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Community structure of nematodes in olive growing areas in İzmir, Manisa, Balıkesir, and Çanakkale provinces, Türkiye

Türkiye'de İzmir, Manisa, Balıkesir ve Çanakkale illerinde zeytin alanlarındaki nematodların komünite yapısı

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ABSTRACT

In this study, we aimed to determine the nematode diversity in soils from olive orchards in İzmir, Manisa, Çanakkale, and Balıkesir provinces. For this purpose, a survey was carried out in 2021-2022; in each orchard, soil samples were collected from 0-60 cm depth, and nematodes were extracted from collected soils by the modified Baermann Funnel method. Thirty-seven genera of nematodes (*Achromodora, Acrobeles, Acrobeloides, Alaimus, Aphelenchus, Aphelenchoides, Boleodorus, Cephalobus, Clarkus, Coslenchus, Ditylenchus, Dorylaimus, Eucephalobus, Filenchus, Geocenamus, Hemicriconemoides, Helicotylenchus, Labronema, Lelenchus, Longidorus, Mesocriconema, Mesodorylaimus, Mesorhabditis, Monhystera, Panagrolaimus, Paratylenchus, Pratylenchus, Pratylenchoides, Psilenchus, Rhabditis, Rotylenchulus, Rotylenchus, Saurtylenchus, Tripyla, Tylenchorhynchus, Tylenchus, Xiphinema*) from 21 families were identified in olive-growing areas. According to feeding habitats, nematodes were classified as plant parasitic (19 genera and one plant-parasitic species from fungivore *Ditylenchus* genera), bacterivores (11 genera), fungivores (3 genera), omnivores (2 genera), and predators (2 genera). Plant-parasitic 27 nematode species (İzmir: 19; Manisa: 16; Balıkesir 15; Çanakkale: 11) were found in soils. The virus vector *Longidorus elongatus* was among the identified important species. The prevalent plant-parasitic species were *Geocenamus brevidens* (32%), *Filenchus thornei* (23%), *Helicotylenchus digonicus* (29%), while the free-living nematodes were *Acrobeloides* spp. (100%*), Aphelenchus* sp. (95.3 %), *Cephalobus* spp. (97%), and *Mesodorylaimus* (91.2%). Within bacterivore nematodes, at least one species from the Cephalobidae family was determined in all soil samples.

Key Words: Nematode fauna, Olive, Türkiye

ÖZ

Bu çalışmada İzmir, Manisa, Çanakkale ve Balıkesir illerinde zeytin bahçelerindeki topraklarda nematod çeşitliliğinin belirlenmesi amaçlanmıştır. Bu amaçla 2021-2022 yılları arasında sürvey yapılmış, her bahçede 0-60 cm derinlikten toprak örneği alınmış ve alınan toprak örneklerinden nematodlar modifiye Baermann Funnel metoduyla izole edilmiştir. Zeytin alanlarında 37 cinse (*Achromodora, Acrobeles, Acrobeloides, Alaimus, Aphelenchus, Aphelenchoides, Boleodorus, Cephalobus, Clarkus, Coslenchus, Ditylenchus, Dorylaimus, Eucephalobus, Filenchus, Geocenamus, Hemicriconemoides, Helicotylenchus, Labronema, Lelenchus, Longidorus, Mesocriconema, Mesodorylaimus, Mesorhabditis, Monhystera, Panagrolaimus, Paratylenchus, Pratylenchus, Pratylenchoides, Psilenchus, Rhabditis, Rotylenchulus, Rotylenchus, Saurtylenchus, Tripyla, Tylenchorhynchus, Tylenchus, Xiphinema*) ait nematod türleri teşhis edilmiştir. Nematodlar beslenme şekillerine göre bitki paraziti (19 cins ve fungivor *Ditylenchus* cinsinden bitki paraziti 1 tür), bakterivor (11 cins), fungivor (3 cins), omnivor (2 cins) ve predatör (2 cins) olarak sınıflandırılmıştır. Topraklarda 27 bitki paraziti nematod türü (İzmir: 19; Manisa: 16; Balıkesir 15; Çanakkale: 11) saptanmıştır. Virüs vektörü *Longidorus elongatus* teşhis edilen önemli türler arasında yer almıştır. Yaygın bitki

paraziti türler, *Geocenamus brevidens* (32%), *Filenchus thornie* (23%) ve *Helicotylenchus digonicus* (29%) olurken serbest yaşayan nematodlarda ise *Acrobeloides* spp. (100%*),* Aphelenchus sp. (95.3 %), *Cephalobus (*97%) ve *Mesodorylaimus* spp. (91.2%) olarak belirlenmiştir. Bakterivor nematodlardan Cephalobidae familyasından en az 1 tür tüm toprak örneklerinde saptanmıştır.

Anahtar Kelimeler: Nematod faunası, Zeytin, Türkiye

Introduction

Oleaceae is one of the most prominent families of plants growing on earth, with 600 trees and shrubs in 30 genera. The family contains an economically important genus Olea, and *Olea europaea* L. is the only species consumed as food (Hashmi et al., 2015). The fruit of this tree, called the olive, first domesticated in the Middle East hundreds of years ago, is either consumed fresh as food or used to produce olive oil (Breton et al., 2009). Olive fruit and leaves are also used in the medicine, cosmetics, and cleaning products industries. This fruit is rich in phenolic acids, phenolic alcohols, and flavonoids and nowadays mostly consumed because of the higher antioxidant content and health benefits. The olive oil produced by pressing berries is a primary food in people's daily consumption.

Olive is mainly grown by farmers in Mediterranean countries, and about 95% of the olive groves in the world are located in the Mediterranean basin. From these countries, Spain, Morocco, Italy, Greece, and the United States come to the fore regarding total production (Mushtaq et al., 2020). Türkiye ranks fourth among olive producers and ranks sixth in the point of area (in hectares) worldwide. Türkiye contributes almost eight percent of the world's olive production, according to Fao (2019). Except for Eastern Anatolia and Central Anatolia regions, olive cultivation is carried out in 36 provinces, and the total production area constitutes 2% of the country's agricultural area. About 76% of the production in the country is done in the Aegean, 14% in the Mediterranean, 5.7% in Marmara, 4% in Southeast Anatolia, and 0.3% in the Black Sea regions (Efe et al., 2013).

The soil fauna contains dozens of different organisms like insects, tardigrades, and fungi, and nematodes from Phylum Nematoda occupy a significant portion. The identified 25.000 nematodes belonged to 2.271 genera and 256 families. The unnamed species are estimated as hundreds, and approximately 365 are identified and named yearly (Anderson, 2000; Hodda, 2011). These organisms have different feeding habitats and are divided into five trophic groups: omnivores, predators, fungivores, bacterivores, and plant-parasitic herbivores (Kennedy and Luna, 2005).

Soil microfauna of olive orchards includes a wide variety of nematodes, and one can be found in any soil anywhere in the world (Kennedy and Luna, 2005). These can be parasitic or nonparasitic free living. Of these, some plant-parasitic species cause root damage and prevent plants from taking up water and nutrients from the soil, while some species play a role in the transmission of virus diseases. For this reason, some are included in the nursery certification system and on the quarantine lists. The initial impact of these pests may not be severe at first, but feeding for several years can cause significant plant damage and yield loss (De Klerk and Loubser, 1988). Additionally, root wound areas may be an entrance pathway for various fungal and bacterial plant pathogens. For instance, *Verticillium dahliae*, a severe disease of olive whose prevalence is 55% in the Aegean region, causes more severe epidemics with the presence of nematodes such as *Pratylenchus vulnus* and *Meloidogyne* spp. (Yolageldi, 2002). Again, diseases like bacterial cancer can remain pathogenic in the soil for about 15 years and may enter healthy trees through wounds in plant roots that emerge after nematode feeding (Gardan et al., 1992).

In contrast, free-living nematodes constitute 52% of all nematodes on the earth and likewise occupy a more prominent place in olive orchards in the point of population. Free-living bacterivorous nematodes play an essential role in

the mineral cycle and can feed on many bacterial species, including plant pathogens. Fungivorous nematodes can also feed on many fungal plant pathogens, such as *Fusarium* sp. and *Botrytis* sp., while predators can suppress pests' populations by feeding (Taher et al., 2017).

The distribution, survival, abundance, and reproduction of nematodes highly depend on the climate and local factors. The area infested by nematodes is regularly increasing by tillage, wind, flooding, soil, and infected rootstock cultivation. Despite the increase in prevalence, many species remain undiagnosed. Across the world, 153 plant-parasitic species belonging to 56 genera from orders Aphelenchida (4 genera/3 species), Dorylaimida (5 genera/36 species), and Tylenchida (48 genera/114 species) co-infest olive production areas. Four genera, including *Mesocriconema, Helicotylenchus, Meloidogyne, Xiphinema,* and *Pratylenchus*, were reported as most harmful because of causing moderate to high damage depending on population density, host susceptibility, and environmental conditions (Ali et al., 2014).

Studies on nematodes and their trophic structure in olive-growing areas are limited. Although there is data on some plant parasitic species, the free-living non-parasitic species are not well known. There needs to be more information on the status of nematode biodiversity in the western provinces of Türkiye. Therefore, a two-year research focused on determining the nematode diversity of olive orchards was conducted in Çanakkale, Manisa, Balıkesir, and İzmir provinces. The community structure (trophic groups of nematodes, diversity of free-living species, abundance) of surveyed olive plantations has been discussed.

Material and Method

A survey in olive orchards and soil sampling

The study was carried out between 2021 (October) and 2022 (October) in olive orchards in the four biggest olive-producer provinces in Marmara (Balıkesir and Çanakkale provinces) Region and Aegean Region (Manisa and İzmir provinces). These provinces are located in the western part of the country, and their olive grove acreage (Balıkesir: 83.612 ha; İzmir: 112.752 ha; Çanakkale: 32.645 ha; İzmir: 93.677 ha) constitutes 36.2% of the total area of Türkiye. During the survey period, the air temperature in four provinces was 19-24 degrees, and the precipitation was 35-70 mm. Randomly selected 77 orchards were sampled. Gemlik, Domat, and Ayvalık olive varieties were primarily grown in surveyed areas.

Table 1. Olive orchard area details of İzmir, Manisa, Balıkesir, and Çanakkale provinces

Olive orchard	Locations	Total production area (ha)	Samples per location	Total samples
İzmir	Kemalpaşa	5.896	4	15
	Bayındır	16.427	4	
	Torbalı	7.025	3	
	Ödemiş	6.026	4	
Manisa	Soma	71.480	6	26
	Akhisar	45.100	5	
	Şehzadeler	2.570	3	
	Kırkağaç	12.200	6	
	Saruhanlı	10.500	6	
Çanakkale	Ayvacık	17.150	3	15
	Bayramiç	4.056	2	
	Bozcaada	179	3	
	Merkez	1.861	3	
	Ezine	11.798	4	
Balıkesir	Burhaniye	18.196	5	21
	Ayvalık	17.300	5	
	Gömeç	11.550	3	
	Havran	8.012	3	
	Edremit	20.128	5	

The soils were taken from the rhizosphere canopy of trees at a soil depth of 0-60 cm, and in each orchard, 1 kg of soil was arranged by mixing subsamples. At least six subsamples were collected from different points in each orchard by moving in a zigzag pattern. A total of 77 soil samples were taken from the survey area. The soil samples were placed in polyethylene bags, labelled, and stored in suitable conditions to prevent moisture loss.

Nematode recovery and identification

Approximately 100 cm^3 of soil was used from each sample to extract nematodes with the modified Baermann Funnel method. In this method, soil samples were placed on sieves with a single layer of filter paper. Sieves were placed in trays, water was added until soils were wet, and nematodes were allowed to submerge within 24 hours. The suspension was poured onto the 400 mesh sieve in the final step, and nematodes were collected. The counting of nematodes was made from 1 ml of the extracted suspension at 20X magnification under the microscope.

All of the plant parasitic nematodes were named based on species, and the free-living species, except for the families Anguinidae, Aphelenchida, and Aphelenchoididae, were defined based on a genus. Nematodes were identified by examining individuals' morphological and morphometric features under the microscope. Published identification keys and descriptions were used in order to determine genera and species. In order to prepare nematode slides, heat-killed females were fixed in TAF (7 ml 40% formaldehyde + 2 ml triethanolamine + 91 ml), Seinhorst 1 (1 part glycerin + 79 parts distilled water), Seinhorst II (5 parts glycerin + 95 parts ethanol) solutions. Processed nematodes were fixed on a glycerin-dropped wax ring placed on the center of the slide. (Seinhorst, 1959).

Extracted nematodes were classified based on Siddiqi (2000). Additionally, the species' feeding habitat, feeding source, and colonizer-persister values were determined (Bongers 1990; Yeates et al. 1993). The absolute frequency of species was calculated with the formula: Number of soil samples containing species/Total number of soil samples×100 (Norton 1978).

Results and Discussion

Community structure of nematodes in olive orchards

Nematode species in olive orchards in survey areas were classified into five trophic groups, and the biodiversity compromised 37 genera of nematodes (fungivores, bacterivores, omnivores, predators, and plant-parasitic) from 22 families and eight orders. They were divided into two groups free-living (bacterivore, fungivore, omnivore and predator) and plant parasites.

Plant-parasitic and bacterial feeders displayed higher abundance in sampled orchards, followed by omnivores, fungal feeders, and predators (Figure 1). At least one bacterivore species was present in all collected samples. The bacterivore, fungivore, omnivore, predator, and plant-parasitics constitute 11, 3, 2, 2, and 20 genera (including one species from Ditylenchus), respectively. The leading nematodes in İzmir, Manisa, Balıkesir, and Çanakkale were plant-parasitic, followed by bacterivore and fungivore species. They constituted nearly half of all collected species. As seen in Figure 1, the ratio of plant-parasitic species among all nematodes in all the orchards was around 50%. The least abundant were predators, with one or two species recovered from soils.

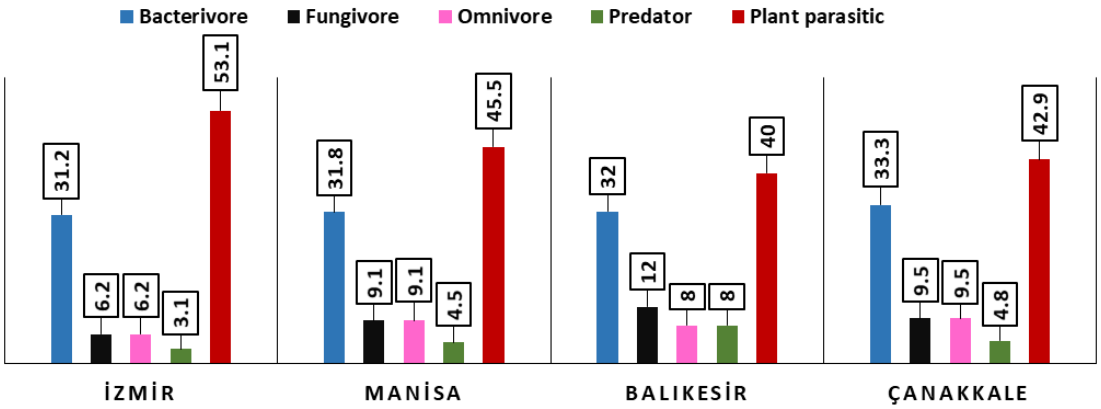

Figure 1. The % proportion of nematode genera detected in İzmir, Manisa, Çanakkale, and Balıkesir provinces by trophic groups.

Free-living nematodes in olive orchards

In this research, free-living nematodes belonging to 18 genera, 12 families, and 8 orders were extracted from soils collected from olive orchards. The identified free-living omnivore, fungivore, bacterivore, and predator nematodes belonged to Dorylaimida, Chromadorida, Rhabditida, Aphelenchida, Mononchida, Monhysterida, and Triplonchida orders (Table 2). The predominant orders were Tylenchida, Aphelenchida, and Rhabditida. *Acrobeloides* spp. was the most common genus occurring in 100% of studied orchards. In addition, free-living nematodes were classified into 1, 2, 3, and 4 groups according to their corresponding c-p (colonizer-permanent) values. While species in the c-p2 class were dominant in all provinces, no species from c-p5 were found. (Figure 2).

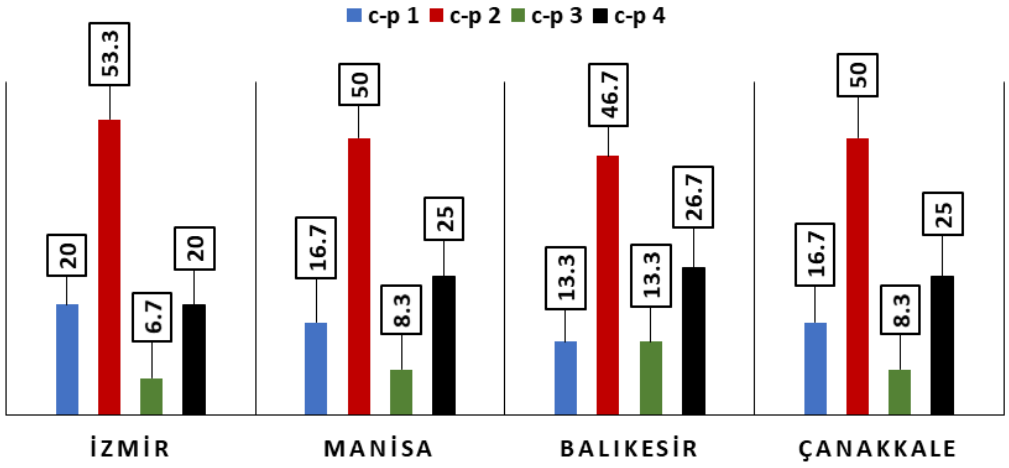

Figure 2. % Proportion of free-living nematodes in terms of colonizer-persister values

Table 2. Omnivore, fungivore, bacterivore, and predator nematodes genea and species identified in olive orchards in Western Türkiye

	Families	**Order**	**Functional guild/c-p**	**Absolute frequency in all samples (%)**	**İ**	M	**B**	**Ç**
Alaimus De Man, 1880	Alaimidae	Dorylaimida	ba2	11.6	+	-	-	+
Achromadora Cobb, 1913	Achromadoridae	Chromadorida	ba3	4.6	-	-	+	-
Acrobeloides Cobb, 1924	Cephalobidae	Rhabditida	ba2	100	+	+	+	+
Acrobeles von Linstow, 1877	Cephalobidae	Rhabditida	ba2	81.8	+	+	+	+
Aphelenchus avenae Bastian, 1865	Aphelenchidae	Aphelenchida	fu2	95.3	+	+	+	+
Aphelenchoides sacchari Fischer, 1894	Aphelenchoididae	Aphelenchida	fu2	13.4	+	-	-	-
Aphelenchoides obtusus Thorne and Malek, 1968	Aphelenchoididae	Aphelenchida	fu2	3.5	-	-	+	-
Aphelenchoides clarus Thorne and Malek, 1968	Aphelenchoididae	Aphelenchida	fu2	2.9	+	-	-	-
Cephalobus Bastian, 1865	Cephalobidae	Rhabditida	ba2	97	+	+	+	+
Clarkus Jairajpuri, 1970	Mononchidae	Mononchida	pr4	13.4	+	+	+	+
Dorylaimus Dujardin, 1845	Dorylaimidae	Dorylaimida	om4	10.5	+	+	+	+
Ditylenchus myceliophagus Goodey, 1958	Anguinidae	Tylenchida	fu2	45	-	+	+	+
Ditylenchus parvus Zell, 1988	Anguinidae	Tylenchida	fu2	2.3	-	+	+	-
Eucephalobus Steiner, 1936	Cephalobidae	Rhabditida	ba2	28.6	+	-	-	-
Labronema Thorne, 1939	Dorylaimidae	Dorylaimida	pr4	0.6	-	-	+	-
Mesorhabditis Osche, 1952	Rhabditidae	Rhabditida	ba1	12.2	+	+	+	+
Mesodorylaimus Andrassy 1959	Dorylaimidae	Dorylaimida	om4	91.2	+	+	+	+
Monhystera Bastian, 1865	Monhysteridae	Monhysterida	ba2	7.6	+	+	+	-
Panagrolaimus Fuchs, 1930	Panagrolaimidae	Rhabditida	ba1	5.2	+	-	-	-
Rhabditis Dujardin, 1845	Rhabditidae	Rhabditida	ba1	61.9	+	+	+	+
Tripyla Bastian, 1865	Tripylidae	Triplonchida	ba3	16.3	+	+	+	+

b**a:** bacterivore **fu:** fungivore **om:** omnivore **pr:** predator İ: İzmir M: Manisa B: Balıkesir Ç: Çanakkale

When the number of free-living individuals in 100 cm^3 soil was counted, *Acrobeloides, Cephalobus*, and *Mesodorylaimus* genera were determined as more abundant (Table 3). The abundance of all genera was under 25 individuals/100 cm^3 soil.

Table 3. The mean abundance of free-living nematodes in 100 cm^3 soil

Species/genera	İZMİR	MANİSA	BALIKESİR	ÇANAKKALE
Alaimus De Man, 1880	1.7±0.7	0	0	2±0.8
Achromadora Cobb, 1913	0	0	3.3±0.9	0
Acrobeles von Linstow, 1877	3.3±1.8	5.2±1.7	2±0.8	4.9±2.2
Acrobeloides Cobb, 1924	18.2±4.7	15.4±3.3	8.7±1.8	2±0.6
Aphelenchus avenae Bastian, 1865	10.1±2	7.8±1.7	7±1.6	4±0.8
Aphelenchoides sacchari Fischer, 1894	6.5±1.7	0	0	0
Aphelenchoides obtusus Thorne and Malek, 1968	0	0	3.3±0.47	0
Aphelenchoides clarus Thorne and Malek, 1968	3.8±0.7	0	0	0
Cephalobus Bastian, 1865	18±3.1	24±2	11.8±1.6	14.3±1.1
Clarkus Jairajpuri, 1970	3.2±0.4	4.2±0.8	4.6±0.5	4±0.9
Dorylaimus Dujardin, 1845	9.6±0.9	5.1±0.6	4.7±0.7	3.8±0.6
Ditylenchus myceliophagus Goodey, 1958	0	13.1±1.3	7.5±0.9	5.2±1
Ditylenchus parvus Zell, 1988	0	4.1±0.7	3.7±0.4	0
Eucephalobus Steiner, 1936	4.2±0.7	0	0	0
Labronema Thorne, 1939	0	0	2	0
Mesorhabditis Osche, 1952	4.8±1.2	5.3±1.1	8.8±1.6	6.8±1.1
Mesodorylaimus Andrassy 1959	20.3±2.8	14.6±2.8	10.3±1.6	11±1.7
Monhystera Bastian, 1865	3.7±0.4	3±0.8	3.3±0.7	0
Panagrolaimus Fuchs, 1930	3.7±0.9	0	0	0
Rhabditis Dujardin, 1845	7.4±1.5	5.2±0.6	4.2±0.6	4.7±1.1
Tripyla Bastian, 1865	4±0.8	3.4±0.9	5.1±1.4	3.6±0.5

Plant parasitic nematodes in olive orchards

Twenty-seven plant-parasitic species were recovered in the survey areas. Of these, 73 % (19 species) were found in İzmir, 61.5% (16 species) in Manisa, 57.7% (15 species) in Balıkesir, and 42.3 % (11 species) in Çanakkale. The identified species belonged to nine families (Boleodorinae, Belonolaimidae, Criconematidae, Hoplolaimidae, Longidoridae, Paratylenchidae, Pratylenchidae, Telotylenchidae, and Tylenchidae) and two orders (Tylenchida and Dorylaimida). The majority (25 species) were from the Tylenchida order. *Pratylenchus* (2 species), *Filenchus* (4 species), and *Helicotylenchus* (4 species) genera came to the fore in terms of the number of species present in the areas we surveyed. On the contrary, in a previous study in Türkiye, 19 Tylenchid species were identified in the Central, Mediterranean, and Black Sea Regions (Cilbirlioğlu, 2007).

The nematodes were divided into a migratory ectoparasite, endoparasite, and microherbivores according to their feeding strategies. Ectoparasitic nematodes were prominent, microherbivorous nematodes were present except Çanakkale, while semi-endoparasites were found only in İzmir, Balıkesir, and Çanakkale. (Figure 3).

Furthermore, nematodes in orchards were species from 2, 3, and 5 colonizer-persister groups. The ratios of c-p2, c-p3, and c-p5 groups in all detected nematode species were 40.7%, 51.8%, and 7.4%, respectively. Nematodes from c-p 5 were found in İzmir but not in Manisa, Çanakkale and Balıkesir (Figure 4).

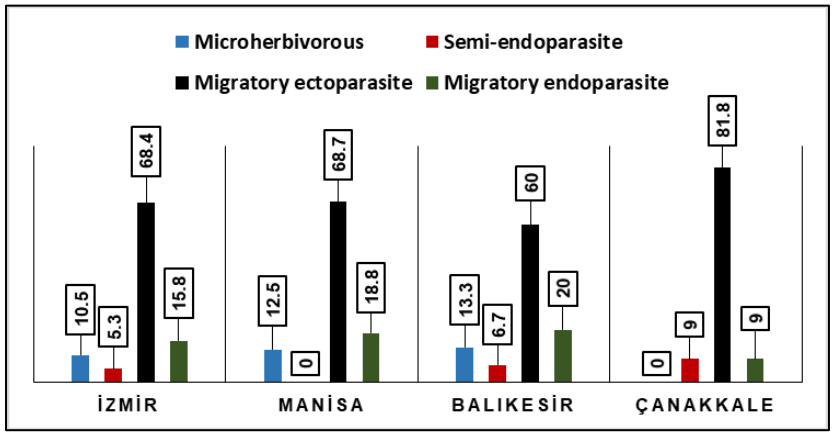

Figure 3. % Proportion of plant-parasitic nematode species classified based on feeding style

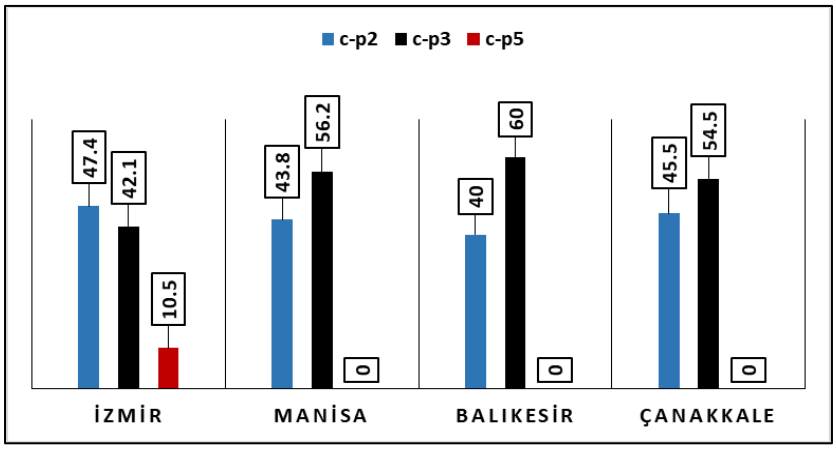

Figure 4. % Proportion of plant-parasitic nematodes in terms of colonizer-persist

However, in this study, some of the detected nematode species (*Boleodorus thylactus, Coslenchus turkeyensis, Filenchus sheri, F. clarus, F. filiformis, F. cylindricus, Tylenchus davainei, Lelenchus leplosoma, Psilenchus hilarulus*) were root-fungal feeders in terms of feeding habitat and the rest were plant feeders. The classification of identified species is given in Table 4.

Table 4. Plant-parasitic nematodes species identified in olive orchards in Western Türkiye

Species	Families	Order	c-p	Feeding Strategy	Absolute frequency in all samples (%)	İ	M	B	Ç
Coslenchus turkeyensis Siddiqi, 1981	Tylenchidae	Tylenchida	2	Microherbivorous	6.5	+	-	-	-
Boleodorus thylactus Thorne, 1941	Boleodorinae	Tylenchida	2	Migratory ectoparasite	18.2	+	+	+	+
Ditylenchus dipsaci Kühn,1857	Anguinidae	Tylenchida	2	Migratory endoparasite	10.4	+	-	-	-
Filenchus thornei (Andrassy, 1954) Andrassy, 1963	Tylenchidae	Tylenchida	2	Migratory ectoparasite	23	+	+	+	+
Filenchus sheri (Khan and Khan, 1978) Siddiqi, 1986	Tylenchidae	Tylenchida	2	Migratory ectoparasite	14.3	+	+	+	+
Filenchus cylindricus (Thorne and Malek) Niblack and. Bernard	Tylenchidae	Tylenchida	2	Migratory ectoparasite	9	+	+	-	+
Filenchus filiformis Ebsary, 1991	Tylenchidae	Tylenchida	2	Migratory ectoparasite	9	-	+	+	-
Geocenamus brevidens (Allen, 1955) Siddiqi, 1970	Telotylenchidae	Tylenchida	3	Migratory ectoparasite	32	+	+	+	+
Helicotylenchus digonicus Perry in Perry, Darling & Thorne, 1959	Hoplolaimidae	Tylenchida	3	Migratory ectoparasite	29	+	+	+	+
Helicotylenchus dihystera (Cobb, 1893), Sher, 1961	Hoplolaimidae	Tylenchida	3	Migratory ectoparasite	14.3	-	+	-	-
Helicotylenchus varicaudatus Yuen, 1964	Hoplolaimidae	Tylenchida	3	Migratory ectoparasite	7.8	-	+	+	-
Helicotylenchus tunisiensis Siddiqi, 1963	Hoplolaimidae	Tylenchida	3	Migratory ectoparasite	10.4	-	-	+	-
Hemicriconemoides gaddi (Loos, 1949) Chitwood & Birchfield, 1957	Criconematidae	Tylenchida	3	Migratory ectoparasite	3.9	+	+	-	-
Lelenchus leprosoma de Man, 1880	Tylenchidae	Tylenchida	2	Migratory ectoparasite	1.3	+	-	-	-
Longidorus elongatus (de Man, 1876) Micoletzky, 1922	Longidoridae	Dorylaimida	5	Migratory ectoparasite	1.3	+	-	-	-
Mesocriconema xenoplax Raski, 1922, Loof and De Grisse, 1989	Criconematidae	Tylenchida	3	Migratory ectoparasite	7.8	-	-	+	-
Paratylenchus nawadus Khan, Prasad & Mathur, 1967	Paratylenchidae	Tylenchida	2	Migratory ectoparasite	3.9	+	-	-	+
Pratylenchoides alkani Yüksel, 1977	Pratylenchidae	Tylenchida	3	Migratory endoparasite	14.2	+	+	+	+
Pratylenchus neglectus Filipjev & Stekhoven, 1941	Pratylenchidae	Tylenchida	3	Migratory endoparasite	13	+	+	+	-
Pratylenchus thornei Sher & Allen, 1953	Pratylenchidae	Tylenchida	3	Migratory endoparasite	10.4	-	+	+	-
Psilenchus hilarulus deMan, 1921	Tylenchidae	Tylenchida	2	Microherbivorous	6.5	+	+	+	-
Rotylenchus cypriensis Antoniou, 1980	Hoplolaimidae	Tylenchida	3	Migratory ectoparasite	7.8	-	-	-	+
Rotylenchulus macrosoma Dasgupta et al., 1968	Hoplolaimidae	Tylenchida	3	Semi-endoparasite	23.3	+	-	+	+
Sauertylenchus maximus Allen, 1955	Telotylenchidae	Tylenchida	3	Migratory ectoparasite	1.9	+	-	-	-
Tylenchorhynchus cylindricus Cobb,1913	Belanolaimidae	Tylenchida	3	Migratory ectoparasite	16.8	+	+	-	+
Tylenchus davainei Bastian, 1865	Tylenchidae	Tylenchida	2	Microherbivorous	5.2	-	+	+	-
Xiphinema pachtaicum Tulaganov, 1938	Longidoridae	Dorylaimida	5	Migratory ectoparasite	3.9	+	-	-	-

İ: İzmir M: Manisa B: Balıkesir Ç: Çanakkale

When the number of individuals per 100 cm^3 soil samples collected in this survey was examined, populations below the economic damage threshold were observed in many species (Table 5). For prevalence *Geocenamus brevidens, Filenchus thornei, Rotylenchulus macrosoma*, and *Helicotylenchus digonicus* were the most common species in survey areas. *Lelenchus leplosoma* and *Longidorus elongatus*, detected only in one orchard, were the rarest.

Table 5. The mean abundance of plant-parasitic nematodes in 100 cm^3 soil

	İZMİR	MANİSA	BALIKESİR	ÇANAKKALE
Coslenchus turkeyensis	2.8±0.7	0	0	0
Boleodorus thylactus	7.7±2.3	6.5±1.7	7.1±1.8	5.5±1.4
Ditylenchus dipsaci	11.7±1.9	0	0	0
Filenchus sheri	4.2±1.2	4±0.7	5±1.3	4.8±1.2
Filenchus thornei	4.5±0.9	3.6±0.5	4±0.6	4.2±0.7
Filenchus cylindricus	3.5±0.5	3±0.7	0	2.8±0.4
Filenchus filiformis	0	3.3±0.4	3	0
Geocenamus brevidens	10.2±1.2	9.9±1.5	9.2±1.8	7.9±1.3
Helicotylenchus dihystera	5.4±1.6	4.2±0.9	0	0
Helicotylenchus digonicus	6.2±1.5	5.7±1.4	6±1.2	4.4±1
Helicotylenchus tunisiensis	0	0	6.8±0.8	0
Helicotylenchus varicaudatus	0	4	5.8±0.6	0
Hemicriconemoides gaddi	2	3	0	0
Lelenchus leplosoma	1.9	0	0	0
Longidorus elongatus	2	0	0	0
Mesocriconema xenoplax	0	0	5.8±1	0
Paratylenchus nawadus	0	0	0	3.5±0.5
Pratylenchus thornei	0	5.2±1.9	5±1.8	0
Pratylenchus neglectus	7.1±1.2	6.1±0.8	6±0.7	0
Pratylenchoides alkani	6.4±0.7	5.6±1.1	4.3±1.3	5±1.7
Pslilenchus hilarilus	3.3±1	3±0.7	4±1	0
Rotylenchulus macrosoma	7.4±0.5	0	7.1±0.8	6.6±0.9
Rotylenchus cypriensis	0	0	0	5±0.8
Sauertylenchus maximus	2	0	0	0
Tylenchus davainei	0	4±0.8	2.6±0.5	0
Tylenchorhynchus cylindricus	3±0.6	2.8±0.4	0	2.7±0.5
Xiphinema pachtaicum	2	0	0	0

In this study in İzmir, Manisa, Çanakkale, and Balıkesir, free-living Cephalobidae (Bacterivore), Anguinidae (Fungivore/Plant-parasitic), Aphelenchoididae (Fungivore), and Dorylaimidae (Omnivore) families took the lead with the number of species identified. Some of these families have also been found in olive orchards in the study by Çetintaş (2017) in Kahramanmaraş province in Türkiye, and in the study area, the prominent genera were *Cephalobus, Acrobeloides*, and *Aphelenchus* .

The presence of nematodes from the Anguinidae and Aphelenchoididae families has also been reported in olive-growing areas in several countries. From the Anguinidae family, *Ditylenchus* species have been found in Spain, Jordan, and Italy. *Aphelenchus avenae* from the family Aphelenchidae has been reported in Greece, Iran, Spain, and Jordan, and *Aphelenchoides* species from Apheleonchoididae have been found in Egypt, Syria, Spain, Jordan, and Italy (Ali et al., 2014). These species can feed on fungi and have been assessed as effective biological control agents for some plant pathogens. For instance, *Aphelenchus avenae* and *Aphelenchoides sacchari* can feed on fungal hyphae of more than 54 fungal species, including plant pathogenic *Alternaria solani* (Ellis et Martin) Sorauer, *Aspergillus niger* van Tieghem, *Botrytis cinerea* Pers, *Fusarium graminearum* Schwabe, *F.*

oxysporum Schltdl, *Gliocladium roseum* Barnier, *Gongronella butleri* (Lendner) Peyronel and dal Vesco, and *Verticillium dahliae* Kleb (Taher et al., 2017). Additionally, by feeding with fungi, some fungivore nematodes indirectly affect the proliferation of plant-parasitic and fungal feeder nematodes, such as *Ditylenchus destructor* (Jun and Kim, 2004, Haraguchi and Yoshiga, 2020).

Ditylenchus dipsaci from the Anguinidae, only found in olive growing areas in İzmir, a species reported from growing areas of 450 different plants, has previously been found in olive areas, but the host status is not known (Archidona-Yuste et al., 2020)

Worldwide, 36 species belonging to five genera in the order Dorylaimida and 48 genera and 114 species in the order Tylenchida were determined (Ali et al, 2014). Within these orders, 27 species were identified in four provinces during this study in Türkiye. Two species belonged to Dorylaimida, and others to Tylenchida. Within Tylenchida *Filenchus* species were found to be most common, occurring in 44.1% of orchards. *Filenchus* spp. can feed on many saprophytic and plant-pathogenic fungi, including *Rhizoctonia solani, Fusarium oxysporum,* and *Pythium ultimum* (Munawar et al., 2022). *Pratylenchus thornei*, *P. neglectus*, *Rotylenchulus macrosoma,* and *Mesocriconema xenoplax* were other identified tylenchids in this study that are considered economically damaging pests of many crop plants. *Pratylenchus* species feed on the cortical parenchyma in the roots of olive trees and can cause necrosis in the cells and a reduction in root growth (Castillo and Vovlas, 2007). Although *Pratylenchus* species have a high distribution in olive fields, in studies, it has been stated that some species should be considered non-pathogenic since, in laboratory studies, it has been determined that these species cannot reproduce well in olives. The low rate of reproduction like one suggests that the olive is not a good host (Castillo et al., 2010). Apart from our study, *Pratylenchus spp.* has been reported in Algeria, Greece, and several other countries, and populations were lower (Hirschmann et al., 1966; Lamberti et al., 1975). Similar results were obtained in our study, and the populations of *Pratylenchus thornei* and *Pratylenchus neglectus* were determined, between 3-8 in fields.

In our study, *Rotylenchulus macrosoma*, which we extracted from soils in İzmir, Manisa, and Çanakkale, was found to multiply 1.9-2.5 times olive in a study conducted by Castillo et al. (2003) and, as a result, was considered parasitic to olive trees.

M. xenoplax causes damage, especially in vineyard areas. The economic damage threshold of this species was determined as 50 individuals/100 grams of soil, and nematodes at this density have been reported to cause a 10-25% yield reduction in the vine (McKenry, 1992). In our study in olive fields, the population threshold of this species remained below the economic damage threshold (Castillo et al., 2003).

Twenty-five species from the Longidoridae family of Dorylaimida order have been identified worldwide (Ali et al, 2014). In our study, only *Xiphinema pachtaicum,* and *Longidorus elongatus* were present in İzmir. *L. elongatus* causes damage as a virus vector and can transmit peach rosette mosaic virus (PRMV), raspberry ringspot virus (RRV), tomato black ring virus (TBRV), and artichoke italian latent virus (AILV) to several host plants. A single nematode individual can transmit the virus to a healthy plant. (Brown et al., 1995). These viruses affect the development of many cultivated plants. Especially peach rosette mosaic virus can cause a 50% yield loss in the grapevine (EPPO, 2016). However, there is no literature record of the presence of these viruses in the olive host plants

Unlike this study, 19 Tylenchid species were identified in the Central, Mediterranean, and Black Sea Regions of Türkiye. Species of *Tylenchorhynchus cylindricus, Rotylenchus cypriensis, Helicotylenchus tunisiensis*, and *Hemicriconemoides gaddi*, which we identified in İzmir, Manisa, and Çanakkale, have been found in Adana, Antalya, Mersin, and Zonguldak by Cilbirlioğlu (2007). On the other hand, in his PhD thesis conducted in Şanlıurfa province, Yıldız

(2007) found six genera of plant parasitic nematodes, nine genera of bacterivores, three genera of fungivores and one genus of omnivore nematodes in olive growing areas whereas Yıldız and Mamay, (2012) found seven genera of plant parasitic nematodes in pomegranate orchrads in the same area.

In this study, the nematode populations in soils were not so high. The vast majority of olive orchards that we surveyed have not been irrigated. However, fertilizer applications have also rarely been made, and the soils were poor regarding nutrients. Nematode populations have been reported to multiply in moist and fertilized-rich soils. Especially bacterivore nematode populations have been reported to be high in organic fertilizer-applied areas (Renco and Kovacik, 2012). The low number of nematodes in our survey areas may be due to these unsuitable environmental conditions. Additionally, nematodes that we identified in olive orchards have different contributions to the soil food web and soil structure. Their improving effects on soil mineral content and soil permeability have been revealed in several studies. Some play a significant role in N mineralization by decomposing organic substances. By feeding and excretion, nematodes promote soluble N at 27%. *Acrobeles* and *Rhabditis* species, which we detected in olive fields in four provinces, have been reported to cause an increase in the amount of nitrogen in the soil by decomposing different organic materials (Schmidt et al., 2020; Khanum et al., 2021). Thus, by knowing the nematode community structure in soils, average soil conditions and nutrient contests can be estimated for olive orchards.

Conclusion

The study results indicate the distribution and frequency of occurrence of the most common nematode species in İzmir, Manisa, Balıkesir, and Çanakkale. During the study, free-living and plant-parasitic several nematode species were identified in olive orchards. At least one free-living or plant-parasitic nematode was found in all orchards. The species richness was higher in İzmir compared to other provinces. Free-living nematodes belonging to 18 different genera were identified, and generally, bacterivorous species were found to be more abundant in 100 cm^3 soil. On the contrary, 27 plant parasitic nematode species were identified. Although the populations of these species are less than ten individuals in 100 cm^3 soil, the abundance was slightly higher in *Ditylenchus dipsaci* and *Helicotylenchus digonicus*. Nematodes were very distributed in agricultural areas. Care should be taken when moving soil or rooted plants from these areas to newly planted areas to prevent the spread of these harmful organisms. Special care should be taken for virus vector nematode species in infected areas to avoid infecting viruses on healthy plants.

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