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Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing Escherichia coli in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

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*Full Length Research Paper*

# Two new invasive species recorded in Kastamonu (Turkey): Oak lace bug [*Corythucha arcuata* (Say, 1832)] and sycamore lace bug [*Corythucha ciliata* (Say, 1832)] (Heteroptera: Tingidae)

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**The oak lace bug, *Corythucha arcuata* (Say) is an important invasive species that causes severe damage to oak species. It was first identified in Europe in 2000. It was recorded for the first time in Turkey in 2003 in Bolu. The sycamore lace bug *Corythucha ciliata* (Say) is an invasive species that causes severe damage to sycamore trees. The first time it was reported in Europe was in 1964 in Italy. It was recorded for the first time in Turkey in 2007 in Bolu province. Sixty-seven adult individuals of *C. arcuata* were collected from Kastamonu in 2013 as well as eight adult individuals of *C. ciliata* in 2013 and 2014. The present study was completed in 2014 with adult specimens collected from the stem and leaves of *Platanus orientalis* L., and *Quercus* spp. trees, located in Kastamonu Central Province and the Çatalzeytin district, and identified in the laboratory. Nymphal skin, egg, adult specimens were observed on the leaves. The damage done by *C. ciliata* to sycamore trees and by *C. arcuata* to oak leaves was determined. In this study, the *C. ciliata* and *C. arcuata* species were recorded for the first time in Kastamonu.**

**Key words:** *Corythucha arcuata*, *Corthucha ciliata*, Kastamonu, oak, sycamore, Tingidae.

## INTRODUCTION

The species of the Tingoidea superfamily are generally small and they tend to stay on the undersides of leaves and therefore go unnoticed. The first sign of their existence is via their feeding on leaves. They are known as plant mites in various parts of the world. They usually overwinter as adults. They lay their eggs on host plants' leaves. They have two or more generations per year (Drew and Arnold, 1977).

The natural distribution area of oak lace bugs, *Corythucha arcuata* (Say, 1832) (Heteroptera: Tingidae) is east of the Rocky Mountains, North America (Rabitsch and Kenis, 2010). *Corythucha arcuata* was reported for the first time in Europe in Northern Italy (in the Lombardy and Piedmond regions) in May 2000 (Bernardinelli and

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Zandigiacomo, 2000; Bernardinelli, 2006). Examples are thought to have appeared a few years earlier and spread to a large area (Bernardinelli and Zandigiacomo, 2000). Later, they were reported in Switzerland in 2002 and in Turkey in 2003 (Forster et al., 2005; Mutun, 2003). They were reported in Iran in 2011 (Samin and Linnavuori, 2011). In 2013, they were reported in Bulgaria and the Balkan Peninsula for the first time (Dobreva et al., 2013). Also in 2013, they were reported in Hungary and Croatia for the first time (György et al., 2013; Hrašovec et al., 2013).

*Corythucha arcuata* was observed in Bolu in Turkey for the first time in 2003 (Mutun, 2003). In 2009, it was reported that *C. arcuata*, which causes severe damage to oak, had dispersed to Düzce, Zonguldak, Sakarya, Kocaeli, Eskişehir, Ankara, Çankırı and Bilecik, a total area of 28.000 $km^2$ in Turkey (Mutun et al., 2009). In 2010, Eroğlu and Keskin (2010) determined the existence and damage caused by *C. arcuata* in their study conducted in Değirmendere and the Solaklı Basins, Trabzon.

Oak lace bugs are small, rectangular, dorsoventrally flattened insects. Adults have transparent, lace-like textured wings that are held flat over the insect’s body. Their wing tips and outer margins extend beyond the body. The adults are cream-colored with black or brown patches (Drake and Ruhoff, 1965). Adults have gray to black front wings and a height of 3-3.5 mm, nymphs have black spines on their bodies. Adults hibernate in bark cracks. Females lay eggs on the undersides of leaves. Development from egg to adult takes 30-45 days and they have 2-4 generations per year (Rabitsch, 2008; Rabitsch and Kenis, 2010).

Adults and nymphs feed directly on the leaf. They feed by piercing the leaf epidermis from the underside of the leaves with their piercing-sucking mouthparts and drawing out the cellular sap material. This causes a reduction of photosynthesis levels, premature defoliation and a consequent discoloration of the leaves. It has also been reported that this feeding may cause increased sensitivity to other insects, various diseases and pollution. Adults and nymphs feed on the lower surface of the leaves, producing many characteristic black spots, while on the upper surface of leaves chlorotic discoloration is the typical symptom (Wittenberg et al., 2006; Rabitsch, 2008; Mutun et al., 2009; Dobreva et al., 2013).

Their hosts are *Quercus alba, Quercus montana, Quercus macrocarpa, Quercus muehlenbergii, Quercus prinoide, Quercus rubra,* sometimes apple trees, chestnuts, maples and wild roses (Drake and Ruhoff, 1965). Their host plants so far discovered in Italy and Turkey are thought to be hybrids: *Quercus robur*, *Quercus pubescens* and *Q, robur* and *Quercus petraea* (Bernardinelli and Zandigiacomo, 2000; Mutun et al., 2009). The potential host plant distribution and growth duration of *C. arcuata* in Europe were researched in a laboratory environment by Bernardinelli (2006). In a study done on leaves cut from different plants, most of the lace bugs (>50%) reached adulthood on deciduous European oaks (*Q. robur*, *Q. pubescens*, *Q. petraea* (*Mattuschka*), *Q. cerris*) and also on *Rubus ulmifolius* and *Rubus ideaus*; a reduction in reaching adulthood (<25%) was detected on *Castanea sativa, Rubus caesius* and *Rosa canina.* It was determined that nymphs could not live on *Q. rubra,* evergreen oaks *Quercus suber* and *Quercus ilex*; *Malus domestica* and four types of silver birches that were tested. It was determined that *C. arcuata* may have numerous host plants in the Palaearctic region but that it prefers deciduous oaks. It was reported that the wide choice and distribution of host plants may have allowed *C. arcuata* to have wide distribution in Europe.

The natural distribution area of the sycamore lace bug, *Corythucha ciliata* (Say, 1832) (Heteroptera: Tingidae) is east of the Rocky Mountains, North America. They are a Nearctic tingid species which feed on undersides of *Platanus* spp. leaves (especially *Platanus occidentalis*). They are found in the eastern parts of USA and the eastern parts of Canada (Halbert and Meeker, 1998; Robinson, 2005; Rabitsch and Kenis, 2010).

The first report of the sycamore lace bugs in Europe was when they were observed in Padua, Southern Italy in late 1964 (Servadei, 1966). They reached Crotia (Majelski and Balarin, 1972a) and Slovenia (Majelski and Balarin, 1972b) within a few years; Serbia (Tomic and Mihaliovic, 1974), Hungary (Jasinka and Bozsits 1977), Switzerland (Dioli, 1975), France (d'Aguilar et al., 1977) (including Corsica) and Spain (Ribes, 1980; Sotresand Vazquez 1981) in the 1970s, and Southern Italy (Sicily), Sardinia, Southern Austria (Mildner, 1983), Germany (Hopp, 1984) in the early 1980s. They were also observed in Bulgaria (1987) (Josifov, 1990) and Greece (1988) (Tzanakakis, 1988), Montenegro (Protic, 1998), the Czech Republic (1995) and Slovakia (1997) (Stehlik, 1997). They are now dispersed throughout most of Europe including Portugal (Kment, 2007; Grosso-Silva and Aguiar, 2007) and Russia (Voight, 2001). Recently, they were found in the United Kingdom on *Platanus acerifolia* and *Platanus orientalis* imported from Italy (Malumphy and Reid, 2006). They were also found in Belgium (Aukema et al., 2007), Holland (Aukema and Hermes, 2009) and Poland (Lis, 2009). At the same time, they were found in Turkey (Mutun, 2009), China (Streito, 2006), Korea (Chung et al., 1996), Japan (Tokihiro et al., 2003), Chile (Prado, 1990) and Australia (Dominiak et al., 2008). This species has probably the largest distribution in Europe within the Heteroptera (Rabitsch, 2008).

The sycamore lace bug was reported for the first time in Turkish fauna in an area of 120 $km^2$ in the northwest of the country in 2007 (Mutun, 2009). Later, it was reported in Tekirdağ in 2009 (Aysal and Kıvan, 2011) and in Trabzon in 2011 (Sevim et al., 2013).

Adult sycamore lace bugs, *C. ciliata* are flat, small and white tingid insects with wide, transparent lace-like wings (Drake and Ruhoff, 1965). They are around 3.3-3.7 mm in length and pale white with light brown ventral faces. The pronotum is partly brown with brown stains on wing cases (Heiss, 1995; Halbert and Meeker, 1998; Robinson, 2005). Nymphs are black, brownish white and have spikes on the body (Drake and Ruhoff, 1965; Robinson 2005). Females lay up to 350 eggs. Eggs are deposited singly or in groups adjacent to veins on the underside of the leaf; hatching is in 7-28 days. Their growth from egg to adulthood takes 35-45 days (Robinson, 2005; Rabitsch and Streito, 2010).

The sycamore lace bug overwinters under peeling barks and other sheltered places. When the temperature reaches 8℃ in spring, adults appear and begin to suck on sprouting leaves. The first eggs are laid in May and the first nymphs hatch from the eggs in the third week of embryonic development. Although around 350 eggs have been reported (d'Aguilar et al., 1977), the egg number per female varies between 80 and 160 (Özsi et al., 2005). In the suitable climate conditions of the Mediterranean region, they have 2-3 generations. They spend the whole growth process on the host tree (Heiss, 1995). *C. ciliata* has five nymphal phases. In Central Europe, second generation adults appear and when the temperatures fall, they look for a place to overwinter (Özsi et al., 2005).

Both adults and nymphs of *C. ciliata* feed on the underside of leaves and cause chlorotic stippling on the underside and cholorotic discoloration on the upperside. The damage causes a reduction in respiration and photosynthesis and reduces the aesthetic value of trees. Consequently, fading occurs and leaves may fall off earlier than usual in late summer (Drake and Ruhoff, 1965; Halbert and Meeker, 1998). Combined with other factors such as disease (for example, cankers on the surface) or environmental stress, the damages caused by *C. ciliata* may affect a tree's life. Along with weakening the tree, it decreases their value (Majelski, 1986; Wittenberg et al., 2006). The sycamore lace bug has become a big problem in Europe since sycamore is a popular shade bearer there. The sycamore lace bug is a particular problem in open-air bars and cafes shaded with sycamores. It may also disturb people in parks and gardens. Usually it only has an aesthetic effect. The bug can, however, also infest houses (Maceljski 1986; Rabitsch and Streito, 2010).

Sycamore lace bugs feed on various species of Platanus (Platanaceae). It is distributed on *P. occidentalis*, *P. orientalis* and *P. acerifolia*, which is a hybrid of the two used as an ornamental tree in cities. In addition, *C. ciliata*'s host plants have been reported as *Fraxinus* spp., *Caryaovata, Brousseneita papyrifera, Chamaedaphne*, ash trees and North American chestnuts (Robinson, 2005; Rabitsch and Streito, 2010; Drake and Ruhoff, 1965).

The main difference between *C. arcuata* and *C. ciliata* is the front wing coloration (Rabitsch and Kenis, 2010). *C. arcuata* can be distinguished from *C. ciliata* by the large, brown strip on the elytra and especially near the basal part of elytra. There are whitish stains on an adult *C. ciliata*'s hemielytra and brown stains on the hemielytra'sridges.

Its relationship with the host plant should be determinative (Halbert and Meeker, 1998).

The aim of this study is to report on *C. arcuata* and *C. ciliata* from Kastamonu, which have not been reported here before. Additionally, it aims to give information, based on the existing literature and observation, about their distribution in Turkey and the world, their biology, the damage they cause and methods to control this damage.

## MATERIALS AND METHODS

The material of the study consists of both species' eggs, nymph shells and adults, and samples of damaged leaves. In our study, adult specimens, which had been collected from *P. orientalis* and *Quercus* spp. in Kastamonu city centre and Çatalzeytin in 2013, were brought to the laboratory and examined. Also, observations were done in the field and the presence of eggs, nymph shells and adults of *C. ciliata* on sycamore leaves and the damage caused, and the presence of eggs, nymph shells and adults of *C. arcuata* and the damage caused on oak leaves was determined. In May 2013, adult specimens were collected by hand and with an aspirator from the walls of the Faculty of Science and Literature building, Kastamonu University, and also stems and leaves from *P. orientalis* trees on both sides of the Karaçomak River which divides Kastamonu city centre, and *Quercus spp.* leaves from around the Çatalzeytin Campus of Kastamonu University Vocational High School. The specimens were killed and preserved in 70% ethyl alchohol. Eggs, nymph shells and *P. orientalis* and *Quercus* spp. leaves found in field observations to be showing discoloration because of damage caused by insects were brought into the laboratory in plastic bags in order to be examined. Specimens were identified and photographed with a Leica S8APO stereomicroscope. Specimens were preserved in 70% ethyl alchohol in Research Laboratory of Department of Biology.

## RESULTS

*C. arcuata* was collected from the walls of the Faculty of Science and Literature building, Kastamonu University in 2013 and 2014. During examinations in the campus and city centre, *C. arcuata* was collected from stems of *P. orientalis* trees on both sides of the Karaçormak River which divides Kastamonu city centre. Adults, eggs, nymph shells, feces and damage caused by *C. arcuata* were found on *Quercus* spp. leaves in field observations done in Çatalzeytin in September 2013.

In observations made in November 2013 and January 2014, *C. ciliata* was collected from stems and leaves of *P. orientalis* trees in Kastamonu city centre. Adults, over-wintering under barks, eggs, nymph shells, feces and damage caused by *C. ciliata* were found on the stems and leaves of *P. orientalis.*

### *Corythucha* STÅL 1873

### *Corythucha arcuata (Say, 1832)*

**Material examined:** KASTAMONU: 5 ♂♂, 3 ♀♀, Kuzeykent, Walls of Faculty of Science and Literature building, Kastamonu University, 23.05.2013; 1 ♂, Merkez, Çengeller, stem of *P. orientalis*, 21 ♂♂, Merkez, between

Kastamonu University, Faculty of Education and Kışla park, stem of *P. orientalis*, 16.09.2013; 13 ♂♂, Kuzeykent, Walls of Faculty of Science and Literature building, Kastamonu University, 27.09.2013; 1 ♂, Faculty of Education, Kastamonu University, stem of *P. orientalis*, 01.10.2013; 10 ♂♂, Kuzeykent, Walls of Faculty of Science and Literature building, Kastamonu University 02.10.2013; 1 ♀, Çatalzeytin, Kastamonu University Vocational High School,Çatalzeytin Campus, leaves of *Quercus spp*., 05.10.2013; 7♂♂, Kuzeykent, Walls of Faculty of Science and Literature building, Kastamonu University, 10.10.2013; 3 ♂♂, Kuzeykent, Walls of Faculty of Science and Literature building, Kastamonu University 22.10.2013; 1 ♂, Çatalzeytin, Kastamonu-Çatalzeytin 88 km highway, road sides, falling leaves of *Quercus* spp., 09.11.2013; 1 ♂, Çatalzeytin, Kastamonu University Vocational High School,Çatalzeytin Campus, leaves of *Quercus* spp., 16.11.2013.

**Distribution in Turkey:** Bolu, Düzce, Zonguldak, Sakarya, Kocaeli, Eskişehir, Ankara, Çankırı, Bilecik and Trabzon (Mutun, 2003; Mutun*et al*., 2009; Eroğlu and Keskin 2010). It is recorded for the first time in Kastamonu.

**Distribution in the world:** North America, Italy, Switzerland, Turkey, Iran, Bulgaria, Hungary and Croatia (Drake and Ruhoff, 1965; Bernardinelli and Zandigiacomo, 2000; Forster et al., 2005; Mutun, 2003; Samin and Linnavuori, 2011; Dobreva et al., 2013; György et al., 2013; Hrašovec et al., 2013).

### *Corythucha ciliata (Say, 1832)*

**Material examined:** KASTAMONU: 2 ♂♂, Merkez, Cumhuriyet Square, stem of *P. orientalis*, 03.11.2013; 2 ♀♀, Faculty of Education, Kastamonu University, under tree barks of *P. orientalis*, 05.11.2013; 2 ♀♀, Parking lot of Kastamonu University Vocational High School, leaves of *P. orientalis*, 1 ♂, Parking lot of Kastamonu University Vocational High School, under tree barks of *P. orientalis*, 12.01.2014; 1 ♀, Faculty of Education, Kastamonu University, under tree barks of *P. orientalis*, 18.01.2014.

**Distribution in Turkey:** Bolu, Tekirdağ and Trabzon (Mutun, 2009; Aysal and Kıvan, 2011; Sevim et al., 2013). It is recorded for the first time in Kastamonu.

**Distribution in the world:** North America, Canada, Italy, Crotia, Slovenia, Serbia, Hungary, Switzerland, France (including Corsica), Spain, Southern Italy (Sicily), Sardinia, Southern Austria, Germany, Bulgaria, Greece, Montenegro, Czech Republic, Slovakia, Portugal, Russia, United Kingdom, Belgium, Holland, Poland, Turkey, China, Korea, Japan, Chile and Australia (Drake and Ruhoff, 1965; Servadei, 1966; Majelski and Balarin, 1972a; Majelski and Balarin 1972b; Tomic and Mihaliovic, 1974; Jasinka and Bozsits 1977; Dioli, 1975;d'Aguilar et al., 1977; Ribes, 1980; Sotres and Vazquez 1981; Mildner, 1983; Hopp, 1984; Josifov, 1990; Tzanakakis, 1988; Protic, 1998; Stehlik, 1997; Kment, 2007; Grosso-Silva and Aguiar, 2007; Voight, 2001; Malumphy and Reid 2006; Aukema et al., 2007; Aukema and Hermes, 2009; Lis, 2009; Mutun, 2009; Streito, 2006; Chung et al., 1996; Tokihiro et al., 2003; Prado, 1990; Dominiak et al., 2008; Halbert and Meeker, 1998; Robinson, 2005; Rabitsch and Kenis, 2010).

## DISCUSSION

In this study, a total of sixty-seven *C. arcuata* specimens were collected. Forty-one of them were collected from the walls of the Faculty of Science and Literature building at Kastamonu University. The building is situated on open land on the northern side of Kastamonu. The specimens were found on the wall as a group. The specimens might have been blown here by the wind or by flying. Twenty-three specimens were collected from a *P. orientalis* stem. At first, we thought that the specimens belonged to *C. ciliata.* However, when we brought the specimens and identified them with the stereomicroscope, we found out they were *C. arcuata. P. orientalis* trees are found frequently on both sides of the Karaçormak River which divides Kastamonu city centre into two, and which is shown in Figure 1a. This area also has the main arterial roads used by pedestrians and vehicles. The fact that *C. arcuata* was on *P. orientalis* stems can be explained by the heavy pedestrian and vehicle traffic on these main arterial roads: insects may have been carried in this way, such that, in September and October, when specimens are found widely, *C. arcuata* was found on sycamore stems and on people's clothes. In this period adults look for an overwintering place and the bark of sycamore is a better place than oak bark. Three specimens were collected from the leaves of *Quercus* spp. in field surveys done in Çatalzeytin. Adults, eggs, nymph shells are shown in Figure 1b, c-d and e, respectively. On the other hand, feces and damage caused by *C. arcuata* collected from the undersides of *Quercus* spp. leaves are shown in Figure 1f.

In laboratory examinations, *C. arcuata* collected in Kastamonu were measured and their length was found to be 3.0-3.5 mm and their width was found to be 1.5-2.0 mm. The eggs were laid on the undersides of the leaves as a group of 30-40, and relatively ordered. As in *C. ciliata,* they were not near the veins, and had a more open positon. Many nymph shells and feces were found on the infested leaves. The black dots created by feces covered almost the whole undersurface of the leaf. A chlorotic discoloration level of 50% was observed on

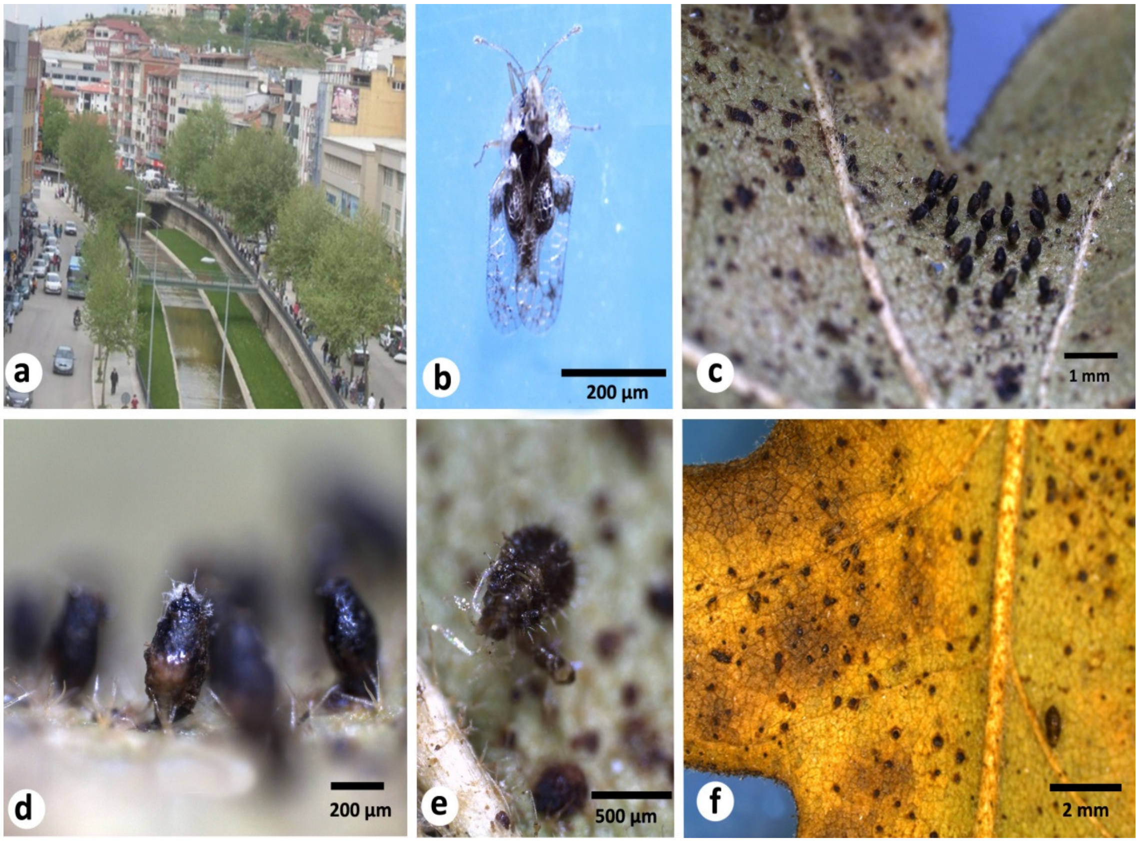


**Figure 1.** a. *P. orientalis*trees on both sides of Karaçomak River; b. Adults of *C. arcuata*; c. Lower leaf surfaces with dark brown spots of oak lace bug excrement and groups of eggs of *C. arcuata;* d. Eggs of *C. arcuata*; e. Nymph shell of *C. arcuata*; f. Feces and chlorotic discoloration of infested oak leaves caused by feeding activity of *C. arcuata*.

infested *Quercus* spp. leaves. Chlorotic discoloration, brown stains and drying are the most visible effects of the pest.

Its wide distribution is possibly caused by human activities, the flight of adults and the wind (Rabitsch and Kenis, 2010). Since the first record of *C. arcuata* in Bolu in 2003, it has been reported in cities nearby with compatible host plants (Mutun et al., 2009). In the study they conducted near large highways, Mutun et al. (2009) concluded that *C. arcuata* appeared to coincide with human activity and other parts of Turkey should be looked at too in order to determine the degree of urgency of this. The fact that Kastamonu and other cities in Turkey in which *C. arcuata* have been reported are close to each other and have similar vegetation shows that *C. arcuata* reached Kastamonu easily. It is possible that species dispersed by flight or were carried by pedestrian and vehicle traffic to Kastamonu. *C. arcuata* is not considered as an important pest species, possibly because it is controlled by its natural enemies. Its environmental and economic effects in Europe are unknown because these natural enemies are not sufficient in Europe, however, since oaks are the primary forest trees in Europe, its effects might be more severe in the areas it appears (Wittenberg et al., 2006; Rabitsch and Kenis, 2010).

In the study, eight specimens of *C. ciliata* were collected from *P. orientalis* trees in the city. Two of the specimens were collected from the stem of *P. orientalis* near Cumhuriyet Square, which is on the main arterial road. Based on the information in literature that adults overwinter under tree barks, four specimens were collected from under loose barks of sycamore while overwintering. This is shown in Figure 2a. Two specimens were collected from the leaves of sycamore. In observation, adults, eggs, nymph shells are shown in Figure 2b-c, d-e and f-g, respectively On the other hand, feces and damage caused by *C. ciliata* were found on the undersides of sycamore leaves as shown in Figure 2h-i.

In this study, specimens of *C. ciliata* collected from Kastamonu had a body length of 3.5-3.9 mm and a body width of 2.2-2.5 mm. Approximately 40-50 eggs were laid on sycamore leaves, as groups of 8-10, relatively ordered, on the undersides of leaves and the sheltered main parts where the veins connect. In observations made on sycamores on the main street of Kastamonu city centre, eggs, nymph shells, feces and chlorotic discolorations were found when fallen leaves were

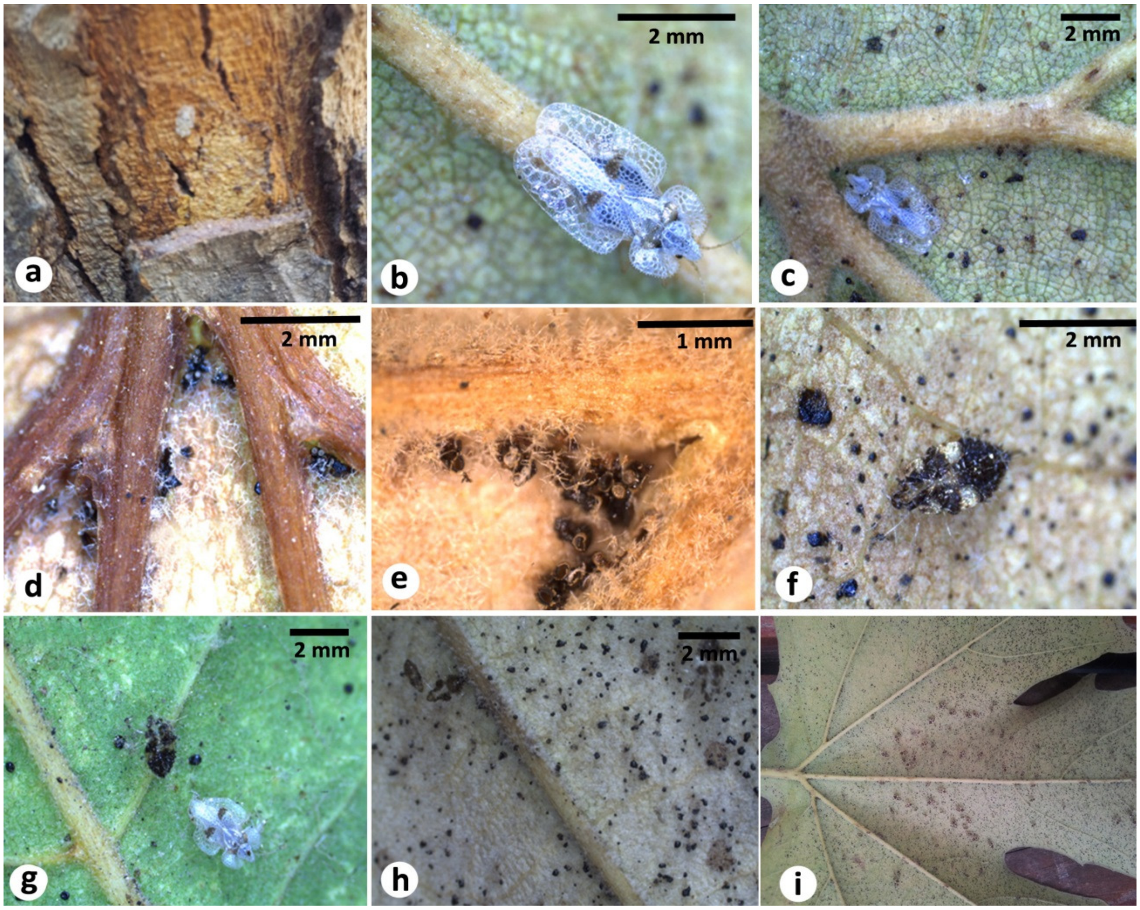


**Figure 2.** a. Adults of *C. ciliata* overwintering under loose barks of *P.orientalis*; b-c. Adults of *C. ciliata* on leaves of *P.orientalis*; d-e. Eggs of *C. ciliata* laid on the lower surface of the leaf of the plane tree; f. Nymph shell of *C. ciliata*; g. Adult and nymph shell of *C. ciliata*; h-i. Feces and chlorotic discoloration of infested plane leaves caused by feeding activity of *C. ciliata*.

examined. This shows that the pest is effective on *P. orientalis* leaves in Kastamonu and causes them to fall off prematurely. It is expected that this species will disperse in a very short time, since *P. orientalis* trees are its primary hosts and are present on sidewalks and parks in Kastamonu city cente and pedestrian and vehicle traffic is very heavy on main arterial roads.

Adults are good flyers and they can easily disperse with the help of the wind. Their long distribution distance possibly occurs through human activity (in vehicles and on clothes). Their method of distribution throughout Europe is, however, probably through human activity (Wittenberg et al., 2006; Rabitsch and Streito, 2010).

During field trips in summer 2007 in Taşkesti and Abant, Bolu, which is located near two main highways and big cities, hundreds of adults were found on heavily infested *P. orientalis* trees. Additionally, various nymph phases, shells, eggs, black feces and signs of feeding were found on the leaves. Although *C. ciliata* adults are not good flyers, it seems that winds and human factors help it to disperse over long distances (Mutun, 2009).

Our research revealed that sycamore lace bugs have indeed spread throughout Kastamonu and cause harmful effects on sycamore trees. It should be noted that due to the ability of lace bugs to easily spread with the help of the wind and human activiy, sycamore trees in urban areas are especially under threat.

Sycamore lace bugs may be controlled with insecticide practices. The alternative method to control sycamore lace bugs is to place sticky material on the barks of the host tree in early spring before the tree sprouts (Özsi et al., 2005). In order to protect from significant damage, the repetitive use of organic phosphorus, synthetic pyrethroid, imidacloprid, thiamethoxam or acetamiprid pesticides is recommended as a control method (Kim et al., 2000; Ju et al., 2009). The use of chemical insecticides for *C. ciliata* control is problematic in urban areas where the pest is present for safety reasons (Halbert and Meeker, 2001). Shapiro-Ilan and Mizel (2012) reported that there are no biological options for controlling *C. ciliata*. They reviewed six different entomopathological nematodes which cause disease on sycamore leaf discs in the laboratory to control *C. ciliata.* Findings on its lethality and production capacity showed that *Heterohabditis indica* (HOM1) has a high potential for suppressing *C. ciliata.* Various entomopathological nematodes and additional studies such as field studies are expected to manage control of *C. ciliata.* Sevim et al. (2013) screened thirteen entomopathogenic fungal strains including 4 isolates of *Beauveria bassiana*, 2 isolates of *Beauveria pseudobassiana*, 6 isolates of *Metarhizium anisopliae*, and 1 isolate of *Isaria fumosorosea* against adults and nymphs of *C. ciliata*. They reported that *B. bassiana* isolate KTU – 24 showed the highest mortality for both adults and nymphs with 86% within 2 weeks after inoculation. This isolate also caused the highest mycosis for adults and nymphs with 83 and 80%, respectively.

*Corythuca* species that include both the oak lace bug *C. arcuata*, found on *Quercus*, and the sycamore lace bug *C. ciliata*, found on *Platanus*, entered Italy from North America and they live on their own host plants. *C. arcuata* appeared ten years ago and has only recently started to spread (Dioli et al., 2007), but *C. ciliata* appeared in 1960s and today they have spread through Europe (Rabitsch, 2010).

This study has examined two tingid species, *C. arcuata* and *C. Ciliata*, with regard to their distribution in Turkey and across the world, their biological characteristics, their host plants, the damage they cause and relevant pest control methods. This study is also the first research which demonstrates that *C. arcuata* and *C. ciliata* have been found in Kastamonu.

## Conflict of Interests

The author(s) have not declared any conflict of interests

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*Full Length Research Paper*

# Soil nematode communities associated with hazelnut orchards in Turkey

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**The study was conducted to investigate the status of soil nematode communities in hazelnut orchards in Ordu province, Turkey. Nematodes were identified to genus level and allocated to trophic groups. A total of 50 taxa were found from hazelnut growing areas including 19 plant parasites, 12 bacterivorous, 4 fungivorous, 4 predators and 11 omnivorous. Genera *Tylenchus* (94.5%), *Gracilacus* (79.1%) and *Helicotylenchus* (56.4%) as plant parasites, *Acrobeloides* (68%) as bacterivores and *Aphelenchoides* (68.2%) as fungivorous were widespread and found in all districts. The highest abundance of plant parasites was in Kabataş (277 individual/ 100 cm$^3$ soil) followed by Gölköy (196.6 ind./ 100 cm$^3$ soil) district. *Criconemella*, *Meloidogyne, Paratylenchus* and *Pratylenchus* were found as important genera by means of the damage potential on hazelnut as plant parasitic group. The other trophic groups were at desirable level for an healthy soil system.**

**Key words:** Hazelnut orchards, hazelnut nematodes, nematode community, nematode abundance, Ordu.

## INTRODUCTION

Hazelnut (*Corylus avellana* L.) is one of the most important nut crops of Turkey, and Turkey is ranked the first place worldwide for hazelnut production and export value. Annual hazelnut production of Turkey is 660 000 tons with shell. Turkey supplies 70% of the world's hazelnut exportation as 146 322 tons with shell among top 20 exporter countries (FAO, 2013). The hazelnut is considered one of the most ancient plants with naturally occuring cultured varieties and wild types in the Black Sea region. The ecological conditions of Black Sea Region of Turkey overlap best with the requirements of hazelnut by moderate climate and high relative humidity throughout year. Although hazelnuts have been grown in more than 35 cities around Turkey, production is primarily concentrated along Turkey's Black Sea coast (Güney, 2014). The provinces Ordu, Giresun, Sakarya, Samsun, Trabzon and Bolu are the main places for hazelnut production in Turkey, but Ordu can be named as the leading province of hazelnut production for Turkey. The growth practices are traditional and generally synthetic fertilizers are used. The irigation method is also ancient and the source of water is rainfall. The pest management approach is conventional with pesticides based on mites and insects. There is no concern of farmers for nematode management by the lack of information for nematodes, high slope of the agriculture orchards and the difficulties of training system. The training system of hazelnut trees in Turkey is multi-stem system for *C. avellana*. Multi-stem form is named as "Ocak" in Turkey

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and that contains 8 or 10 stems of the plant. Harvest is carried out by hand. Another training system is single-trunk form for *Coryllus colurna* which can be grafted with shrub form, *C. avellana* and suitable for mechanical harvest. In addition to that, single-trunk form is a modern training system for Ordu province and Turkey and still in trails of Hazelnut Research Institute (Giresun, Turkey).

Hazelnut has some pests and diseases. Therefore commercial hazelnut production is difficult without management. Considering the pests of hazelnut, the pest status of hazelnut have been investigated by many of the scientists so far and the main focus was on the insect and mite pests of hazelnut. For instance, insects can reduce the yield of hazelnut between 15-60% and the level of this loss is dependent on the year, growing conditions and control measures (Milenkovic and Mitrovic, 2001). This explains the reason of intensive focus on insect pests. Insects and mite species as the pests of hazelnut for Turkey and other countries were reported by many authors (AliNiazee, 1983; Hill, 1987; Ioachim and Bobarnac, 1997; Ak et al., 2005; Özman-Sullivan, 2006; Saruhan and Tuncer, 2010; Saruhan and Şen, 2012). General control strategies against the pests on crops may include application of insecticides, classical and augmentative biological control, utilization of resistant varieties, and use of bio-based preparations (AliNiazee, 1998). Until the discovery of the management or control techniques of the pests mentioned above, the first step to carry out is to identify the pests species or determine the fauna of the cultivar. In addition to these perspectives, nematode fauna for hazelnut is also a subject in the limited numbers of researches and management. Only a few authors pointed out the nematode pest status of hazelnut in some countries: Greece (Kyrou, 1976), Spain (Pinochet et al., 1992) and California, US (Norton et al., 1984). When considering Turkey for the nematode pest status of hazelnut; only Kepenekci (2002) studied on nematodes associated with hazelnut and pointed out several nematodes occuring in hazelnut orchards and reported the nematodes, *Filenchus afghanicus Hemicycliophora punensis, Pratylenchoides hispaniensis, Pratylenchus pratensisobrinus, Helicotylenchus crenacauda*, *Hemicycliophora sturhani, Merlinius (=Scutylenchus) lenorus, Tylenchorhynchus cylindricus* as plant parasitic species and *Ditylenchus anchilosposomus* as fungivorous species in the west part of Blacksea region of Turkey. In this context, it is difficult to say that there are investigations adequately about nematodes of hazelnut in Turkey and worldwide. Therefore, the requirement to detailed investigation of nematodes in the hazelnut rhizosphere was obvious and it was determined with this investigation on province scale where the hazelnut production is ancient and commercial. We hope to elucidate the hazelnut producers clearly about the presence and importance of nematodes on hazelnut with this study.

Our objectives were to make an investigation for more detailed nematode faunal assemblages including the free-living and plant parasitic trophic groups in hazelnut orchards of Ordu province. This survey will provide a backround for further research about nematode fauna of hazelnut.

## MATERIALS AND METHODS

This study examined the frequency of occurence and abundance of particular nematode trophic groups in hazelnut growing areas in Ordu province, Turkey. The totals of 110 hazelnut orchards from 18 districts (Figure 1) were surveyed for investigation.

### Description of the study sites

A survey was carried out in Ordu provinces, in Black Sea Region of Turkey located at Latitude 40° 59' 5" N and Longitude 37° 52' 44" E on the altitude ranging from 10 to 1900 m above sea level with mean annual rainfall of 1177. 0 mm. Ordu has a borderline oceanic/humid subtropical climate like most of the eastern Black Sea coast of Turkey; with warm and humid summers; cool and damp winters. The water temperature is always cool and fluctuates between 8 and 20°C throughout the year. A distinct characteristic of Ordu is its being the center of hazelnut production. Ordu is the most important producer city (230.397, 0 ha) and produces the 32% of the hazelnut production of Turkey. Sampling was done randomly in orchards of the 18 districts.

### Soil status of the province

The soil status of Ordu province is presented in Table 1. The soils of the province can be mainly considered as reasonably good in organic content, clay in soil texture, low calcerous and mostly acidic in soil reaction.

### Soil sampling

During September 2013, a total of 110 hazelnut orchards in Ordu province were surveyed for plant parasitic and free-living nematodes. Five "Ocak" from each orchard were selected randomly and soil samples were taken from the rhizosphere at 5-30 cm depth, from the both sides of an Ocak regardless of direction. Soil probe is used once on each side of an Ocak. In this way, ten points from one orchard were sampled. The collected ten soil samples from each orchard were mixed homogeneously to constitute a composite sample. Each soil sample was thoroughly mixed and 1 kg of sub-sample was taken from the soil composite. The soil samples were put into polyethylene bags and properly labeled, then they were brought to laboratory. Soil samples were stored for two weeks at 4°C in refrigerator till the extraction time. After extraction, the rest of soil composite was stored in the refrigator in case of the of the soil.

### Extraction of nematodes from soil

The soil samples were mixed and 100 $cm^3$ aliquot of each sub-sample was extracted by using modified Bearmen Funnel Technique (Hooper et al., 2005). Then, nematodes were counted and identified to genus level using light microscope. For each genus, frequency of occurance and nematode abundance in the eighteen districts were calculated. Abundance and frequency were represented by individual/100 $cm^3$ soil and %, respectively for the five trophic groups including plant parasitic, bacterivorous, fungivorous, omnivorous and predator nematodes by following Yeates et al. 1993.

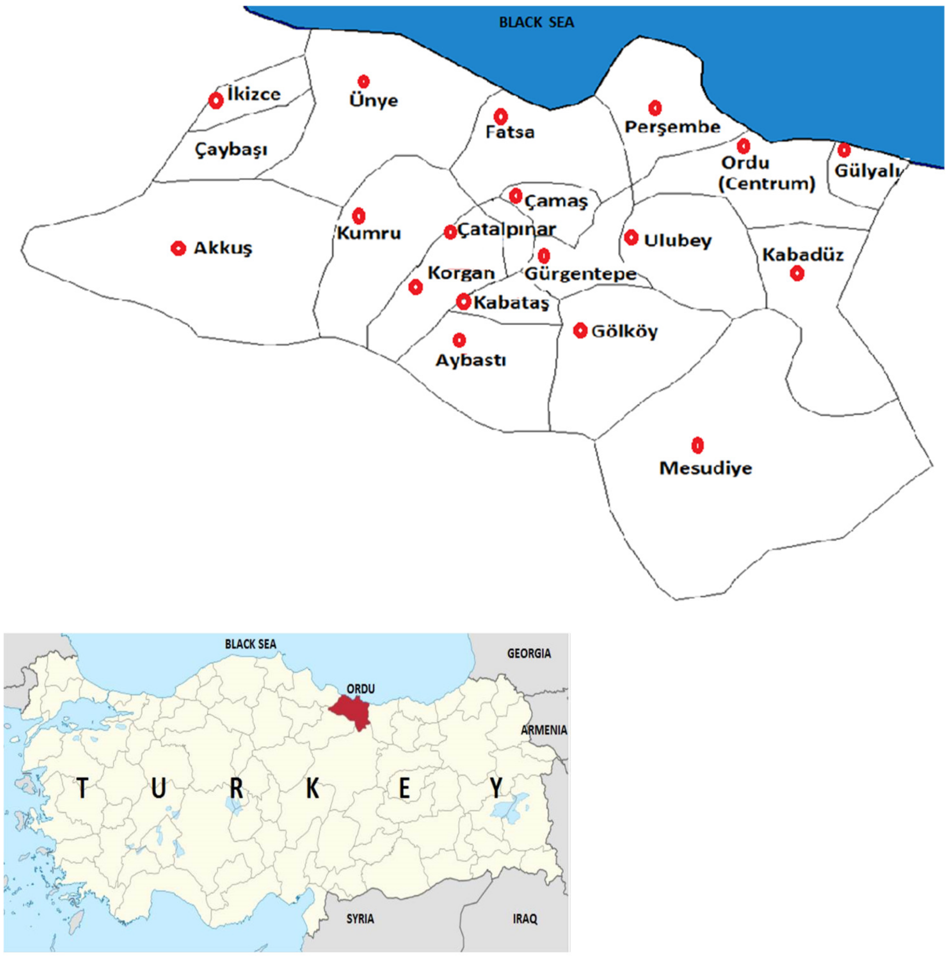


**Figure 1.** Map of Ordu province indicating the surveyed locations of hazelnut plantation, (Anonymous, 2014).

**Table 1.** The soil status of Ordu province (Şekeroğlu et al., 2006).

| **Parameter** | **Soil parameter** | | **%** |
|---|---|---|---|
| Status of texture | Loamy | | 12.1 |
| | Clay loamy | | 58.6 |
| | Clay | | 29.0 |
| Status of calcerous content | Low calcerous | <1% | 83.1 |
| | Calcerous | 1-5% | 4.7 |
| | Moderately calcerous | >5-15 | 6.0 |
| Organic content | Low-moderately fine | <2% | 21.4 |
| | Moderately | 2-3% | 25.0 |
| | Good | 3-4% | 23.3 |
| | High | >4% | 30.3 |
| pH (soil reaction) | Moderately acidic | 4.5-5.5 | 19.6 |
| | Slightly acidic | 5.5-6.5 | 27.9 |
| | Neutral | 6.5-7.5 | 34.9 |
| | Slightly alkaline | 7.5-8.5 | 0.5 |

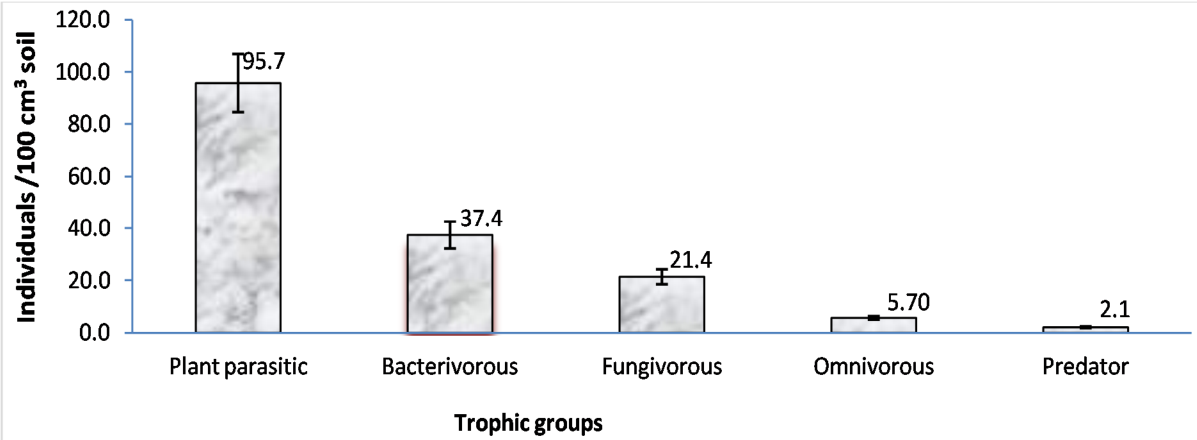


**Figure 2.** Mean nematode abundance of the five trophic groups in the hazelnut orchads in Ordu province (means ± standard deviation).

During the identification, Siddiqi (2000), Yeates et al. (1993), Jairajpuri et al. (1992) and the illustrated web pages such as Interactive Diagnostic Key to Plant Parasitic, Freeliving and Predaceous Nematodes by UNL Nematology Lab for free-living nematodes were used mainly.

## RESULTS

Nematode faunal analysis of 110 hazelnut orchads showed that the plant parasitic nematodes were the most abundant (95.7 ind./100 $cm^3$ soil) trophic group (Figure 2). As plant parasitic group; the genera, *Tylenchus, Gracilacus, Helicotylenchus* has been found in the all investigated districts (Table 3). The nematodes of the genus *Tylenchus* were the most abundant (45.8 ind./100 $cm^3$ soil) with frequency of occurrence of 94.5% followed by genus *Gracilacus* (25.4; 79.1%), *Helicotylenchus* (8.4; 56.4%), *Pratylenchus* (2.3; 22.7 %), *Meloidogyne* (5.9; 14.5%) and *Criconemella* (1.6; 24.5 %) (Table 2). The mean abundance of plant parasitic nematode species were the highest in Kabataş district (277 ind./ 100 $cm^3$ soil) followed by Gölköy (196.6) and Çamaş (170.8) districts (Figure 3).

Bacteriovorouss were the second widespread and diverse group with ten genera after plant parasitic nematodes. The bacterivorous genera, *Acrobeloides* and *Plectus* were recorded in all districts and the mean abundance and frequency values were 20.6 (61.8%) and 2.3 (49.1%) respectively (Table 2). The abundance of this group was the highest in Aybastı (104.8 ind./ 100 $cm^3$ soil) followed by Perşembe (83.5) and Çamaş (74.6) (Figure 3). The fungivorous group had the highest values in Akkuş (92 inds./ 100 $cm^3$ soil) followed by Kabataş (39.7) and Perşembe (31.5) (Figure 3). The genera, *Aphelenchoides* and *Aphelenchus* in this group were recorded in all districts and the abundance and frequency values were 13.5 (68.2%) and 5.0 (53.6%) respectively. *Ditylenchus* and *Tylencholaimus* were also recorded fungivorous genera: (2.6; 22.7%) and (3.5; 37.3%) respectively (Table 2).

Amoung the omnivorous group, the most abundant and frequent genera were *Aporcelaimus* (2.5; 50.9%), *Prodorylaimus* (1.0; 20.9%), *Eudorylaimus* (0.7; 16.4%) (Table 2) for this trophic group. Omnivorous reached the highest abundance in the Fatsa and Ünye districts (12.2 ind./100 $cm^3$ soil) (Figure 3). The highest abundance of predators was in Gülyalı (8.3 ind./ 100 ml soil) followed by Ulubey (5.4) and Mesudiye (4.3) districts (Figure 3) and the first three genera were represented by *Clarkus* (1.0, 28.2%), *Tripyla* (0.7; 22.7%) and *Mononchus* (0.5; 18.2%) nematodes (Table 2).

## DISCUSSION

In this survey, the distribution of nematodes under trophic groups was detected at genus level regarding their abundance and frequency values for hazelnut. This study is the first detailed faunistic and numeric investigation of nematode assemblages belonging to different trophic groups for hazelnut in the region and Turkey.

At the end of our investigation, the abundance and frequency of *Tylenchus* were relatively higher than the other plant parasitic groups. Even though it is a weak parasitic group, this genus might have a damage potential for hazelnut with its high abundance (45.8 ind./ 100 $cm^3$ soil) and frequency (94.5%) values. Siddiqi (2000) also reported that *Tylenchus* feeds on algae, mosses and lichens. The *Gracilacus* is the second remarkable genus as being encountered plant parasitic group in all districts with abundance of 25.4 ind./ 100 $cm^3$ soil and frequency of 79.1%. *Gracilacus* spp. can feed deep in the cortical tissue of the roots with their long stylet (Siddiqi, 2000). The species of this genus, *Gracilacus straeleni,* was for the first time reported in soil around the roots of hazelnut (*C. avellana*) in northern

**Table 2.** Mean frequency of occurence (%) and nematode abundance (per 100 $cm^3$ / soil) associated with hazelnut orchards in Turkey.

| Trophic groups | Number of positive samples | Frequency (%) | Abundance (per 100 $cm^3$ /soil) | Range |
|---|---|---|---|---|
| **Plant parasitic** | | | | |
| *Tylenchus* | 104 | 94.5 | 45.8 | (2-375) |
| *Gracilacus* | 87 | 79.1 | 25.4 | (1-575) |
| *Helicotylenchus* | 62 | 56.4 | 8.4 | (1-161) |
| *Pratylenchus* | 25 | 22.7 | 2.3 | (1-63) |
| *Meloidogyne* | 16 | 14.5 | 5.9 | (2-196) |
| *Criconemella* | 27 | 24.5 | 1.6 | (1-42) |
| *Paratylenchus* | 20 | 18.2 | 1.1 | (2-35) |
| *Merlinius* | 12 | 10.9 | 1.2 | (1-85) |
| *Rotylenchus* | 9 | 8.2 | 0.9 | (1-65) |
| *Tylenchorhynchus* | 7 | 6.4 | 0.5 | (2-25) |
| *Heterodera* | 7 | 6.4 | 0.7 | (3-43) |
| *Trophurus* | 6 | 5.5 | 0.7 | (1-37) |
| *Nagelus* | 4 | 3.6 | 0.2 | (2-10) |
| *Xiphinema* | 3 | 2.7 | 0.1 | (2-5) |
| *Psilenchus* | 3 | 2.7 | 0.1 | (2-7) |
| *Filenchus* | 2 | 1.8 | 0.2 | (11-15) |
| *Paratrophurus* | 2 | 1.8 | 0.5 | (15-43) |
| *Criconema* | 2 | 1.8 | 0.1 | (2-3) |
| Unknown | 4 | 3.6 | 0.2 | (1-3) |
| **Bacterivorous** | | | | |
| *Acrobeloides* | 68 | 61.8 | 20.6 | (1-228) |
| *Plectus* | 54 | 49.1 | 2.3 | (1-20) |
| *Cephalobus* | 50 | 45.5 | 4.3 | (2-41) |
| *Eucephalobus* | 52 | 47.3 | 3.8 | (1-56) |
| Monhysteridae | 42 | 38.2 | 1.6 | (1-12) |
| *Rhabditis* | 27 | 24.5 | 2.7 | (1-101) |
| *Prismatolaimus* | 25 | 22.7 | 0.8 | (1-10) |
| *Alaimus* | 25 | 22.7 | 0.8 | (1-11) |
| *Alaimidae* | 15 | 13.6 | 0.6 | (1-13) |
| *Achramodora* | 11 | 10.0 | 0.4 | (1-11) |
| *Wilsonema* | 9 | 8.2 | 0.5 | (1-25) |
| *Cervidellus* | 5 | 4.5 | 0.1 | (1-3) |
| **Fungivorous** | | | | |
| *Aphelenchoides* | 75 | 68.2 | 13.5 | (1-238) |
| *Aphelenchus* | 59 | 53.6 | 5.0 | (1-35) |
| *Ditylenchus* | 25 | 22.7 | 2.6 | (1-39) |
| *Tylencholaimus* | 41 | 37.3 | 3.5 | (1-47) |
| **Predators** | | | | |
| *Clarkus* | 31 | 28.2 | 1.0 | (1-11) |
| *Tripyla* | 25 | 22.7 | 0.7 | (1-8) |
| *Mononchus* | 20 | 18.2 | 0.5 | (1-6) |
| *Seinura* | 2 | 1.8 | 0.0 | (1-2) |
| **Omnivorous** | | | | |
| *Aporcelaimus* | 56 | 50.9 | 2.5 | (1-28) |
| *Prodorylaimus* | 23 | 20.9 | 1.0 | (1-15) |
| *Eudorylaimus* | 18 | 16.4 | 0.7 | (1-18) |
| *Dorylaimus* | 14 | 12.7 | 0.5 | (1-9) |
| *Aporcelaimellus* | 9 | 8.2 | 0.4 | (1-8) |

**Table 2**. Contd.

| | | | | |
|---|---|---|---|---|
| *Unknown* | 9 | 8.2 | 0.2 | (1-4) |
| Dorylaimidae | 6 | 5.5 | 0.2 | (2-8) |
| *Mesodorylaimus* | 5 | 4.5 | 0.2 | (1-15) |
| *Campydora* | 5 | 4.5 | 0.2 | (1-5) |
| *Belondira* | 4 | 3.6 | 0.1 | (1-4) |
| Actinolaimidae | 1 | 0.9 | 0.0 | (2-2) |

Greece. The abundance was about 100 specimens/200 g soil and the plant showed the discoloration of the leaves and retarded growth (Kyrou, 1976). This indications suggests that hazelnut might be host of *Gracilacus* but need to be identified at species level and the damage potantial on hazelnut cultivars should be examined for Turkey. *Helicotylenchus* was the other recorded genus (56.4%) in all districts but in low abundance (8.4 ind./ 100 $cm^3$ soil). The low values of abundance for this genus showed that it has no damage potential on hazelnut, but it must be considered that *Helicotylenchus* is the migratory endoparasite which causes cell destruction without modifying the host tissues (Luc et al., 2005). *Helicotylenchus* was also reported as the dominant genus in conventional agricultural areas (Tsiafouli et al., 2004). Conventional hazelnut production is a great part of Ordu province. Kepenekci (2002) reported that *Helicotylenchus crenacauda* occured in 12 out of 20 soil samples of hazelnut. Therefore, in case of any high population of this genus, there might be the problem on the root system of hazelnut and requires the detailed damage threshold on hazelnut. The genus *Pratylenchus* was also recorded as 2.3 ind./ 100 $cm^3$ soil and 22.7 % but not in all districts. Pinochet et al.(1992) detected the damage potential on hazelnut in species level of *Pratylenchus vulnus* that can succesfully reproduce on hazelnut in Spain. Norton et al. (1984) reported that hazelnut (*C. avellana*) is the host of *Pratylenchus crenatus* in California. *Pratylenchus pratensisobrinus* was recorded on the root and soil of hazelnut in Turkey by Kepenekci (2002). These reports are evidence that *Pratylenchus* has a potantial to damage hazelnut and needs to be identified at species level and study of its damage at different population levels for root system. Some investigations in Turkey also pointed out the presence of *P. thornei*, and *P. neglectus* on wheat (Sahin et al., 2008) and *P. thornei* on cabbage (Mennan and Handoo, 2006).The other genera as plant parasitic group, *Meloidogyne*, *Criconemella, Paratylenchus* are important genera by means of the damage potantial on other perennial crops except hazelnut.Yüksel (1982) reported that *Meloidogyne* spp. are not destructive to hazelnut which is one of the most important crop of the Black Sea region. Since that report, there is no detailed investigation about the damage potantial of genus *Meloidogyne* on hazelnut and that remained unknown. Although genus *Criconemella* is in high frequency but in low number (1.6; 24.5 %) for Ordu province, no report was pointed out *Criconemella* damage on hazelnut till now. The importance of this genus can be mentioned as having species that cause damage on perennial crops (Nyczepir and Pusey, 1986; Nyczepir et al., 1997). Hunt et al. (2005) also identified the genus as migratory ectoparasites on perennial crops, trees and vines, but only a few species have been proved to be harmful. As the last important plant parasitic genus, *Paratylenchus* was also considerably in high frequency but low number (1.1; 18.2%). Although the occurence and damage status of this genus were reported on some prennial crops (Campos and Villain, 2005; El-borai and Duncan, 2005), the status on hazelnut is still unknown.

*Acrobeloides* was the most abundant (20.6 ind./ 100 $cm^3$ soil) and frequent (61.8%) genus among bacterivore genera. This genus was reported as the dominant genus in conventional production areas (Tsiafouli et al, 2004; Yildiz and Elekcioglu, 2011; Yildiz, 2012) and also contains species that provides long-term effectiveness in the soil for the biological control of the fungi. The nematode of the genus consumes a range of rhizosphere-inhabiting bacteria. After digestion process, the nematodes release the bacterial contents into the soil which play the suppression role of fungi and may also promote plant growth in this way (Bird and Ryder, 1993). The nematodes of the genus Plectus also frequently occured (49.1%) but in low abundance (2.3 ind./ 100 $cm^3$ soil*)*. This genus is one of the most widely distributed and common nematode taxa of freshwater and terrestrial habitats in the world and can survive under extreme desiccation, freezing conditions and other types of stress (Adhikari, 2010). In addition, species of *Plectus* reproduce through parthenogenesis and this cosmopolitan genus contains 78 species (Tahseen and Mustaqim, 2011). Therefore, these all perspectives of the genus might be the reason that makes the genus to be recorded in all district in our investigation.

The fungivorous genera, *Aphelenchoides, Aphelenchus, Ditylenchus,* and *Tylencholaimus* were found in this study. Fungivorous nematodes have been viewed to play an important role in organic matter decomposition (Ishibashi and Choi, 1991). Omnivorous and predatory nematodes were the last groups found in the investigation. When compared with the other groups, they were relatively in low abundance (Omnivores: 5.7 and predators:

**Table 3.** Mean frequency of occurence (%) and range of the important plant parasitic nematode genus by districts.

| Region | *Criconemella* spp. | | *Gracilacus spp.* | | *Helicotylenchus* spp. | | *Meloidogyne* spp. | | *Paratylenchus* spp. | | *Pratylenchus* spp. | | *Tylenchus* spp. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Frequency | Range | Frequency | Range | Frequency | Range | Frequency | Range | Frequency | Range | Frequency | Range | Frequency | Range |
| Merkez | 42 | 1-3 | 67 | 1-80 | 25 | 6-10 | 17 | 4-21 | 17 | 2-4 | 0 | 0 | 100 | 1-107 |
| Akkuş | 25 | 0-1 | 75 | 4-12 | 100 | 4-60 | 100 | 8-102 | 50 | 3-6 | 75.0 | 1-8 | 100 | 15-123 |
| Aybastı | 0 | 0 | 25 | 0-34 | 75 | 1-22 | 25 | 0-36 | 25 | 0-2 | 0 | 0 | 75 | 9-70 |
| Çamaş | 80 | 3-42 | 80 | 3-102 | 80 | 4-15 | 0 | 0 | 20 | 0-4 | 0 | 0 | 80 | 7-375 |
| Çatalpınar | 0 | 0 | 75 | 5-121 | 25 | 0-1 | 25 | 0-2 | 25 | 0-14 | 25 | 0-14 | 100 | 9-163 |
| Fatsa | 18 | 3-8 | 91 | 2-185 | 55 | 1-17 | 18 | 33-88 | 0 | 0 | 27 | 2-63 | 100 | 3-105 |
| Gölköy | 0 | 0 | 100 | 2-55 | 71 | 4-161 | 0 | 0 | 43 | 2-19 | 57 | 2-46 | 100 | 10-325 |
| Gülyalı | 33 | 0-2 | 67 | 2-15 | 67 | 6-10 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 9-40 |
| Gürgentepe | 29 | 3-4 | 100 | 1-61 | 100 | 1-60 | 14 | 0-21 | 0 | 0 | 0 | 0 | 100 | 1-190 |
| İkizce | 0 | 0 | 100 | 2-13 | 50 | 2-27 | 0 | 0 | 0 | 0 | 50 | 6-11 | 100 | 4-19 |
| Kabadüz | 60 | 2-10 | 80 | 2-22 | 40 | 2-4 | 20 | 0-11 | 0 | 0 | 20 | 0-6 | 80 | 6-70 |
| Kabataş | 0 | 0 | 100 | 1-575 | 33 | 0-2 | 0 | 0 | 0 | 0 | 0 | 0 | 66 | 2-225 |
| Korgan | 60 | 3-6 | 80 | 2-15 | 40 | 1-6 | 0 | 6 | 20 | 0-10 | 20 | 0-17 | 75 | 1-207 |
| Kumru | 0 | 0 | 75 | 2-41 | 75 | 4-20 | 0 | 0 | 50 | 2-4 | 50 | 2-4 | 100 | 15-59 |
| Mesudiye | 0 | 0 | 33 | 0-7 | 67 | 4-15 | 0 | 0 | 67 | 2-7 | 33 | 0-2 | 100 | 2-10 |
| Perşembe | 10 | 0-4 | 90 | 3-120 | 50 | 1-20 | 10 | 0-6 | 20 | 5-35 | 30 | 1-9 | 100 | 8-213 |
| Ulubey | 56 | 2-11 | 44 | 2-35 | 78 | 2-53 | 11 | 0-15 | 22 | 2-5 | 22 | 1-2 | 100 | 6-63 |
| Ünye | 0 | 0 | 100 | 1-216 | 30 | 0-2 | 20 | 13-196 | 10 | 0-2 | 20 | 4-14 | 100 | 1-107 |

2.1 ind./ 100 $cm^3$ soil) (Figure 2). Omnivorous and predatory could be more sensitive in defining the soil ecosystem status (Xiang et al., 2006), but they undoubtedly play an important role by feeding all types of organisms. Predator nematodes eat all types of nematodes or protozoa while omnivorous consume a variety of organisms including bacteria, fungus, protozoa, other nematodes and roots and may have a different diet at each life stage (Hoorman, 2011).

The soil properties on nematode communities cannot be overlooked as well. The texture might effect the density and distribution of nematodes in soil profile (Mcsorley and Frederick, 2002) and when the percentage of clay increased, the root penetrating ability of plant parasitic nematodes might decrease (Prot and Van Gundgy, 1981). The soil reaction factors can also have some effect on nematode groups. In general, pH is inhibitory to most nematode activities below 5.0 and above 8.0 (Ravichandra, 2008). For instance, the number of nematodes was negatively affected in acid soil reaction at pH 4.0 with lowest nutrient application rate. In additon to combinations of higher nutrient rates, low pH significantly reduced the number of bacterial-feeding nematodes, whereas it increased the number of hyphal-feeding nematodes. Indirect effect of nutrient and pH via other components of the soil food web is also in question (Korthals et al, 1996). Organic content is another important fraction of the soils and it can be considered as a positive source on nematode communities. Shabeg et al. (2007) reported that during period of 4 years in field plots of different crops transitioning from conventional to organic farming practice, nematode faunal profile estimates showed that the food webs were highly enriched and moderately to highly structured and the decomposition channels were bacterial in both systems. Bacterivore nematodes were more abundant in the organic soil compared to conventional system.

By the lights of these, the nematode communities vary in different sites and are effected by agronomic applications. In case of any nematode management attempts on hazelnut, as for other crops, site, land or country-spesific management pratices must be considered and applied because

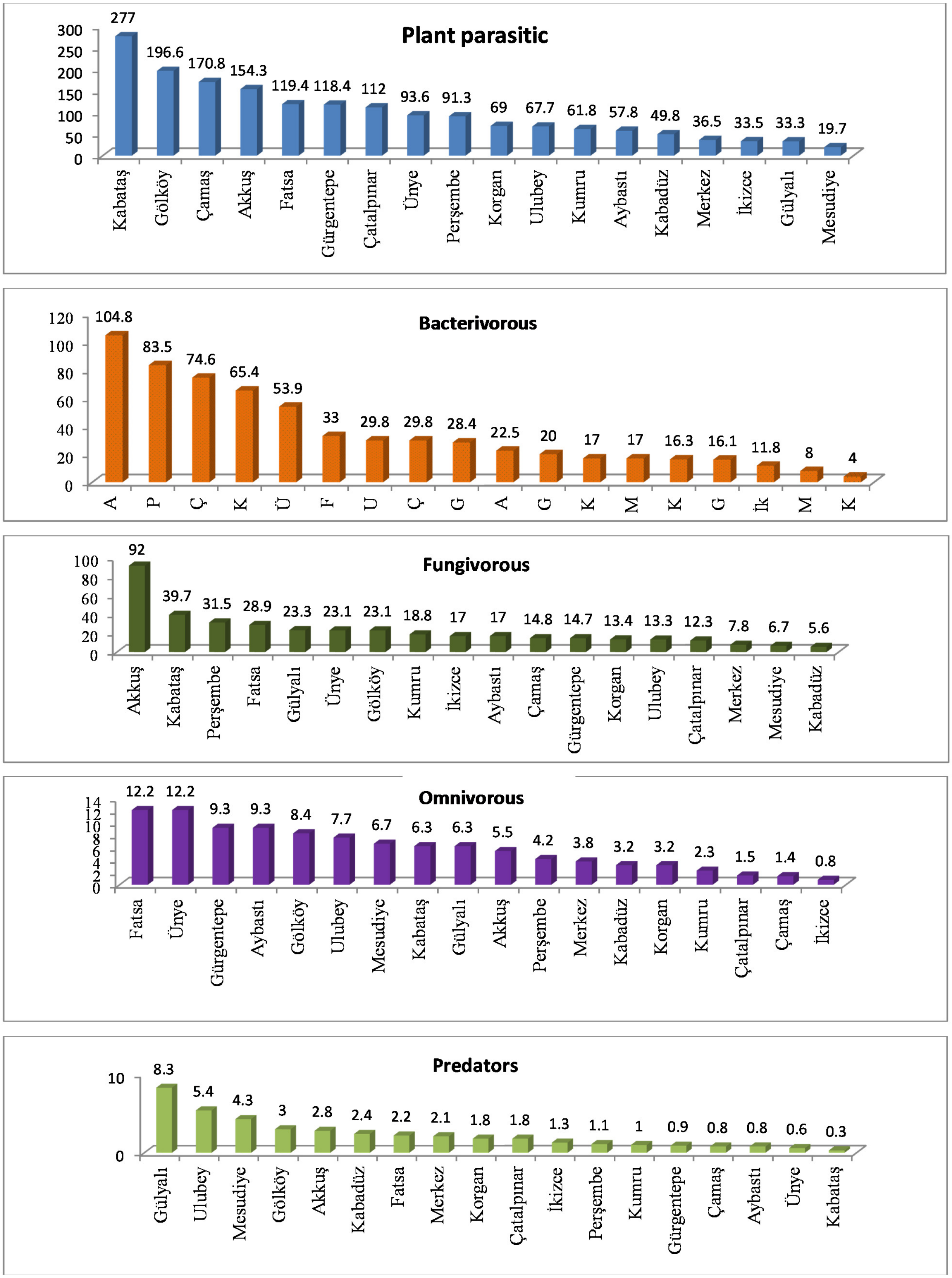


**Figure 3.** The mean abundance (ind./100 cm$^3$ soil) of trophic groups: plant parasitic, bacterivorous, fungivorous, omnivorous and predators among districts.

nematode groups are dependent on the effects of spesific conditions.

As a concequence, this survey pointed out the general nematode status of hazelnut for an intensive production area. Many factors such as fertilization, climate, soil texture, cultivation and cultivar are expected to affect the abundance and frequency. Therefore, the results would change from region to region. When considering the levels of free living trophic groups (bacterivorous, fungivorous), the values were in desirable levels for ecosystem. On the other hand, plant parasitic group was the highest in abundance and frequency of occurrence. This suggested that it has potential for damage or yield loss in case of any increasing levels especially for *Pratylenchus* and *Gracilacus* genera which need to be studied on. The nematode problems might seem as unimportant on hazelnut for classical Ocak training system because of the lack of any management practice on hazelnut, but will undoubtly be very important for any further application with modern training systems like single trunk tree form grafted with cultivar. Because the growth decline on single trunk form can be observed easily when compared with the multistem shrub form (Ocak), the modern systems are in progress for hazelnut in Black Sea region. In these perspectives, any study on yield loss caused by nematodes on hazelnut would provide more information for management of the crop, especially for modern systems in world scale and Turkey. This faunistic investigation is expected to be beneficial for researchers and growers in the future.

## Conflict of Interests

The author(s) have not declared any conflict of interests.

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