A SURVEY OF PLANT-PARASITIC NEMATODES ASSOCIATED WITH FORAGE CROPS IN BINGOL, TURKEY

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Summary. During June 2011, a survey was conducted in four districts of Bingol province, Turkey, to investigate the occurrence, population abundance and spatial distribution of plant parasitic nematodes associated with forage crops. A total of 24 soil samples were collected and processed for this study. The plant parasitic nematodes detected in the samples included *Ditylenchus microdens, Filenchus* sp., *Helicotylenchus platyurus*, *H. carolinensis, H. varicaudatus*, *Longidorus* sp., *Meloidogyne* sp., *Merlinius bavaricus, M. brevidens*, *Merlinius* sp., *Paratrophurus* sp., *Paratylenchus tenuicaudatus, Paratylenchus* sp., *Pratylenchoides erzurumensis, Pratylenchus crenatus*, *P. thornei*, *Sauertylenchus maximus, Trophurus* sp., *Tylenchorhynchus brassicae*, *Tylenchus exiguus, Xiphinema pachtaicum* and *X. index*. Of these, *Helicotylenchus platyurus, H. carolinensis* and *Paratylenchus tenuicaudatus* represent new country records for Turkey. In addition, all the species identified are reported for the first time in Bingol province, Turkey. However, the host status of the forage crops to these nematodes needs to be investigated.

Keywords: Morphological analysis, pastures, rangelands, soil population levels.

Bingol is a highly mountainous province located in the Eastern Anatolia's Upper Euphrates region, lying between 40-41.5° east longitude and 38.5-39.5° north latitude. Numerous pastoral lands reside in valleys and on hillsides of the mountains at an elevation between 1014 and 1768 m above sea level. The climate of the area is temperate with cold and snowy winter, rainy spring and hot and dry summer. Annual mean rainfall, temperature and relative humidity are 787 mm, 11.9 °C and 57%, respectively (Anonymous, 2010b). Forage crops are the main agricultural commodity produced in the area (8,253 km^2) and are grown in rangelands (land composed by self-seeding indigenous herbaceous plants) and pastures [land planted to specific grasses or grass-legume mixtures by landowners (Bernard *et al*., 1998)]. Rangelands and pastures are the most important natural resource in the area and support the local livestock industry, which is the main income source of the region.

The damage induced by plant-parasitic nematodes to forage crops is well documented (Freckman *et al*., 1979; Pedersen and Rodriguez-Kabana, 1984; Lauenroth and Milchunas, 1991; Griffin *et al*., 1996; Bernard *et al*., 1998; Mercer *et al*., 2008). Yildiz (2007) reported that the nematodes in pastures in the southeastern semi-arid regions of Turkey were more abundant than in similar arable lands. However, there have been no systematic studies on plant-parasitic nematodes that occur in the mountainous region, in Bingol province.

The objective of this study was to investigate the species composition, abundance and distribution of plant-parasitic nematodes in Bingol rangelands and pastures.

The nematode survey was conducted during June of 2011. A total of 24 soil samples were collected from rangelands and pastures in the central district of Bingol (B), Genc (G), Karliova (K) and Solhan (S) (Bingol province, Turkey). The types of rangelands and pastures sampled in each district were representative of each district's flora and fauna. Rangelands and pastures in the central districts of Bingol, Genc, Karliova and Solhan are spread between the mountains. Pastures are more prevalent than rangelands in Karliova and Solhan districts, which are located at higher elevations than Bingol and Genc districts. Sampled districts and locations are shown in Fig. 1. The following ecological characteristics, flora composition and management practices differentiate rangelands and pastures in Bingol Province.

Rangelands: Usually located in the mountain valleys, receiving little or no management and composed by legumes and grasses in equal proportion or sometimes predominated by legumes, mostly *Lotus* spp., *Medicago* spp., *Vicia* spp. and *Trifolium* spp. These lands are subject to prolonged drought conditions after mid-summer, rough surfaced, open to the public, and usually cover large areas. Soil type ranges from clay to loam with 7.1-7.7 pH, salinity 0.2-0.3 dS/m and organic matter between 1.23 and 1.71%.

Pastures: Grazing lands managed by land owners dominated by specific grasses such as *Lolium* spp., *Poa* spp., *Festuca* spp., and *Bromus* spp. Soil type is usually heavy, clay and dark brown. Most are leveled to permit irrigation, and bordered or fenced; the grass is either grazed in the season or cut for winter use.

Soil sample locations were at approximately 10 km intervals. Each sample included soil plugs taken from 10 different points, 20 m apart, in an area of about 4000 m^2 by using a garden spade to a depth of 25-30 cm. A sub-

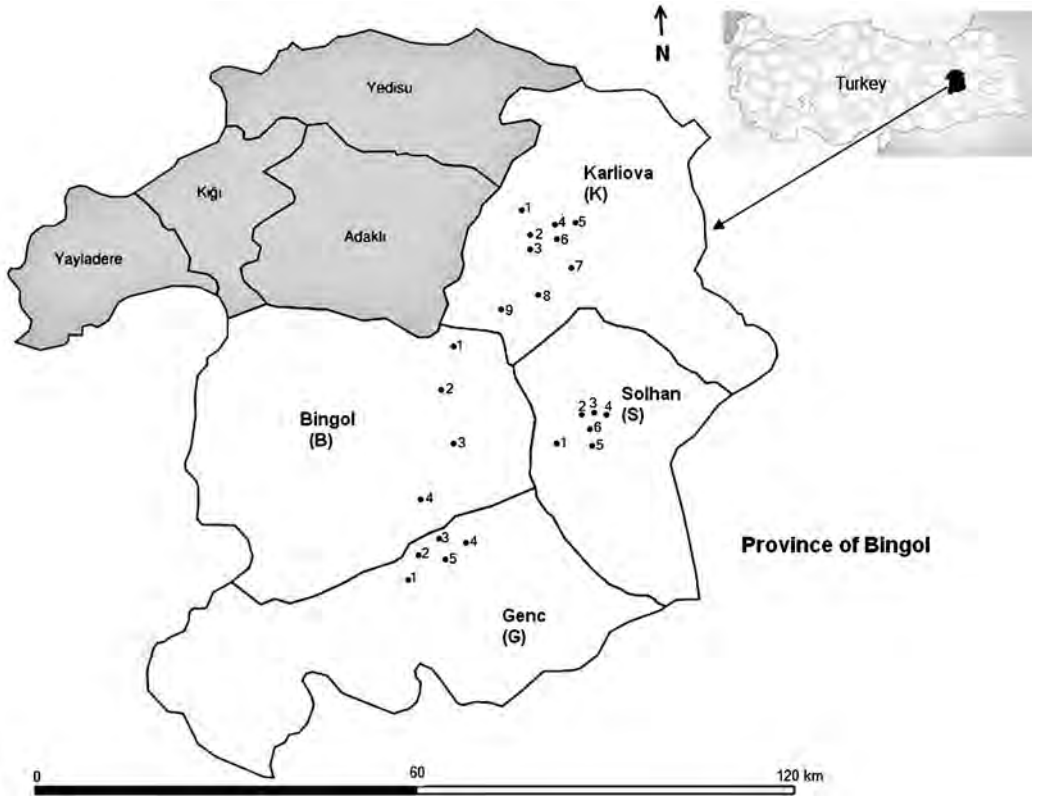

Fig. 1. Sampled locations of the districts and position of Bingol province in Turkey.
B, Bingol; G, Genc; K, Karliova; S, Solhan.

sample of one dm^3 soil was then taken to the laboratory for processing.

Nematodes were extracted from 100 cm^3 of soil by using a modified "Petri-dish" Baermann funnel method. Collected nematodes were transferred to graduated cylinders, allowed to settle for 6 hours and then placed in 15 ml tubes. Nematodes were counted under a light microscope at 100× magnification and identified to the genus level. Their incidence and abundance were expressed as a percentage of their occurrence in the studied sites and as number of nematodes/100 cm^3 of soil, respectively. After recording their incidence and abundance, nematodes were heat killed at 70-75 °C for 45 seconds and fixed in TAF (Hooper, 1986). Preserved specimens were transported to the USDA, ARS Nematology Laboratory, embedded in anhydrous glycerin and mounted on wax-circled glass slides. Nematodes were identified to species by morphological analysis using the most recent taxonomic keys (Handoo and Golden, 1989; Handoo, 2000; Siddiqi, 2000; Handoo *et al.*, 2007). Morphological observations and measurements were made with a Leitz DMRB compound microscope provided with an ocular micrometer.

The incidence of a given taxon was calculated as the percent occurrence of a particular taxon in the samples using the following equation: Incidence = (samples containing the taxon/total sample numbers) × 100. Abundance of a given taxon indicates the number of the taxon in a 100 cm^3 portion of a given sample. Since pastures are infrequent in Bingol and Genc districts, a comparison of nematode abundance values between rangelands and pastures was limited to the sampled sites in Karliova and Solhan districts, where pastures are more common than rangelands.

The data were subjected to analysis of variance to determine significance levels of the difference between the means of nematode abundances among the sampled districts.

A total of 22 species and thirteen genera of nematodes were identified from the pastures in the four different districts of Bingol province. Nematodes found and their associated locations are given in Table I.

The study revealed that *Helicotylenchus platyurus* and *Pratylenchus thornei* are the most common species with 90% and 89% incidence, respectively, and also the most abundant species across the sampled sites. The abundance of *H. platyurus* and *P. thornei* in 100 cm^3 soil was in the range 40-650 and 30-2,700 individuals, respectively. The distribution of *H. platyurus* was uniform in Karliova, Bingol and Genc districts but in Solhan had lower abundance values. *Pratylenchus thornei* also had similar distribution features, but was the most abundant in Genc pasture soils (Table II).

Helicotylenchus was represented by the three species *H. varicaudatus, H. carolinensis* and *H. platyurus*. Among them, *H. platyurus* was the dominant species

Table I. Nematode species and associated locations in districts of Bingol Province, Turkey.

Nematode	Associated location*
Ditylenchus microdens Thorne *et* Malek, 1968	*B-1, G-3, K3*
Filenchus sp. Andrássy, 1954	*B-2, B-3, G-1, G-3, K-2, K-7*
Helicotylenchus carolinensis Sher, 1966	*K-3*
H. platyurus Perry, 1959	*B-1, B-2, B-3, B-4, G-1, K-2, K-4, K-5, K-6, K-7, K-8, S-1, S-2*
H. varicaudatus Yuen, 1964	*G-5*
Longidorus sp. Micoletzky, 1922	*K-7, G-3*
Meloidogyne sp. Göldi, 1892	*K-3*
*Merlinius bavaricus (*Sturhan, 1966) Siddiqi, 1970	*G-1, K-8*
M. brevidens (Allen, 1955) Siddiqi, 1970	*B-2, G-3, K-6, K-7*
Merlinius sp. Siddiqi, 1970	*K-1*
Paratrophurus sp. Arias, 1970	*K-1, K-2*
Paratylenchus tenuicaudatus Wu, 1961	*G-3, G-*
Paratylenchus sp. Micoletzky, 1922	*G-3, G-4*
Pratylenchoides erzurumensis Yüksel 1977	*B-3, S-1*
Pratylenchus crenatus Loof, 1960	*K-3*
P. thornei Sher *et* Allen, 1953	*4B-2, B-3, B-4, G-1, G-4, G-5, K-2, K-4, K-5, K-6, K-7, S-1*
Sauertylenchus maximus (Allen, 1955) Siddiqi, 2000	*B-1, G-5, K-9, K-10*
Tylenchorhynchus brassicae Siddiqi, 1961	*K-6*
Trophurus sp. Loof, 1956	*B-2, G-1, K-2*
Tylenchus exiguus de Man, 1876	*G-1, G-3,K-2, K-4, K-7, S-1*
Xiphinema index Thorne *et* Allen, 1950	*K-4, K-5*
X. pachtaicum (Tulaganov, 1938) Kirjanova, 1951	*K-7*

*B, Bingol; G, Genc; K, Karliova; S, Solhan.

across the sampled sites (Table I). *Helicotylenchus varicaudatus* had been reported from Turkey by Evlice and Okten (2008) in pear orchards in Ankara district. *Pratylenchus* was represented by two species, *P. crenatus* and *P. thornei*. *Pratylenchus thornei* was the most widespread and abundant species throughout the study area. *Meloidogyne* sp. was found only in one site (number 3) very close to a river in Karliova district and at a very low density (3 J2/100 cm^3 soil). *Meloidogyne* spp. are not frequently encountered nematodes in natural and dry land agricultural areas in Turkey, but they are widespread in coastal greenhouses and in the main vegetable growing areas close to rivers (Devran and Sogut, 2009; Yildiz and Elekcioglu, 2011).

Sauertylenchus maximus (= *Tylenchorhynchus maximus* or *Bitylenchus maximus*) is another important plant-parasitic nematode not commonly encountered in Turkey. It was first reported by Saltukoglu (1974) from the Istanbul region of northwest Turkey. Its detection is a new record from the eastern Anatolian temperate pastures in Bingol. *Merlinius brevidens* is another widespread stunt nematode, but not in high numbers. Other nematode genera, such as *Paratylenchus*, *Ditylenchus, Filenchus*, *Longidorus*, *Trophurus*, *Xiphinema* and *Paratrophurus* (Table II), occurred in low numbers. The detections of *H. platyurus, H. carolinensis* and *Paratylenchus tenuicaudatus* are new records for Turkey.

The cumulative abundance and incidence values of the detected nematodes in rangelands and pastures were similar in Bingol, Genc and Karliova districts and smaller in Solhan district (Table II). The values of these indices appeared to be greater in rangelands than pastures in Karliova and Solhan districts (Table III). The more diverse plant composition of rangelands may have favoured a more diverse nematode fauna with greater densities than that in pastures (Yeates, 1999; Yildiz and Elekcioglu, 2011). Lesion (especially *Pratylenchus thornei*), spiral (*Helicotylenchus* spp.) and stunt (*Merlinius* spp., *Tylenchorhynchus* spp.) nematodes were widespread and abundant species in pastoral areas of eastern Turkey, similar to nematode inhabitants of other pastures with distant geography and dissimilar climate

Table II. Mean population abundance and incidence of nematodes in districts of Bingol province.

Nematode genus	Abundance[1] (Nematodes/100 cm^3 soil)				P*	Incidence (%)[2]			
	B[2]	G	K	S		B	G	K	S
Ditylenchus	7±2ab	13±2a	5±2b	3±2b	*	23	54	43	13
Filenchus	10±3b	16±4a	7±4b	10±2b	*	25	60	11	31
Helicotylenchus	245±13a	264±12a	204±12ab	70±7b	*	100	100	89	83
Longidorus	5±3b	12±3a	9±4ab	0±0c	*	25	40	22	0
Meloidogyne	0±0b	0±0b	3±3a	0±0b	*	0	0	11	0
Merlinius	70±7b	124±7a	118±13a	60±8b	*	75	100	100	83
Paratrophurus	0±0b	0±0b	47±6a	0±0b	*	0	0	33	0
Paratylenchus	10±3c	108±10a	29±6c	57±6b	*	25	100	56	33
Pratylenchoides	5±2b	64±7a	2±3b	0±0b	*	25	54	0	0
Pratylenchus	265±13ab	1100±38a	109±10b	37±6c	*	100	100	100	67
Trophurus	7±3b	15±4ab	24±4a	3±2b	*	12	37	26	0
Tylenchorhynchus	47±6b	63±9ab	71±4a	2±1b	*	31	25	55	0
Tylenchus	100±12b	152±7a	131±9ab	107±10b	*	75	100	100	83
Xiphinema	0±0b	4±2ab	11±4a	0±0b	*	0	20	33	0

[1]Abundance: Number of nematodes found in all samples. [2]B, Bingol; G, Genc; K, Karliova; S, Solhan.
[2]Incidence: % of occurrence in the samples.
*Significant at P<0.05.

(Valdez, 1976; Bernard *et al*., 1998; Talavera and Navas, 2002; Stirling and Lodge 2005).

In conclusion, we understand the limitations of this study since the morphological identification of the species of plant-parasitic nematodes was not corroborated by molecular analyses. However, the data presented provide a good indication of the predominant damaging nematodes in forage land of eastern Turkey. These data also indicate that very serious pests of forage crops, such as root-knot nematodes (*Meloidogyne* sp.) and cyst-forming nematode parasites of forage legumes (*Heterodera trifolii*) are uncommon or absent in the sampled areas.

Table III. Nematode abundance (Nematodes/100 cm^3 soil) in rangelands and pastures in Karliova and Solhan districts.

Nematode genus	Karliova		P*	Solhan		P
	P[1]	RL		P	RL	
Filenchus	171±12a	37±6b	*	142±9	21±6	*
Helicotylenchus	237±12a	90±11b	*	75±6	60±9	NT
Longidorus	11±4a	0±0b	*	0±0	0±0	-
Merlinius	143±14a	30±4b	*	85±8	10±4	*
Paratrophurus	9±3a	0±0b	*	0±0	0±0	-
Paratylenchus	37±6a	0±0b	*	70±8	20±3	*
Pratylenchoides	3±3a	0±0a	*	0±0	0±0	-
Pratylenchus	123±11a	60±9b	*	40±2	30±1	NT
Trophurus	5±4a	1±1b	NT	1±1	1±1	NT
Tylenchorhynchus	7±1a	3±1b	NT	3±1	1±1	NT
Tylenchus	154±9a	50±4b	*	130±11	60±3	*
Xiphinema	9±5b	20±4a	NT	0±0	0±0	-

[1]P = pastures, RL = rangelands. *: P<0.05, NT: Not Significant.

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