-mixed composite sample of approximately 1 kg was obtained for nematode extraction. Soil type and temperature at 0-30 cm depths were recorded during the sampling.

Nematodes were extracted from plant tissue samples by maceration-centrifugal-flotation (Coolen, 1979) and from rhizosphere soil samples by sugar centrifugation (Jenkins, 1964). For light microscopy examination, specimens were killed with gentle heat, fixed in FAA solution, processed to dehydrated glycerin and mounted on glass slides (De Grisse, 1969). Nematode specimens were examined through a Zeiss compound microscope with Nomarski differential interference contrast up to 1,000× magnification. Measurements were made using a camera lucida and expressed as mean ± standard deviation with ranges in parentheses. Unless indicated otherwise in the text, all measurements are expressed in micrometers (µm). Nematode species detected were compared with published original morphological and morphometric descriptions and redescrptions of the species under study. Type specimens of *Tylenchorhynchus*

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canalis were obtained as reference material from the United States Department of Agriculture Nematode Collection in Beltsville, Maryland.

RESULTS

Table I lists the nematode species detected and their

Table I. Detection frequencies and population densities of plant parasitic nematodes associated with ornamental cut flower plants in Mahallat, Iran, during 2005-2006.

Flower plant	Number of samples	Nematode species	% detection frequency ^a	Nematodes per 100 cm ³ soil
Calla	1	<i>Aphelenchus avenae</i>	100	16
Carnation	15	<i>Aphelenchus avenae</i>	27	5
		<i>Boleodorus thylactus</i>	47	10
		<i>Ditylenchus myceliophagus</i>	13	2
		<i>Helicotylenchus crassatus</i>	7	594
		<i>H. digonicus</i>	27	10
		<i>H. pseudorobustus</i>	13	4
		<i>Irantylenchus vicinus</i>	7	7
		<i>Merlinius brevidens</i>	53	14
		<i>Pratylenchus neglectus</i>	60	37
		<i>P. thornei</i>	47	26
		<i>Tylenchorhynchus dubius</i>	7	672
Chrysanthemum	8	<i>Aphelenchus avenae</i>	25	16
		<i>Boleodorus thylactus</i>	27	10
		<i>Ditylenchus kbeirii</i>	13	3
		<i>D. myceliophagus</i>	13	5
		<i>Helicotylenchus digonicus</i>	88	8
		<i>H. pseudorobustus</i>	25	18
		<i>H. vulgaris</i>	13	7
		<i>Irantylenchus vicinus</i>	13	7
		<i>Merlinius brevidens</i>	38	3
		<i>Pratylenchus neglectus</i>	63	9
		<i>P. penetrans</i>	25	52
		<i>P. thornei</i>	75	13
		<i>Zygotylenchus guevarai</i>	13	3
Gladiolus	11	<i>Aphelenchoides subtenuis</i>	9	20
		<i>Aphelenchus avenae</i>	82	22
		<i>Ditylenchus kbeirii</i>	27	7
		<i>D. myceliophagus</i>	27	11
		<i>Filenchus sandneri</i>	9	10
		<i>Irantylenchus vicinus</i>	18	5
		<i>Helicotylenchus crenacauda</i>	9	4
		<i>H. digonicus</i>	36	19
		<i>H. pseudorobustus</i>	36	10
		<i>Pratylenchus thornei</i>	45	11
Iris	15	<i>Aphelenchus avenae</i>	13	56
		<i>Boleodorus thylactus</i>	27	10
		<i>Helicotylenchus digonicus</i>	20	6
		<i>H. pseudodigonicus</i>	7	42
		<i>H. pseudorobustus</i>	47	2
		<i>H. vulgaris</i>	40	9
		<i>Merlinius brevidens</i>	73	37
		<i>Pratylenchus neglectus</i>	53	17
		<i>P. thornei</i>	87	18
		<i>Zygotylenchus guevarai</i>	33	31
Rose	10	<i>Aphelenchus avenae</i>	70	30
		<i>Boleodorus thylactus</i>	27	10
		<i>Ditylenchus kbeirii</i>	40	7
		<i>D. myceliophagus</i>	50	5
		<i>Helicotylenchus crenacauda</i>	10	3
		<i>H. pseudorobustus</i>	50	75
		<i>H. vulgaris</i>	20	36
		<i>Pratylenchus neglectus</i>	60	30
		<i>P. thornei</i>	60	25

Continued

Table I. Continuation.

Flower plant	Number of samples	Nematode species	% detection frequency ^a	Nematodes per 100 cm ³ soil
Snapdragon	4	<i>Aphelenchus avenae</i>	75	5
		<i>Boleodorus thylactus</i>	25	18
		<i>Ditylenchus kbeirii</i>	25	4
		<i>Helicotylenchus pseudorobustus</i>	100	5
		<i>Zygotylenchus guevarai</i>	25	18
Stock	3	<i>Aphelenchus avenae</i>	33	2
		<i>Helicotylenchus vulgaris</i>	67	7
		<i>Paratylenchus similis</i>	100	7
		<i>Zygotylenchus guevarai</i>	67	10
Tuberose	8	<i>Aphelenchus avenae</i>	13	40
		<i>Ditylenchus myceliophagus</i>	13	3
		<i>Helicotylenchus digonicus</i>	38	4
		<i>H. vulgaris</i>	25	4
		<i>Merlinius brevidens</i>	25	7
		<i>Paratylenchus nainianus</i>	13	7
		<i>Pratylenchus neglectus</i>	50	6
		<i>P. thornei</i>	38	8
		<i>Zygotylenchus guevarai</i>	63	10
Tulip	1	<i>Boleodorus thylactus</i>	100	27
		<i>Helicotylenchus pseudorobustus</i>	100	19
		<i>Pratylenchus neglectus</i>	100	42
		<i>P. thornei</i>	100	23
		<i>Zygotylenchus guevarai</i>	100	3

^aPercentage of samples per plant host in which nematode species was detected.

^bMean value of nematodes in 100 cm³ soil of total number of samples per plant host.

frequency of detection in association with individual ornamental cut-flower species. Twenty-one nematode species belonging to twelve genera were identified. Nematode species varied in their frequency of distribution amongst all ten plant species: *Aphelenchus avenae* Bastian, 1865, primarily a mycetophagous species, was the most commonly detected (9 plant species), followed by *Helicotylenchus pseudorobustus* (Steiner) Golden, *Pratylenchus thornei* Sher et Allen (7 plant species), *Boleodorus thylactus* Thorne, *Pratylenchus neglectus* (Rensch) Filipjev et Schuurmans Stekhoven, *Zygotylenchus guevarai* (Tobar Jiménez) Braun et Loof (6 plant species), *Ditylenchus myceliophagus* Goodey (mycetophagous), *Helicotylenchus digonicus* Perry, in Perry, Darling et Thorne, *H. vulgaris* Yuen (5 plant species), *Ditylenchus kbeirii* Fortuner et Maggenti, *Pratylenchus vicinus* (Szczygiel) Sumenkova, *Merlinius brevidens* (Allen) Siddiqi (4 plant species), *Helicotylenchus crenacauda* Sher (2 plant species), *Aphelenchoides subtenuis* (Cobb) Steiner et Buhner (mycetophagous), *Filenchus sandneri* (Kheiri) Raski et Geraert, *Helicotylenchus crassatus* Anderson, *H. pseudodigonicus* Szczygiel, *Paratylenchus nainianus* Edward et Misra, *P. similis* Khan, Prasad et Mathur, *Pratylenchus penetrans* (Cobb) Filipjev et Schuurmans Stekhoven and *Tylenchorhynchus dubius* (Bütschli) Filipjev (one plant species).

Numbers of nematodes per 100 cm³ soil were greatest for *Helicotylenchus* spp., *Pratylenchus* spp. and *Aphelenchus avenae* than for other nematode species associated with all surveyed plant species except for *Tylenchorhynchus dubius* on carnation. The soil type for all samples was sandy and soil temperatures ranged from 12 to 18 °C from June 2005 through May 2006. This is the first detection of *H. crassatus*, *H. crenacauda*, *Paratylenchus similis*, *Pratylenchus penetrans*, and *T. dubius* in Iran.

DISCUSSION

Most nematode species detected in the Mahallat survey resembled populations earlier reported for other geographic regions. However, minor morphological and morphometric differences observed in some species are discussed below.

Spiral nematode species

Helicotylenchus spp. were commonly found in all ten plant species. Morphometrics of *Helicotylenchus* spp. detected are given in Table II. The Mahallat population of *H. crenacauda* had a greater range in body length and "a" value than Sher's original description of an Indonesian

population (Sher, 1966). Phasmid distance above anus was greater for *H. pseudodigonicus* than originally reported on strawberry by Szczygiel (1969). *Helicotylenchus pseudorobustus* had a shorter tail than the Switzerland population (7.5-12 μm vs. 17-23 μm) reported by Steiner (1914) and typified the Mahallat population.

A prominent truncate lip region differentiated *H. crassatus*, *H. digonicus*, *H. pseudodigonicus* and *H. vulgaris* from *H. crenacauda* and *H. pseudorobustus* with a hemispherical lip region. All six species closely resembled their original descriptions with some minor differences. *Helicotylenchus crassatus*, morphologically similar

Table II. Morphometrics of female *Helicotylenchus* spp. associated with flowering ornamental plants in Mahallat, Iran. Measurements are in μm and in the form: mean \pm SD (range).

Character	<i>H. crassatus</i>	<i>H. crenacauda</i>	<i>H. digonicus</i>	<i>H. pseudodigonicus</i>	<i>H. pseudorobustus</i>	<i>H. vulgaris</i>
n	10	7	8	8	9	9
L	774.0 \pm 54.7 (654-830)	754.0 \pm 73.6 (654-839)	741.0 \pm 56.4 (683-862)	902.0 \pm 119.8 (727-1,034)	808.0 \pm 68.4 (736-939)	1,092.0 \pm 43.7 (1,023-1,162)
a	32.3 \pm 3.1 (25.7-36.3)	33.8 \pm 2.0 (31.2-37.4)	33.6 \pm 3.7 (29.4-39.2)	29.4 \pm 2.1 (26.7-33.0)	33.7 \pm 4.5 (27.7-40.5)	35.8 \pm 4.0 (31.3-44.7)
b'	5.6 \pm 0.7 (3.8-6.7)	5.8 \pm 0.6 (5.1-6.5)	5.5 \pm 0.3 (5.1-6.0)	6.0 \pm 0.7 (5.0-6.9)	5.4 \pm 0.6 (4.8-6.6)	7.3 \pm 0.5 (6.7-8.4)
c	62.7 \pm 7.5 (48.0-73.0)	53.2 \pm 3.9 (47.9-57.8)	64.1 \pm 4.6 (56.4-68.8)	71.6 \pm 15.5 (50.0-94.8)	49.2 \pm 5.7 (38.2-57.4)	93.1 \pm 10.6 (82.1-116.1)
c'	1.0 \pm 0.1 (0.8-1.1)	1.2 \pm 0.1 (1.1-1.3)	0.9 \pm 0.1 (0.8-1.1)	0.8 \pm 0.2 (0.6-1.0)	1.3 \pm 0.3 (1.0-1.8)	0.8 \pm 0.1 (0.6-0.8)
V	63.8 \pm 3.0 (61-71)	64.0 \pm 2.5 (61-68)	63.6 \pm 1.2 (62-66)	61.2 \pm 2.0 (59-63)	61.9 \pm 1.8 (60-65)	60.9 \pm 1.5 (59-64)
O	29.5 \pm 3.2 (23.5-33.6)	35.8 \pm 1.6 (33.6-38.2)	27.4 \pm 6.0 (18.2-33.6)	27.4 \pm 3.2 (21.4-31.9)	30.1 \pm 7.0 (12.1-35.7)	26.1 \pm 2.1 (23.4-29.4)
Stylet	25.7 \pm 1.2 (25-27)	26.9 \pm 1.3 (25-29)	24.6 \pm 1.7 (24-27)	30.9 \pm 2.2 (28-34)	26.1 \pm 1.0 (25-27)	33.0 \pm 2.2 (30-37)
Dorsal gland orifice	8.4 \pm 0.9 (6.4-9.1)	9.6 \pm 0.4 (9.1-10.0)	7.4 \pm 1.4 (5.4-9.1)	9.4 \pm 1.4 (7.3-11.8)	8.5 \pm 1.9 (3.6-10.0)	9.4 \pm 1.0 (8.2-11.8)
Ant. end to excretory pore	106 \pm 6.5 (100-122)	103.0 \pm 4.6 (94-108)	99.0 \pm 6.4 (93-110)	112.0 \pm 5.5 (104-118)	108.0 \pm 3.4 (101-110)	122.0 \pm 5.0 (116-129)
Vulval body width	24.0 \pm 0.8 (23-25)	22.3 \pm 1.5 (20-25)	22.2 \pm 1.6 (19-25)	30.7 \pm 3.6 (25-35)	24.3 \pm 3.4 (18-31)	30.7 \pm 2.8 (25-34)
Anal body width	12.8 \pm 0.7 (12-14)	12.2 \pm 0.4 (12-13)	12.3 \pm 0.8 (11-14)	16.0 \pm 1.8 (14-18)	12.8 \pm 1.2 (12-15)	15.7 \pm 1.0 (14-17)
Tail length	12.4 \pm 1.4 (10-15)	14.2 \pm 1.0 (14-16)	11.6 \pm 1.1 (10-13)	12.8 \pm 1.6 (11-15)	9.3 \pm 1.65 (7-12)	11.8 \pm 1.0 (10-13)
No. of lip region annules	4	4-5	3	4-5	3-4	4-5
No. of tail annules	6-9	8-11	5-7	5-11	8-13	5-7
No. of annules phasmid ant. to anus	0-2	4-6	3-5	8-10	1-7	11-14

to *H. digonicus*, was differentiated from the latter species and the others with truncated lip regions by a very thick, pyriform vagina (thin and cylindrical in *H. digonicus*). *Helicotylenchus crassatus* was associated with carnation and herein constitutes a first reported detection in Iran. *Helicotylenchus digonicus* was differentiated from *H. pseudodigonicus* and *H. vulgaris* by shorter stylet (24-27 μm *vs.* 28-34 μm and 30-38 μm , respectively) and phasmid to anus distance (3-5 annules anterior to anus *vs.* 8-10 annules and 11-14 annules anterior to anus, respectively). *Helicotylenchus vulgaris* was differentiated from *H. pseudodigonicus* mainly by a more sharply truncate lip region (*vs.* slightly truncate) and phasmid to anus distance. Of the species with a hemispherical lip region, *H. crenacauda* was differentiated from *H. pseudorobustus* by the shape of the tail terminus (disc-shaped indentation *vs.* bluntly rounded), inner longitudinal lateral lines in posterior tail (areolated *vs.* not areolated) and spermatheca (inconspicuous, not offset *vs.* prominent, offset).

Root-lesion nematode species

Three species of *Pratylenchus* were detected during the survey of which *P. thornei* and *P. neglectus* were more commonly distributed than *P. penetrans*, that was only found in chrysanthemum. Prior to the current study, Kheiri (1972a) reported the first occurrence of *P. neglectus* and *P. thornei* on wheat in Kharadj, Iran. Mor-

phometrics of *Pratylenchus* spp. are given in Table III. All three species resembled earlier reported descriptions.

Other species

Morphology and morphometrics of the Mahallat population of *Aphelenchus avenae* (Table IV) closely resembled descriptions of a population cultured on *Allium cepa* L. (Jairajpuri, 1968) with the exception of longer body length (648-1353 μm *vs.* 550-860 μm and greater c value (34.2-55.1 *vs.* 25.0-35.0).

Kheiri (1970) found *Filenchus cerealis* in rhizosphere soils of sunflower and rye in Kharadj, Iran. The Mahallat population closely resembled the original description by Kheiri (1970) and redescriptions by Raski and Geraert (1987) and Brzeski (1997) with the exception of a slightly larger range for body length (405-507 μm *vs.* 365-415 μm) and c (12.8-15.1 *vs.* 10-11). Later, Brzeski (1997) synonymized *F. cerealis* with *F. sandneri*. Kheiri (1972a, 1972b) also reported *Irantylenchus clavidorus* and *Boleodorus thylactus* in soils of agricultural crops cultivated in central and northern Iran. Sumenkova (1984) synonymized *I. clavidorus* with *I. vicinus*. In comparison, Mahallat populations of *I. vicinus* and *B. thylactus* on ornamental plants bore only slight differences in a greater c (6.9-8.3 *vs.* 5.7-6.4) for *I. vicinus* and a less sclerotized cephalic framework for *B. thylactus*.

Table III. Morphometrics of *Pratylenchus* spp. associated with flowering ornamental plants in Mahallat, Iran. Measurements are in μm and in the form: mean \pm SD (range).

Character	<i>P. neglectus</i>		<i>P. penetrans</i>		<i>P. thornei</i>
	Female	Female	Male	Female	
n	13	14	3	12	
L	562.0 \pm 79.3 (418-712)	602.0 \pm 60.4 (504-700)	519.0 \pm 17.6 (504-539)	609.0 \pm 52.2 (512-694)	
a	32.8 \pm 3.9 (25.0-39.5)	33.7 \pm 3.8 (27.8-41.1)	-	40.9 \pm 3.9 (33.1-46.3)	
b'	5.4 \pm 0.9 (4.1-6.9)	4.7 \pm 0.6 (3.9-5.6)	4.6 \pm 0.1 (4.5-4.7)	5.4 \pm 0.6 (4.5-6.4)	
c	24.4 \pm 3.5 (16.9-29.0)	25.9 \pm 7.1 (18.5-41.3)	23.2 \pm 2.3 (21.3-25.8)	26.8 \pm 2.2 (22.9-29.8)	
c'	2.3 \pm 0.4 (1.8-3.1)	2.0 \pm 0.3 (1.4-2.4)	1.9 \pm 0.4 (1.6-2.4)	2.6 \pm 0.3 (2.2-3.1)	
V	82.6 \pm 1.2 (80-85)	79.2 \pm 3.6 (72-87)	-	77.9 \pm 2.4 (74-84)	
Stylet	18.1 \pm 0.9 (16-20)	16.0 \pm 0.7 (15-17)	15.0	16.6 \pm 0.8 (15-18)	
Ant. end to excretory pore	79.0 \pm 3.4 (75-84)	81.0 \pm 5.5 (76-89)	75.0	80.0 \pm 3.4 (77-87)	
Vulval body width	17.4 \pm 3.9 (14-26)	17.7 \pm 2.2 (15-22)	-	14.9 \pm 0.8 (14-16)	
Anal body width	10.3 \pm 2.4 (7-15)	12.4 \pm 2.7 (8-17)	11.8 \pm 2.4 (10-15)	8.8 \pm 1.1 (7-10)	
PUS	19.7 \pm (12-37)	21.5 \pm 4.7 (14-33)	-	22.4 \pm 6.4 (15-34)	
Tail length	24.9 \pm 2.9 (20-30)	24.6 \pm 5.2 (13-33)	22.4 \pm 1.4 (21-24)	22.7 \pm 1.4 (21-25)	
No. of lip region annules	2	3-4	3-4	3	
No. of tail annules	15-26	9-21	-	19-35	
Spicule	-	-	15.7 \pm 1.4 (15-17)	-	

Table IV. Morphometrics of *Aphelenchus avenae*, *Boleodorus thylactus*, *Filenchus sandneri*, and *Irantylenchus vicinus* associated with flowering ornamental plants in Mahallat, Iran. Measurements are in μm and in the form: mean \pm SD (range).

Character	<i>Aphelenchus avenae</i>		<i>Boleodorus thylactus</i>		<i>Filenchus sandneri</i>	<i>Irantylenchus vicinus</i>	
	Female	Male	Female	Male	Female	Female	Male
n	12	2	8	2	6	8	4
L	892.0 \pm 184.6 (648-1353)	783.0 \pm 72.3 (732-834)	604.0 \pm 66.2 (521-682)	559.0 \pm 86.8 (498-621)	474.0 \pm 38.5 (407-507)	921.0 \pm 92.5 (816-1080)	872.0 \pm 74.2 (764-925)
a	40.0 \pm 7.9 (28.1-61.3)	-	37.0 \pm 4.3 (29.9-45.3)	42.3 \pm 4.5 (39.1-45.5)	34.5 \pm 4.5 (27.4-39.6)	35.8 \pm 7.0 (27.3-47.2)	44.8 \pm 11.7 (32.3-55.8)
b	5.0 \pm 0.8 (4.0-7.0)	5.1 \pm 1.0 (4.3-5.8)	5.7 \pm 0.6 (4.9-6.7)	5.3 \pm 0.8 (4.8-5.9)	5.5 \pm 0.7 (4.4-6.4)	7.4 \pm 0.5 (6.9-8.3)	7.2 \pm 0.6 (6.4-7.7)
b'	7.7 \pm 0.7 (6.6-8.9)	6.6	-	-	-	-	-
c	42.5 \pm 6.7 (34.2-55.1)	35.9 \pm 0.9 (35.3-36.6)	10.0 \pm 1.4 (8.4-12.6)	8.2 \pm 1.5 (7.1-9.2)	14.2 \pm 1.0 (12.8-15.1)	6.9 \pm 1.0 (5.9-9.3)	5.7 \pm 0.7 (4.8-6.5)
c'	1.7 \pm 0.3 (1.3-2.1)	1.5 \pm 0.1 (1.5-1.6)	6.2 \pm 1.0 (4.5-7.7)	7.6 \pm 1.3 (6.7-8.6)	3.8 \pm 0.4 (3.4-4.4)	10.2 \pm 1.7 (7.6-13.2)	12.4 \pm 2.1 (10.6-15.1)
V	76.0 \pm 7.0 (61-88)	-	65.2 \pm 1.3 (64-68)	-	78.0 \pm 3.3 (75-85)	63.6 \pm 2.7 (61-70)	-
Stylet	18.8 \pm 1.7 (15-22)	15.4	11.4 \pm 1.1 (10-13)	10.4 \pm 0.6 (10-11)	9.5 \pm 0.9 (8-11)	10.7 \pm 0.6 (10-12)	10.4 \pm 0.5 (10-11)
Ant. end to excretory pore	-	-	83.0 \pm 3.1 (80-88)	82	-	101.0 \pm 6.7 (89-108)	95.0 \pm 2.8 (92-98)
Max. body width	22.9 \pm 5.6 (15-35)	-	16.4 \pm 1.8 (15-19)	13.2 \pm 0.6 (13-14)	13.9 \pm 2.3 (12-18)	26.6 \pm 5.5 (17-32)	20.3 \pm 3.9 (16-24)
Anal body width	12.6 \pm 3.3 (8-19)	14.1 \pm 0.6 (14-15)	10.0 \pm 0.9 (9-12)	9.1 \pm 1.3 (8-10)	8.8 \pm 0.9 (7-10)	13.3 \pm 2.0 (11-17)	12.7 \pm 2.1 (11-15)
PUS	-	-	12.4 \pm 5.3 (6-15)	-	9.3 \pm 4.4 (5-15)	12.4 \pm 2.5 (9-16)	-
Tail length	21.1 \pm 3.3 (8-19)	21.8 \pm 2.5 (20-24)	62.0 \pm 10.0 (45-70)	69.0 \pm 1.9 (67-70)	33.4 \pm 2.2 (31-37)	134.0 \pm 13.2 (116-155)	155.0 \pm 10.3 (141-164)
Spicule	-	16.4 \pm 3.8 (14-19)	-	15.9 \pm 1.9 (15-17)	-	-	19.1 \pm 2.4 (16-22)
Gubernaculum	-	6.4	-	3.5	-	-	6.4 \pm 1.1 (5-7)

TYLENCHORHYNCHUS DUBIUS
(Bütschli, 1873) Filipjev, 1936
= *T. canalis* Thorne *et* Malek, 1968 (n. syn.)
(Table V)

Female. Lip region hemispherical or slightly flattened anteriorly, set off from body by constriction, lip annules 5-6; stylet knobs rounded, posteriorly sloped; excretory pore at base of isthmus or near cardia; sinuous canals

present, distinct or less distinct, absent in two specimens, extending variably to anterior and posterior intestinal regions, posterior canals end preanally or within tail region; postanal intestinal sac absent or present, when present then extending variably through the length of the tail (within anterior fourth of tail length; up to half tail length in one specimen); tail cylindrical, tapering to a broadly or, more commonly, narrowly rounded striated terminus.

Table V. Morphometrics of *Tylenchorhynchus dubius* associated with flowering ornamental plants in Mahallat, Iran, during 2005-2006 in comparison with reported morphometrics of *T. dubius* and *T. canalis*. Measurements are in μm and in the form: mean \pm SD (range).

Character	<i>T. dubius</i>						<i>T. canalis</i>	
	Mahallat, Iran		Allen, 1955		Ray <i>et</i> Das, 1983		Thorne <i>et</i> Malek, 1968	
	Female	Male	Female	Male	Female	Male	Female	Male
n	11	8	10	10	5	2	?	?
L	726.9 \pm 47.7 (660-789)	736.6 \pm 45.0 (678-804)	620-780	650-710	680-875	650-700	1,000	860
a	25.5 \pm 1.9 (22.6-28.2)	27.7 \pm 1.0 (26.2-29.1)	30-35	33-37	31-33	28	39	33
b	5.3 \pm 0.3 (4.9-6.0)	5.5 \pm 0.3 (5.1-5.8)	5-6	5.0-5.6	5-6	5.1-5.8	7.1	6.1
c	14.4 \pm 1.2 (12.8-16.4)	13.9 \pm 0.9 (13.0-15.2)	13-16	12-15	13-15	12-14	13	14.5
c'	2.5 \pm 0.1 (2.3-2.7)	2.5 \pm 0.2 (1.9-2.7)	-	-	2.9-3.1	-	-	-
V	54.6 \pm 2.7 (52-62)	-	54-57	-	54-56	-	53	-
S	1.5 \pm 0.1 (1.4-1.6)	2.3 \pm 0.1 (1.5-1.7)	-	-	-	-	-	-
MB	48.5 \pm 3.5 (45-59)	49.5 \pm 2.2 (52-58)	-	-	-	-	-	-
Lip region height	3.7 \pm 0.5 (3-4)	3.6 \pm 0.2 (3-4)	-	-	-	-	-	-
Lip region width	8.0 \pm 0.4 (8-9)	7.6 \pm 0.5 (7-8)	-	-	-	-	-	-
Stylet	20.1 \pm 0.8 (18-22)	20.5 \pm 1.0 (20-22)	18-19	16-17	17-18	17-18	20	-
Knob height	1.4 \pm 0.2 (1-2)	1.5 \pm 0.2 (1-2)	-	-	-	-	-	-
Knob width	4.1 \pm 0.4 (4-5)	3.9 \pm 0.6 (3-4)	-	-	-	-	-	-
Dorsal gland orifice	2.6 \pm 0.5 (2-4)	2.5 \pm 0.4 (2-3)	2-3	-	-	-	-	-
Ant. end to nerve ring	91.4 \pm 5.8 (81-103)	93.2 \pm 5.3 (84-102)	-	-	-	-	-	-
Ant. end to excretory pore	114.5 \pm 6.1 (106-127)	112.1 \pm 7.1 (102-122)	-	-	-	-	-	-
Mid-body width	28.6 \pm 2.1 (25-32)	26.6 \pm 1.9 (24-29)	-	-	-	-	-	-
Vulval body width	28.6 \pm 2.1 (25-32)	-	-	-	-	-	-	-
Anal body width	20.5 \pm 1.5 (18-22)	20.7 \pm 1.1 (20-23)	-	-	-	-	-	-
Tail length	50.8 \pm 5.0 (42-60)	53.2 \pm 2.7 (50-59)	-	-	-	-	-	-
Phasmid to anus distance	18.4 \pm 4.6 (14-29)	19.9 \pm 3.3 (16-24)	-	-	-	-	-	-
Spicule length	-	25.9 \pm 1.5 (24-28)	-	26	-	24	-	-
Gubernaculum length	-	13.1 \pm 0.6 (12-14)	-	12	-	12-13	-	-
No. of lip annules	5-6	6	6-7	-	6-7	-	-	-
No. of tail annules	37-44	-	-	-	41-48	-	-	-

Male. Similar to female. Gubernaculum simple, curved at proximal end.

Habitat and locality. Soil around roots of *Dianthus caryophyllus* L. in Mahallat, Markazi province, Iran.

Voucher specimens. Seven females and three males deposited in the University of California Davis Nematode Collection (UCDNC) of the Department of Nematology, University of California, Davis, California, USA. One female and one male deposited in the USDA Nematode Collection, Beltsville, Maryland, USA.

Remarks. The Mahallat population of *Tylenchorhynchus dubius* resembled earlier descriptions of *T. dubius* and *T. canalis* Thorne et Malek (1968) with the exception of slightly greater ranges of values for stylet length (18.0-22.0 μm vs. 18.0-19.0 μm in *T. dubius*, 20 μm in *T. canalis*) and V (52-62% vs. 50-57% in *T. dubius*, 53% in *T. canalis*).

Allen (1955) distinguished *T. dubius* by "the four incisures in the lateral field, the set-off (hemispherical) lip region, the faint labial sclerotization, the annulation around the terminus of the tail, and the post-anal intestinal sac". The excretory pore was described as located at the base of the isthmus and lateral sinuous canals were not reported. Likewise, *T. canalis* was distinguished by the "flattened, well set off lip region, posterior location of the excretory pore and hemizonid, lateral canals and post-rectal blind sac extending to the end of tail cavity" (Thorne and Malek, 1968). Other characters noted in the description of the species that may suggest distinction between *T. dubius* and *T. canalis* include differences in gubernaculum shape, stylet knob shape and body length. A greater distal curvature of the gubernaculum in *T. canalis* in contrast to slight ventral curvature in *T. dubius* was observed in type specimens and also originally illustrated. Of six type specimens, this greater curvature was present in only two specimens that were oriented subventrally. Therefore, gubernaculum shape was not consistent in all type specimens of *T. canalis* and often resembled the simple curvature found in *T. dubius*. Similarly, basal knobs varied from posteriorly sloped to posteriorly sloped with slightly anteriorly directed tips in type specimens of *T. canalis*. Body length for *T. canalis* was documented as 1.0 mm (1,000 μm ; Table V); however, body length of twelve female type specimens indexed under *Tylenchorhynchus* 8 (Thorne and Malek, 1968) had a range of 648-1,071 μm . Sinuous canals in the intestinal region are not peculiar to *T. canalis* alone and have also been reported for *T. cylindricus* (Siddiqi, 1972). However, the latter species is mainly differentiated from *T. dubius* by a smooth non-striated tail terminus and prominent, cup-shaped basal knobs.

The Mahallat population clearly combined all stated distinguishing characters of *T. dubius* and *T. canalis*, indicating thereby that sinuous canals, excretory pore position, lip region shape and post-anal intestinal sac are

variable characters that cannot be used to distinguish the two species. Because of the similarity in morphology and morphometrics, *T. canalis* is herein proposed as a junior synonym of *T. dubius*.

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