DOI: 10.26650/forestist.2019.346284
Forestist 2019, 69(1): 1-10

İSTANBUL UNIVERSITY
CERRAHPAŞA

Original Article

Distribution, biology, morphology and damage of *Cinara cedri* Mimeur, 1936 (Hemiptera: Aphididae) in the Isparta Regional Forest Directorate

Isparta Orman Bölge Müdürlüğü sedir ormanlarında *Cinara cedri* Mimeur, 1936 (Hemiptera: Aphididae)'nin yayılışı, morfolojisi, biyolojisi ve zararı

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ABSTRACT

In 2015-2016, a study was performed examining the distribution, colony dispersion in tree canopies, occurrence rate in shoots at different ages, morphology, and the damage of the cedar aphid (*Cinara cedri* Mimeur 1936) (Hemiptera: Aphididae) This study was completed alongside biological observations in the Isparta Regional Forest Directorate. This study was conducted across 46 sites at an elevation of 820-1738 meter (m) and the distribution of this species was determined by a survey. Compared to other sites, the *Cinara cedri (C. cedri)* population was found to be higher in 10 sites with young stands with an average height of 1000-1200 m. These sites were established through plantation. Colonies were typically observed on the shoots from the previous year and on branch axils. They were found to feed on shoot tips and trunks of young trees and preferred shoots with a diameter of 1.0-1.5 centimeter (cm) on the southern and eastern aspects of the trees. It was observed that *C. cedri* mostly fed on shoots of the previous year, which caused the needles to dry and turn red. Damage was observed especially on young trees from which the dried needles fell and defoliation was concentrated particularly on the shoot tips and tops of the trees. It was found that honeydew was secreted by those insects fed with sap, and this secretion then covered the needles, shoots and branches, resulting in fumagine. The populations overwintered as eggs and then nymphs hatched during the first week of April. The adult stage was reached after completing four nymph periods over a time span of between one week and 10 days. These adults then reproduced parthenogenetically, with winged viviparous individuals appearing between May and June, and oviparous emerging in October. The final stage of the cycle was a period of mating and then egg-laying.

Keywords: Cedar aphid, *Cinara cedri*, damage, Isparta, life cycle

ÖZ

Çalışma, 2015-2016 yıllarında Isparta Orman Bölge Müdürlüğü'nde, sedir yaprak biti (*Cinara cedri* Mimeur 1936) (Hemiptera: Aphididae)'nin yayılışı, türün ağaç tepe tacındaki koloni dağılımı ve farklı yaşlardaki sürgünlerde bulunma oranı, morfolojisi, biyolojisi ile zararı tespit edilmiştir. Çalışma, 820-1738 m arasında yükseltiye sahip 46 alanda gerçekleştirilmiştir. Plantasyon sahaları, genç meşcere ve ortalama 1000 m yükseltide bulunan 10 alanda diğer alanlara göre *C. cedri*'nin popülasyonunun daha fazla olduğu belirlenmiştir. Kolonilerin genellikle bir önceki yıla ait sürgünlerde ve dal koltuğunda bulunduğu, ayrıca sürgün ucu ile genç ağaçların gövdesinde de beslendikleri, ağacın güney ve doğu bakıdaki 1,0-1,5 cm çapındaki sürgünleri tercih ettiği görülmüştür. *C. cedri*'nin çoğunlukla bir önceki yıla ait sürgünlerde beslendiği ve ibrelerin kuruyup kızarmasına yol açtığı gözlenmiştir. Zararın özellikle genç ağaçlarda olduğu, kuruyan ibrelerin döküldüğü ve yapraksızlaşmanın ağacın sürgün uçları ile tepe kısmında olduğu görülmüştür. Zararlının öz suyu ile beslenmesi nedeniyle ballı madde salgıladığı ve ballı maddenin dalların üzerini kapladığı ve fumajin oluşumuna neden olduğu belirlenmiştir. Popülasyonlar kışı yumurta döneminde geçirmiş, Nisan ayının ilk haftasında yumurtadan çıkan kanatsız viviparların yaklaşık bir hafta ile 10 günlük sürede dört nimf dönemini tamamlayarak erginliğe ulaşmışlardır. Mayıs-Haziran aylarında kanatlı viviparların görüldüğü, ekim ayının son haftasında oviparların ortaya çıktığı ve çiftleşerek yumurta bıraktıkları gözlenmiştir.

Anahtar Kelimeler: *Cinara cedri*, Isparta, sedir yaprak biti, yaşam döngüsü, zarar

Cite this paper as:
Oğuzoğlu, Ş., Avcı, M., 2019. Distribution, biology, morphology and damage of *Cinara cedri* Mimeur, 1936 (Hemiptera: Aphididae) in the Isparta Regional Forest Directorate. *Forestist* 69(1): 1-10.

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Received Date:
24.10.2017
Accepted Date:
23.10.2018

INTRODUCTION

Taurus cedar (*Cedrus libani* A. Rich.) is one of four cedar species distributed across the world. The Taurus cedar, which is naturally found in Turkey, Lebanon and Syria, is distributed across approximately 482.391 hectares (ha) in Turkey, 2.300 ha in Lebanon and 400 ha in Syria (Aksoy and Özalp, 1990; Aytar et al., 2011; Khuri et al., 2000; OGM, 2015). The Taurus cedar is one of the most commonly used tree species in the plantations of Turkey after the Crimean pine (*Pinus nigra* J. F. Arnold subsp. *pallasiana* (Lamb.) Holmboe) (Boydak, 2014; Yaltırık, 1988).

Cinara cedri was identified in 1936 by J. M. Mimeur in Morocco *Cedrus atlantica* (Mimeur, 1935). *C. cedri* is an aphid belonging to the Hemiptera order and Aphididae family and especially chooses cedar species as a host (Binazzi et al., 2015; Lieutier and Ghaioule, 2005; Mimeur, 1935). Due to the quality of cedar wood and its wide use as an ornamental plant, *C. cedri* is distributed across different areas of the world along with its host. This species was first recorded in Turkey in 1959 in Gaziantep on *C. libani* (Tuatay and Remaudiere, 1964). This species was found in Ankara, Konya (Center, Akşehir), Burdur (Center, Bucak-Sobya-Kızılgöl, Çeltikçibeli), İstanbul (Dolmabahçe-Bahçeköy-Yıldız), Hatay (Karaağaçlı), Eskişehir, Afyon, Isparta (Şarkikaraağaç-Kızıldağ), Antalya (Center, Elmalı-Çığlıkara, Kaş-Sütleğen-Çereli), Samsun (Bafra), Bartın, Tekirdağ, Adana, Karaman, Niğde, Osmaniye, Mersin, Kahramanmaraş and Kastamonu (Aslan, 2014; Aytar, 2006; Çanakçıoğlu, 1975; Düzgüneş et al., 1980; Görür et al., 2009; Uygun et al., 2000; Ülgentürk et al., 2012, 2013; Ünal and Özcan, 2005).

C. cedri causes damage by sucking the sap from the shoots and leaves of cedar trees which consequently leads to the needles turning red and drying out (Tuatay, 1999). The secreted honeydew sticks to leaves and shoots causing occlusion of the stoma and lenticels. Additionally, the fungus growing on this secretion leads to fumagine, thereby blocking photosynthesis of the tree. Several fly and bee species are also attracted to the honeydew and the trees which are also damaged from disease-related factors associated with these species. Loss of increment is observed on the damaged trees and their seed production yield decreases (Binazzi et al., 2015; Çanakçıoğlu, 1975; Núñez-Perez and Tizado, 1996). Despite its damaging effects, this species provides nutrition for ants, bees and fly species due to its honeydew secretion and is important for the continuation of the ecological balance. It is known that ants that visit aphids on plants increase honeydew secretion, which facilitates the predation of some harmful insects by ants and keeps away the natural enemies of aphids (Ülgentürk et al., 2012).

A semi-arid climate is the influencing environment across 35% of Turkey and most of this area is potential plantation fields. In recent years, the majority of plantation studies have been performed in semi-arid areas. Cedar is a species which is commonly used in semi-arid areas. Therefore, it is very important to protect the existing cedar forests and to identify the species that cause damage to cedar forests whilst undertaking efforts to control these species with a view to establishing healthy forests.

The purpose of this study was to contribute to the control of the species by determining the morphological features of *C. cedri* that damages cedar forests, as well as its distribution, damage and biology.

MATERIAL AND METHODS

The study was conducted in the natural and plantation cedar forests of Isparta Regional Forest Directorate in 2015-2016. While collecting samples from shoots where *C. cedri* was found, the shoot diameter of the colony, distance to shoot tip, and colony width were measured and recorded in the field report along with information regarding coordinates, elevation, aspect, and stand in the areas where *C. cedri* was found. Furthermore, the egg, nymph and adult stages of *C. cedri,* in addition to features such as the part of the tree they feed on, whether it causes colour change damage, formation of fumagine, distribution of the colony on the tree canopy, and colony density were investigated and photographed. Both nymphs and adults were cultivated and monitored in laboratory conditions, and information on their biology and morphology was recorded. Adults were placed in Eppendorf tubes with 70% alcohol, prepared as per Martin (1983) and were categorized as per Blackman and Eastop (2012).

The identification key for global aphid species belonging to the genera *Cedrus* is presented below (Blackman and Eastop, 2012).

Key to aphids on *Cedrus* (Blackman ve Eastop, 2012):

1 Antenna processus terminalis/ basal part of last antennal segment more than 1. siphunculi long and tubular, swollen distally .....*Illinoia morrisoni*
- Antenna processus terminalis/ basal part of last antennal segment less than 1. siphunculi are broad hairy cones 2
2 Rostral segment V short, flask-shaped, pointed only at tip, hardly longer than its basal width. siphunculi cones with few hairs, in 1-2 rings around pore .....*Schizolachnus pineti*
- Rostral segment V acutely pointed, dagger-shaped, usually twice or more as long as its basal width. siphunculi cones large and dark with numerous hairs 3
3 Antenna 5-segmented. Dorsal hairs of aptera club-shaped, ornamented with numerous barbules .....*Cinara laportei*
- Antenna 6-segmented. Dorsal hairs normal, pointed 4
4 Hairs on body and appendages short; those on antenna III maximally about as long as basal diameter of segment .....*Cinara curvipes*
- Hairs mostly long; longest hairs on antenna III maximally more than 2 × basal diameter of segment 5
5 Body lenght 3.0 mm or less. Dorsal length of hind tarsus I distinctly longer basal width 6
- Body lenght more than 3.0 mm. Dorsal length of hind tarsus I shorter than basal width 7
6 Aptera with 0-1 secondary rhinaria on antenna III. antenna IV longer than antenna VI. abdominal tergit 1-6 without any extensive dark sclerotisation .....*Cinara cedri*
- Aptera with c. 5 secondary rhinaria on antenna III, antenna IV shorter than antenna VI, and abdominal tergit 1-6 with an extensive pattern of dark sclerotisation .....*Cinara deodarae*

7 Aptera with hind tarsus II less than 4 × hind tarsus I. antenna III with more than 40 long hairs, very few of these less than 2 × basal diameter of segment. Body length 3.8-7.8 milimeter (mm) .....*Cinara confinis*

- Aptera with hind tarsus II 4 or more × hind tarsus I. antenna III with less than 30 hairs of very variable length, often less than 2 × basal diameter of segment. Body length c.3.3 mm .....*Cinara indica*

RESULTS AND DISCUSSION

Hosts of *Cinara cedri*

C. cedri was observed on *C. libani* in the study field. However, according to the literature, it was also observed on *C. atlantica*, *C. deodora*, *C. brevifolia*, *Thuja* sp., *Pinus* sp., *P. brutia* (Binazzi et al., 2015; Görür et al., 2009; Lieutier and Ghaioule, 2005; Ülgentürk et al., 2013; Ünal and Özcan, 2005).

Distribution of *Cinara cedri* in the forests in the study field and effects of different field and stand characteristics on the distribution of *Cinara cedri*

As a result of the survey conducted to determine the distribution of *C. cedri* in Isparta Regional Forest Directorate's natural and plantation forests, the presence of the species was noted in 46 fields where the studies were conducted (Figure 1).

When the stand structure of the study sites was investigated, it was observed that 26 sites contained a cedar-Crimean pine mixed stand, 18 sites had a pure cedar stand, one site had a fir-cedar stand, and one site contained a cedar-Kasnak oak stand. Nine sites were found to be natural and 37 sites were identified as plantation forests. When the sites were assessed in terms of stand age, it was observed that 33 sites had young stands, 11 sites had mixed stands and two sites had old stands. The four areas (Isparta-center, SDU campus, Gökçay Park and Ayazmana Park) are close to the settlement area, therefore stand properties of these areas were not given (Table 1). In review of literature, no information was found regarding stand characteristics or aspects of the sites where *C. cedri* was found. Çanakçıoğlu and Mol (1998) and Usta and Keskin (1992) stated that when the population of *C. cedri* became dense, they preferred young seedlings in particular. It was found that *C. cedri* was intensely distributed (particularly across young stands established in plantations) in the study sites Bucak, Atabey, Gönen, Keçiborlu, Yukarıgökdere-Beşkuyu, Uluborlu, Isparta-center, SDU campus, Eğirdir-center, Gökçay Park and Yalvaç City Forest. The species distribution was found between elevations of 820 m (Bucak) and 1738 meter (m). Regarding dense populations, observations were recorded at elevations between 1000-1200 m.

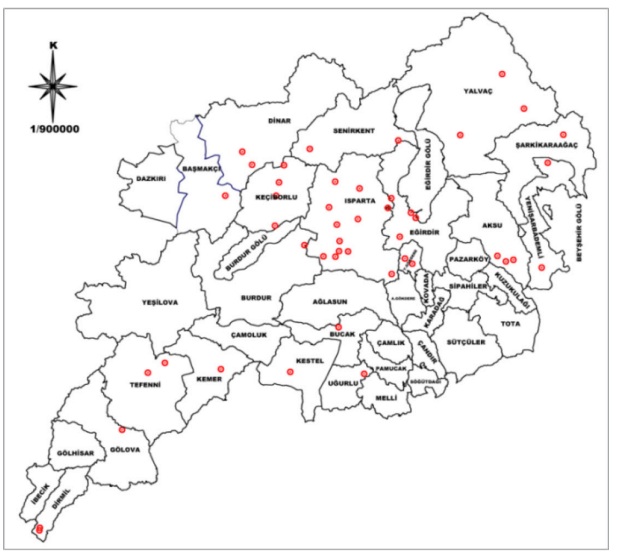


Figure 1. Locations of *Cinara cedri* detected in Isparta Forest Regional Directorate

Serttaş et al. (2012) stated that *C. cedri* was found in the Antalya-Çığlıkara Nature Protection Area at an average elevation of 1830 m. Çanakçıoğlu (1975) had reported *C. Cedri* in the same place at an elevation of 1000-1750 m, in Ankara Atatürk Forest Farm at 900 m, in İstanbul Bahçeköy at 110 m, in Antalya-Kaş-Çerçeli at 1710 m, in Burdur at 925 m, in Eskişehir at 790 m and in Afyon at 1020 m. Tosun (1975) reported the occurrence of *C. cedri* in the garden of Antalya Regional Forest Directorate at 40 m, in the Isparta-Şarkikaraağaç-Kızıldağ cedar forest at 1300 m, Burdur-Bucak-Sobya Kızılgöl forest at 1600 m, in Burdur-Çeltikçibeli region at 950 m. The elevations at which *C. cedri* presence was identified in this study were similar to those reported in the literature.

Morphology

Egg

In the study, it was observed that when the *C. cedri* eggs were first laid at the end of October and November, they were light brown in colour and subsequently turned a dark glossy brown. It was found that eggs were laid generally on the needles at the tip of shoots, with a few of them on the needles of the shoots from the previous year, forming either a single line or two lines (Figure 2). It was noted that similar conclusions which were given in the study of Çanakçıoğlu (1975). Çanakçıoğlu and Mol (1998) and Usta and Keskin (1992) stated that eggs were dark brown and glossy, 0.7-1.0 mm in length and 0.2-0.3 mm in width. According to the measurements recorded in this study, eggs were 0.43 mm in width and 1.17 mm in length - greater than those values reported in the literature.

Nymph

It was observed that the dark coloured stripes on the thorax and abdomen area appearing towards the 4th nymph stage became clearer and the head area of those individuals that were a light bronze grey brown during the 1st nymph stage turned from dark brown to light brown. Moreover, it was found that during the 1st nymph stage, the thorax and abdomen were thin and long, yet towards the 4th nymph stage they were enlarged. It was observed that the density of the waxy layer varied amongst

Table 1. Characteristics of the land and stand of 46 *Cinara cedri* detected localities in study area

No	Locality	Altitude (m)	Aspect	Coordinate	Nature/Plantation	Stand property*
1	Isparta-Center	1043	Plain	37°46'43''N-30°32'49''E	Plantation	-
2	Isparta-SDÜ Campus	1019	East	37°49'49''N-30°32'05''E	Plantation	-
3	Bucak-Karapınar Village	820	Southwest	37°21'46''N-30°22'00''E	Plantation	Sa
4	Isparta-Sağ Âşık Tomb	838	West	37°21'46''N-30°39'26''E	Plantation	Sc2
5	Eğirdir-Barla	1182	East	37°55'04''N-30°44'49''E	Plantation	SÇka
6	Dinar-Tekin Village	874	Plain	38°03'04''N-30°09'07''E	Plantation	Sa0
7	Başmakçı-Sarıköy	1024	Plain	37°54'40''N-30°05'24''E	Plantation	Sc1
8	Dinar-Dikici	931	West	38°00'40''N-30°11'32''E	Plantation	Sa
9	Keçiborlu	1067	North	37°54'57''N-30°17'28''E	Plantation	Sa
10	Gelendost	951	Plain	38°07'17''N-31°00'54''E	Plantation	Sa0-2
11	Eğirdir-Center	976	Northwest	37°52'24''N-30°49'36''E	Plantation	Sa0
12	Isparta-Çobanisa Village	1716	West	37°47'49''N-30°47'04''E	Nature	Scd1
13	Yukarıgökdere-Beşkuyu	1738	South	37°43'44''N-30°48'25''E	Nature	Scd2
14	Isparta-Güneyce	880	West	37°40'45''N-30°45'22''E	Plantation	ÇkSab2
15	Isparta-Gökçay Park	1153	Plain	37°44'49''N-30°32'45''E	Plantation	-
16	Isparta-Hisartepe	1485	Northwest	37°43'45''N-30°31'56''E	Plantation	SÇka0
17	Yenişarbademli	1415	Southwest	37°42'33''N-31°20'52''E	Nature	ÇkSc3
18	Aksu	1213	South	37°43'35''N-31°12'21''E	Plantation	ÇkSa
19	Aksu-Yakaafşar	1275	Northeast	37°44'36''N-31°10'19''E	Plantation	Sa0
20	Aksu-Yaka	1326	North	37°43'55''N-31°14'08''E	Plantation	ÇkSa
21	Atabey	1041	South	37°56'45''N-30°37'14''E	Plantation	SÇka
22	Gönen	1086	East	37°57'55''N-30°31'24''E	Plantation	ÇkSab2
23	Keçiborlu-Center	1042	West	37°57'29''N-30°18'03''E	Plantation	Sa1
24	Keçiborlu-Özbahçe Village	1337	Northwest	38°00'45''N-30°19'07''E	Plantation	ÇkSb3
25	Keçiborlu-Senir Town	1026	Southeast	37°49'17''N-30°17'24''E	Plantation	Sa
26	Senirkent-Kapıdağ	1507	North	38°06'00''N-30°46'10''E	Nature	Sc1
27	Isparta-Senirce Village	1025	East	37°53'03''N-30°30'06''E	Plantation	Sa
28	Altınyayla-Kumluağıl	1604	South	36°50'19''N-29°24'19''E	Nature	SÇkcd2
29	Altınyayla-Tamtır	1564	South	36°50'48''N-29°24'23''E	Nature	SÇkcd2
30	Çavdır	1150	Southeast	37°09'51''N-29°42'51''E	Plantation	Sab2-1
31	Tefenni	1138	Southeast	37°20'47''N-29°48'27''E	Plantation	ÇkSab2
32	Karamanlı	1121	Northwest	37°22'45''N-29°52'23''E	Plantation	Sa-3
33	Kızıldağ NP**	1421	North	38°02'22''N-31°21'52''E	Nature	Sc3
34	Çarıksaraylar	1301	South	38°07'43''N-31°25'28''E	Plantation	ÇkSab2
35	Yalvaç-City Forest	1116	Northwest	38°18'58''N-31°10'36''E	Plantation	SÇkbc2
36	Yalvaç-Bağkonak	1136	West	38°12'31''N-31°15'57''E	Plantation	SÇka0
37	Burdur-Gökçebağ Village	1169	North	37°45'46''N-30°24'31''E	Plantation	Sa0
38	Bucak-Katran Mountain	1136	North	37°21'54''N-30°05'38''E	Nature	GScd1
39	Isparta-Kuleönü	1025	West	37°50'58''N-30°37'02''E	Plantation	SÇka0

Table 1. Characteristics of the land and stand of 46 *Cinara cedri* detected localities in study area (continue)

No	Locality	Altitude (m)	Aspect	Coordinate	Nature/Plantation	Stand property*
40	Büyükgökçeli	1047	North	37°53'13''N-30°44'04''E	Plantation	ÇkSa
41	Eğirdir-Center	1016	Northeast	37°51'27''N-30°50'45''E	Plantation	Sa0
42	Uluborlu	1150	Northwest	38°03'58''N-30°25'09''E	Plantation	Sa3
43	Isparta-Ayazmana Park	1045	North	37°44'48''N-30°34'54''E	Plantation	-
44	Bucak-Seydiköy	892	East	37°30'27''N-30°33'07''E	Plantation	Sb3
45	Kasnak Oak NPA**	1192	Southeast	37°42'46''N-30°50'11''E	Nature	SMkcd2
46	Gölcük NP***	1400	Southeast	37°43'45''N-30°29'05''E	Plantation	ÇkSab2

*Stand property: Main tree species; S: *Cedrus libani*; Çk: *Pinus nigra*; Mk: *Quercus vulcanica*; G: *Abies cilicica*
Age classes of stands according to diameter of 1.30 m; a: 0-7.9 cm, b: 9-19.9 cm, c: 20-35.9 cm, d: 36-51.9 cm, e: >52 cm
Canopy closure; 0: 1-10%, 1: 11-40%, 2: 41-70%, 3: 71-100%.
**NPA: Nature Protection Area; ***NP: Nature Park

Figure 2. Egg, nymph and adult form of the *Cinara cedri* populations respectively

individual specimens. In winged specimens, morphologically similar features were found in transition to the nymph phase. However, wing colours were different in head, thorax and siphunculi. Wings that were bright white during the 1st nymph phase turned darker at the 4th nymph phase. In the winged specimens, the siphunculi area and legs were darker in colour and there were black and grey coloured stripes on the head and thorax area. It was observed in the study that the head, thorax and abdomen area along with the intersection area of the femur and tibia was dark in colour whereas the legs and antennae were yellowish brown (Figure 2). Antenna, leg, abdomen and thorax characteristics were similar to the findings reported by Çanakçıoğlu (1975), Çanakçıoğlu and Mol (1998) and Cebeci (2003).

Mendel et al. (2016) and Cebeci (2003) stated that winged specimens did not have dark coloured stripes and the wings were a greyish-yellow colour. In this study, however, it was observed that some individuals had grey-white wings while some had dark stripes on their wings (Figure 2). This was interpreted to signify that *C. cedri* might have morphological variations under the influence of ecological features.

Adult

In the study, it was observed that adults were generally a dark/black colour in the head region with dark coloured stripes on the thorax and abdomen. It was found that the legs and antennae were dark compared to the nymph stage. However, specimens whose bodies were red in colour were also observed (Figure 2). Usta and Keskin (1992) stated that the head region in adults was dark; Görür (2014) stated that adults' head regions were black in colour - similar to the findings of this study. Çanakçıoğlu (1975) stated that both the winged and wingless viviparous insects had a length of 3.0-4.4 mm while Usta and Keskin (1992) reported lengths ranging from 3.0-3.8 mm. In this study, the average length of adults was found to be length 3.09 mm and width was 1.71 mm - these values were similar to those reported in the literature.

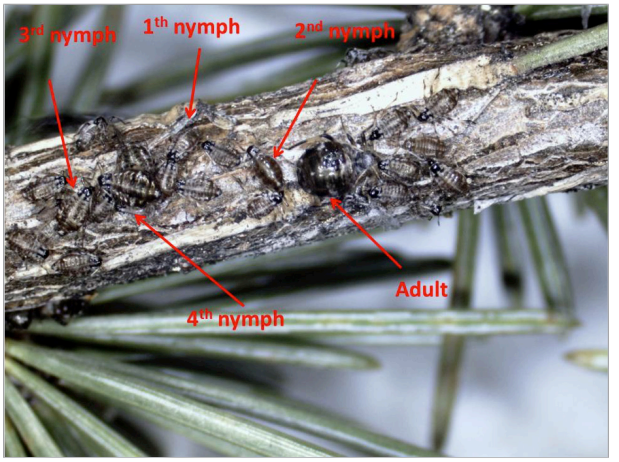


Figure 3. Nymph stages and adult of the *Cinara cedri* on a shoot (29 April 2016)

Biology

In this study, unhatched eggs were also observed in addition to the wingless viviparous specimens that hatched on 03.04.2016. Çanakçıoğlu (1975) stated that the eggs in the İstanbul Bahçeköy Park of the Faculty of Forestry did not hatch on 05.03.1965 - some hatched on 08.04.1965 while most of them hatched on 19.04.1965, which was similar to the findings of this study. In this study, it was observed that a maximum of nine eggs were laid on a needle and Usta and Keskin (1992) and Çanakçıoğlu and Mol (1998) reported similar findings. It was found that wingless viviparous individuals completing four nymph phases in 10 days became adults after parthenogenetically reproducing and these specimens hatched between May and June. In contrast, oviparous individuals were observed to copulate and lay eggs in October-November (Görür et al., 2009).

It was observed that while there was a significant rise in the population twice a year during June and September, the species completed its lifecycle on a single host (Figure 3). These

Figure 4. Damage on needles of *Cinara cedri*

findings are similar to those reported by Usta and Keskin (1992), Çanakçıoğlu and Mol (1998) and Toper Kaygın and Çanakçıoğlu (2003).

Damage

It was observed that *C. cedri* mostly fed on the shoots of the previous year and caused the needles to dry out and turn red.

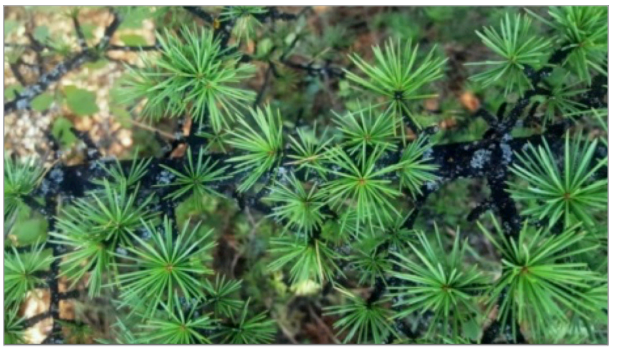
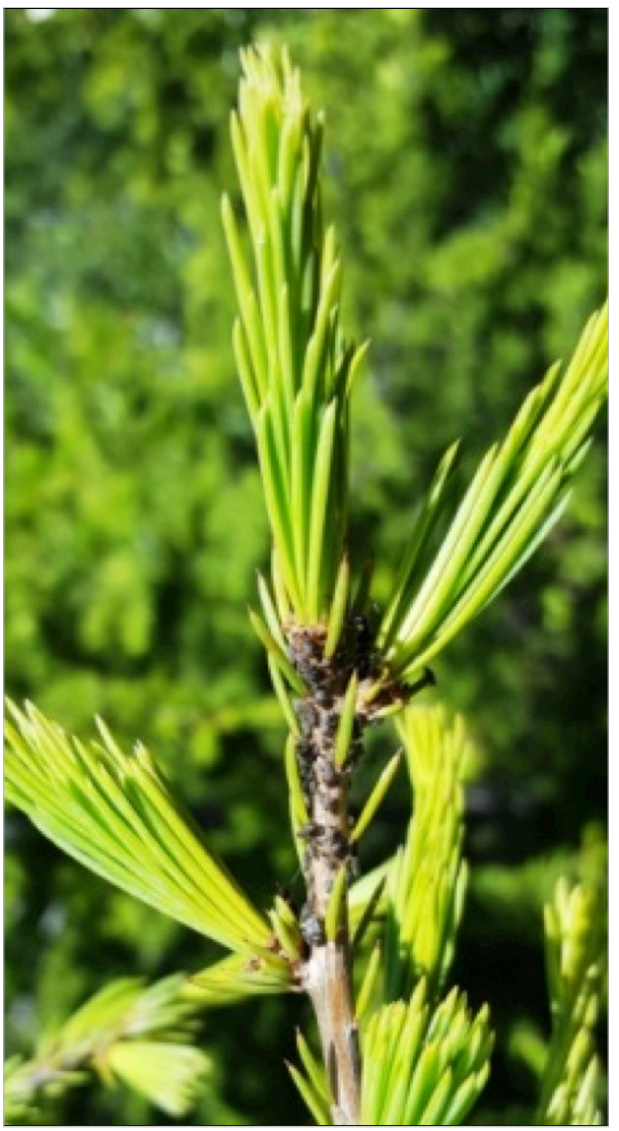


Figure 5. Honeydew on needles and fumagine formation



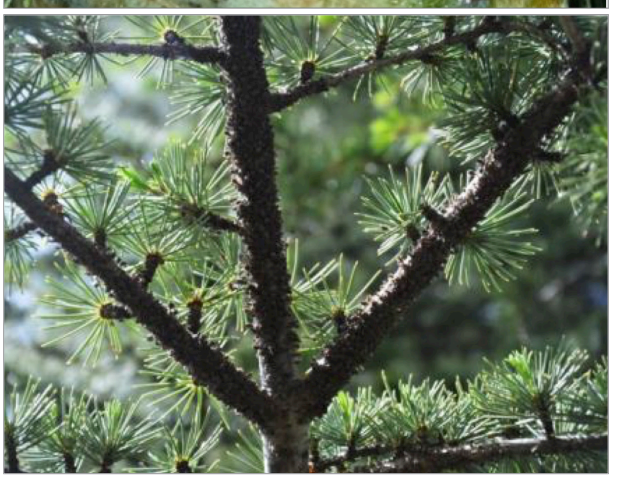


Figure 6. *Cinara cedri* colonies at the end of shoot and cone petiole

Damage was found on young trees in particular, from which the dried needles fell, and that defoliation occurred on shoot tips and canopies. The signs observed in this study were similar to those reported in literature (Binazzi et al., 2015; Çanakçıoğlu, 1975; Düzgüneş et al., 1980; Núñez-Pérez and Tizado, 1996; Tuatay, 1999; Usta and Keskin, 1992; Ünal and Özcan, 2005). Although it was stated in the literature that the seed production capacity of dried needles decreased and led to increment loss, this was not observed in this study. In our study, it was found that the damage was high particularly in Uluborlu and Bucak-Karapınar sites (Figure 4). Binazzi et al. (2015) stated that *C. cedri* might form dense colonies under suitable micro-climate conditions while Mendel et al. (2016) stated that there might be significant loss of needles due to the damage of the species and that would cause the tree to lose its vitality. As it was stated by Çanakçıoğlu and Mol (1998) and Usta and Keskin (1992), the population during high density periods preferred young seedlings in particular, while damage from the species was also found on young trees in this study in Uluborlu and Bucak-Karapınar.

It was found that since *C. cedri* fed on sap, there was a honeydew secretion and honeydew covered the needles, shoots and branches. It was observed that bees were attracted to this honeydew and that fungi growing on honeydew led to fumagine on trees. Intense fumagine formation was found especially in Uluborlu and Bucak-Karapınar (Figure 5). It was also found that colony presence was very high in city centres, parks and gardens and that honeydew secretion dripped on roads, sidewalks and on cars in carparks. Fumagine formation was also reported by many other authors (Binazzi et al., 2015; Çanakçıoğlu, 1975; Düzgüneş et al., 1980; Núñez-Pérez and Tizado, 1996; Tuatay, 1999; Usta and Keskin, 1992; Ünal and Özcan, 2005) and the first damage to this species in our country was observed in the plantation fields in the Mediterranean region (Aytar, 2006).

Dispersal across the tree canopies and occurrence rate on the shoots at different ages of colonies of *Cinara cedri*

In this study, colonies of *C. cedri* were mostly seen on shoots in south and east sections, while fewer were observed on shoots in north and west sections. Çanakçıoğlu (1975) stated that *C. cedri* colonies were only observed on those sections of the cedar that were exposed to light. Colonies were observed particularly on lower branches of both old and young trees, and on the trunks, shoots, shoot tips, branches, branch axils, and cone stems of young trees (Figure 6). Similar findings were also noted in the literature (Aytar, 2006; Çanakçıoğlu and Mol, 1998; Düzgüneş et al., 1980; Tuatay, 1999; Usta and Keskin, 1992; Ünal and Özcan, 2005). However, no information was found in the literature regarding the observation on cone stems. Görür (2014) stated that *C. cedri* was also feeding intensely in trunk cracks. In this study, *C. cedri* was not found in trunk cracks but it was observed on the trunks themselves of young trees.

In the study, the colonies were found on shoots with a diameter of 1.0-1.5 cm. Núñez-Pérez and Tizado (1996), stated that *C. cedri* individuals existed densely on 1.5 cm-diameter branches, which was consistent with the measurements recorded in this study. The thickest shoot diameter was found in shoots located in Bucak-Karapınar with 4.7 cm. Mendel et al. (2016) stated that sometimes colonies covered trunks at a diameter of 5-6 cm. The distance of the colony to the shoot tip was found to be 22.14 cm on average and the width of the colony was 4.11 cm. In the literature no information was found regarding the distance of the colony to the shoot tip and the width of the colony.

CONCLUSION

According to the findings in the areas studied, in general, intensive damage of *C. cedri* was not found. A small number of colonies were observed - mostly on shoots - and (apart from a few sites) yellowing and abscission of leaves along with formation of fumagine were not found intensely. It was found that the *C. cedri* population was higher in those 10 sites established by plantation with young stands and located at an average elevation of 1000-1200 m compared to the others. However, on the trees in the Uluborlu cedar plantation forest, a high amount of fumagine formation from previous years, along with yellowing in some trees and contraction and decrease in needles were observed. In the Bucak-Karapınar village cedar-Crimean pine plantation forest, needle contraction and decrease along with yellowing of trees were identified, yet fumagine formation was observed to be less dense. Furthermore, in city centres, parks and gardens, colonies were much denser and honeydew secretion dripped on roads, sidewalks and cars in carparks.

Many aphid species can easily increase their population size on a variety of hosts and this highlights the importance of the control of these species. As aphids are the prey of many species including Hymenoptera, Coleoptera, Diptera and Neuroptera orders, they have a lot of natural enemies. Therefore, in ecosystems where aphids are intensely observed, biological control is considered more beneficial as opposed to chemical control with its many known side effects. However, in order to switch to biological control, natural enemies should initially be identified. This study is part of a master's thesis and in this study natural enemies of the pest were identified. In this study, it can be stated that natural enemies were effective and kept the balance of the pest population throughout the study field in general.

It is suggested that during forestry activities, as well as identifying natural enemies, the inclusion of other species where possible, preservation of in-forest bushlands and increasing efficiency via a variety of natural enemies, would help maintain the balance of *C. cedri* populations in cedar plantations. Thus, chemical intervention would no longer be required. In populated areas, however, the use of bio-insecticides may be recommended in order to avoid exposure to intense honeydew secretion and fumagine formation. Moreover, the collection and extermination of shoots on which eggs and colonies are found or enabling parasitoid emergence could help contribute to the control of the species.

Ethics Committee Approval: This study does not contain an approach involving humans or animals as a subject. Based on this, ethics committee approval was not necessary for this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – Ş.O., M.A.; Design - Ş.O., M.A.; Supervision - M.A.; Resources - Ş.O., M.A.; Materials - Ş.O., M.A.; Data Collection and/or Processing - Ş.O., M.A.; Analysis and/or Interpretation - Ş.O., M.A.;Literature Search - Ş.O.; Writing Manuscript - Ş.O.; Critical Review – M.A.; Other – Ş.O., M.A.;

Acknowledgements: As this study is part of a master's thesis, we would like to thank the Süleyman Demirel University Fellowship Training Program Coordination for their support with project numbered ÖYP-06475-YL15.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received financial support from Süleyman Demirel University Fellowship Training Program Coordination with project numbered ÖYP-06475-YL15.

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