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Original article (*Orijinal araştırma*)

New contributions to the Turkish aphid fauna and species composition (Hemiptera: Aphididomorpha) in Isparta forests[1]

Türkiye afit faunasına yeni bir katkı ve Isparta ormanlarındaki afit türlerinin (Hemiptera: Aphididomorpha) kompozisyonu

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Abstract

A study was conducted on the aphid fauna of *Pinus nigra* Arnold. subsp. *pallasiana* (Lamb.) Holmboe., *Pinus brutia* Ten., *Cedrus libani* A. Rich., *Abies cilicica* (Antoine & Kotschy) Carrière (Pinaceae), *Juniperus* spp. (Cupressaceae), *Quercus* spp. (Fagaceae) and *Robinia pseudoacacia* L. (Leguminosae) forests in Isparta Province between 2018 and 2020. Using systematic and random sampling, 9,252 specimens in 68 species from the families Aphididae and Phylloxeridae (14 species at genus level only) were identified between 2018 and 2020. It was determined that *Appendiseta robiniae* (Gillette, 1907) collected from *R. pseudoacacia* is a Nearctic species, which was identified as a new record for the aphid fauna of Türkiye. Fifty-five species were detected in 2019, and a further 51 in 2020 using systematic sampling. The species with the highest number of specimens in 2019 were *Myzocallis boerneri* Stroyan, 1957 (16.0%), *Eulachnus rileyi* (Williams, 1911) (12.3%) and *Cinara cedri* Mimeur, 1936 (10.4%). In 2020, the species with the highest number of specimens were *E. rileyi* (10.1%), *A. robiniae* (9.3%) and *Cinara orientalis* (Takahashi, 1924) (7.2%). The highest number of aphid species was collected from *P. nigra* in the three years (2018-2020). The second highest numbers were collected from *Quercus coccifera* L. in 2018 and 2020, and *P. brutia* in 2019.

Keywords: Alien species, aphid, forest trees, Isparta, Türkiye

Öz

Bu çalışma Isparta ilinde *Pinus nigra* Arnold. subsp. *pallasiana* (Lamb.) Holmboe., *Pinus brutia* Ten., *Cedrus libani* A. Rich., *Abies cilicica* (Antoine & Kotschy) Carrière (Pinaceae), *Juniperus* spp. (Cupressaceae), *Quercus* spp. (Fagaceae) ve *Robinia pseudoacacia* L. (Leguminosae) ormanlarında afit faunasını belirlemek amacıyla gerçekleştirilmiştir. Sistematik ve rastgele örnekleme kullanılarak 2018-2020 yıllarında olmak üzere Aphididae ve Phylloxeridae familyalarından 68 türe (14'ü cins düzeyinde) ait 9252 birey toplanmıştır. Nearktik bir tür olan ve *R. pseudoacacia*'dan toplanan *Appendiseta robiniae* (Gillette, 1907)'nin Türkiye afit faunası için yeni kayıt olduğu belirlenmiştir. Sistematik örnekleme kullanılarak 55 tür 2019, 51 tür ise 2020 yılında tespit edilmiştir. En fazla birey sayısına sahip olan türler 2019 yılında *Myzocallis boerneri* Stroyan, 1957 (%16.0), *Eulachnus rileyi* (Williams, 1911) (%12.3) ve *Cinara cedri* Mimeur, 1936 (%10.4); 2020 yılında ise *E. rileyi* (%10.1), *A. robiniae* (%9.3) ve *Cinara orientalis* (Takahashi, 1924) (%7.2) olmuştur. En fazla yaprak biti tür sayısı her üç (2018-2020) yılda da *P. nigra*'dan toplanmıştır. *Pinus nigra*'nın ardından en fazla tür sayısı, 2018 ve 2020 yıllarında *Quercus coccifera* L., 2019 yılında ise *P. brutia*'dan toplanmıştır.

Anahtar sözcükler: Yabancı tür, yaprak biti, orman ağaçları, Isparta, Türkiye

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Introduction

Insects have high levels of species diversity and coexist with many living things in virtually all terrestrial ecosystems. Their importance is due to their various functions, such as participation in the food cycle, pollination, biological management of pests, and wood and litter decomposition, that assist conservation and ensure the continuity of ecosystems (Gullan & Cranston, 2012). Relationships like competition and nutritional status among living things specify the structure of ecosystems. The phytophagous species, which invade the ecosystem and increase their population, are called invasive species when they cause economic or ecological damage. If these harmful populations do not reach an ecological balance within a certain period, many ecological relationships such as biological diversity and the food cycle can then be negatively impacted (Ayres & Lombardero, 2000; Gullan & Cranston, 2012). Aphids (Hemiptera: Aphididomorpha), which are considered significant pests, increase their populations readily by feeding on agricultural, ornamental and forest plant species, and they cause economic loss (Wieczorek et al., 2019).

Aphids cause direct damage by feeding on phloem sap, and they also cause indirect damage by leading to sooty mold and by being a vector of plant pathogens (Uygun et al., 2000; Wieczorek et al., 2019). The sooty mold formation blocks stoma, and it prevents photosynthesis and respiration. However, due to their feeding, a loss of quality and yield was observed in plants that lead to gall formation, leaf curving, yellowing and necrosis resulting in a decrease in seed yield, sprout formation, rates of photosynthesis, chlorophyll quantity and plant nutritional elements (Görür, 2008; Wieczorek et al., 2019; Özdemir, 2020). They feed on many parts of their host plants such as the leaf, stem, root and tubers according to their mouth texture. Therefore, usually more than one type of aphid species can feed on the same host tree plant (Carter & Maslen, 1982). Particularly, the species that are members of the genus *Lachnus* Burmeister, 1835 (Hemiptera: Aphididae) feed on both leaves and stems of the broadleaved and coniferous trees (Chen et al., 2016).

In Europe, many of the invasive aphid species cause significant damage to agriculture, ornamental plants and forest trees (Coeur d'acier et al., 2010). According to Blackman & Eastop (2022), there are 5,000 aphid species in 510 genera, and according to Favret (2022) the number is 5 325 species in 534 genera. However, Simon et al. (2021) suggested that there are about 6 000 aphid species currently recognized. This number of species is estimated to be much higher due to their small body size, higher adaptability, cyclical parthenogenesis and camouflage on a different part of host plants (Blackman & Eastop, 2022; Favret, 2022). Over half of all aphids in the world feed on trees. Of the forest trees, 170, 70, 51, 225, 8 and 29 aphid species were detected on the *Pinus* spp., *Picea* spp., *Abies* spp., *Quercus* spp., *Cedrus* spp. and *Juniperus* spp. respectively (Blackman & Eastop, 2022). In North America, it was found that aphid species on coniferous trees caused major damage (Keen, 1938). Furniss & Carolin (1977) reported that aphid species cause yellowing of needles, slow down growth and cause early defoliation, especially in young trees infested with *Cinara* (*Schizolachnus*) *pineti* (Fabricius, 1781) (Carter & Maslen, 1982). Straw et al. (2005) reported that the *Elatobium abietinum* (Walker, 1849) can cause considerable loss of needles in *Picea sitchensis* (Bong.) Carrière (Pinaceae).

Çalışkan et al. (2012) reported that the North American species, *Myzocallis* (*Lineomyzocallis*) *walshii* (Monell, 1879), which was detected in Adana on *Quercus* sp., was detected for the first time in Europe (France) in 1988, and it then spread rapidly and was observed in many European countries. *Cinara curvipes* (Patch, 1912) as an invasive aphid species was reported in Türkiye in 2015 (Görür et al., 2015).

This study aimed to determine aphid species and their host plant associations in the forests of Isparta Province, Türkiye.

Materials and Methods

This study was conducted in 2018 to 2022 on *Pinus nigra* Arnold. subsp. *pallasiana* (Lamb.) Holmboe., *Pinus brutia* Ten., *Cedrus libani* A. Rich., *Abies cilicica* (Antoine & Kotschy) Carrière (Pinaceae), *Juniperus* spp., *Quercus* spp., and *Robinia pseudoacacia* L. (Leguminosae), which are the main forest trees in Isparta Province. According to the management data of the General Directorate of Forestry, the most common tree species in Isparta Province were determined and sample areas were created in the forests of these tree species. The field sample number was based on the number of areas where tree species are in pure stands, and systematic sampling was performed in 34 areas (8 areas for *P*. *nigra*, 4 for *P*. *brutia*, 5 for *C*. *libani*, 8 for *Juniperus* spp., 2 for *A*. *cilicica*, 5 for *Quercus* spp., and 2 for *R*. *pseudoacacia*) between 2019 and 2020 (Figure 1). Since there are more than one species in the oak and juniper sample areas, sample areas specified as *Juniperus* and *Quercus* genera. In addition, random sampling was carried out within the study areas.

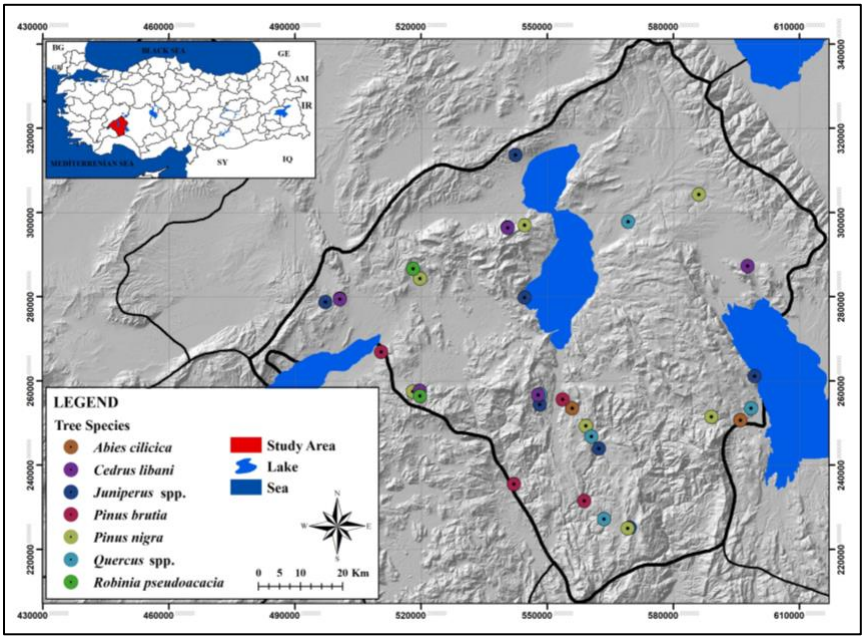

Figure 1. Distribution of sample areas according to tree species in the study area.

Circular sampling areas with a radius of about 25 m (2 000 m^2) were assessed for each tree species using systematic sampling in designated areas and the shoot of the nearest 10 trees in four cardinal directions was sampled by selecting the center point of each sample area. The samples were collected from the 10 trees adjacent to these trees were then sampled in the next month. This was to ensured that the samples were taken from all the trees in the area (Stekolshchikov & Kozlov, 2012). To eliminate any edge effect, trees found on the roadside or near gaps inside the stand were excluded as far as possible (Leather, 2005). Aphids generally feed on the young shoot so it is difficult to detect species with low population density in the canopy of trees, so 30 cm of shoot tips were taken of the sampled branches (Bryant, 1976).

The aphids were collected after they were stimulated with a fine brush (No. 0) and the samples were preserved in 96% ethanol in Eppendorf tubes. The preparation of the samples followed the methods of Martin (1983). Voucher samples were stored at the Entomology Museum of the Forestry Faculty at the Isparta University of Applied Sciences.

The identification of the specimens followed Blackman & Eastop (2022) and assistance was received from Prof. Dr. Gazi Görür (Niğde Ömer Halisdemir University, Faculty of Arts and Sciences) for the diagnosis. The species names and synonyms were checked according to Favret (2022) and de Jong et al. (2022).

Results and Discussions

The 65 species from the family Aphididae within the superfamily Aphidoidea and three species from the family Phylloxeridae within the Phylloxeroidea superfamily in the infraorder Aphididomorpha were detected by the end of the initial field work in 2018 and the systematic and random sampling between 2019 and 2020. In total, 9,252 specimens were collected during the study, with 165 of in the initial fieldwork. Fourteen of the specimens were classified at the genus level due to being alatae and immature specimens. *Thelaxes suberi* (Del Guercio, 1911) was the most abundant species in 2018 with 38 specimens and *Myzocallis* (*Myzocallis*) *boerneri* Stroyan, 1957 with 835 specimens and *Appendiseta robiniae* (Gillette, 1907) with 360 specimens were the most abundant species in 2019 and 2020 respectively (Table 1).

Table 1. Aphid species were identified in forests of Isparta Province between 2018 and 2020

No	Species	2018		2019		2020		Total	
		No	%	No	%	No	%	No	%
1	*Acyrthosiphon* (*Acyrthosiphon*) *gossypii* Mordvilko, 1914	0	0.00	1	0.02	2	0.05	3	0.03
2	*Acyrthosiphon* (*Acyrthosiphon*) *pisum* (Harris, 1776)	0	0.00	6	0.12	0	0.00	6	0.06
3	*Aphis* (*Aphis*) *craccivora* Koch, 1854	0	0.00	129	2.48	252	6.49	381	4.12
4	*Aphis* (*Aphis*) *spiraecola* Patch, 1914	0	0.00	0	0.00	13	0.33	13	0.14
5	*Aphis* sp.	0	0.00	1	0.02	86	2.22	87	0.94
6	*Appendiseta robiniae* (Gillette, 1907)	0	0.00	178	3.42	**360**	**9.27**	538	5.81
7	*Cinara* (*Cinara*) *acutirostris* Hille Ris Lamber's, 1956	0	0.00	3	0.06	0	0.00	3	0.03
8	*Cinara* (*Cinara*) *brauni* (Börner, 1940)	0	0.00	3	0.06	11	0.28	14	0.15
9	*Cinara* (*Cinara*) *cedri* Mimeur, 1936	2	1.21	**542**	**10.41**	141	3.63	**685**	**7.40**
10	*Cinara* (*Cinara*) *curvipes* (Patch, 1912)	0	0.00	31	0.6	48	1.24	79	0.85
11	*Cinara* (*Cinara*) *intermedia* (Pasek, 1954)	6	3.64	44	0.85	72	1.85	122	1.32
12	*Cinara* (*Cinara*) *juniperensis* (Gillette & Palmer, 1925)	1	0.61	79	1.52	25	0.64	105	1.13
13	*Cinara* (*Cedrobium*) *laportei* (Remaudière, 1954)	0	0.00	7	0.13	97	2.50	104	1.12
14	*Cinara* (*Cinara*) *maghrebica* Mimeur, 1934	0	0.00	51	0.98	0	0.00	51	0.55
15	*Cinara* (*Cinara*) *matsumurana* Hille Ris Lambers, 1966	0	0.00	1	0.02	13	0.33	14	0.15
16	*Cinara* (*Cinara*) *pectinatae* (Nordlinger, 1880)	0	0.00	74	1.42	0	0.00	74	0.80
17	*Cinara* (*Cinara*) *pini* (L., 1758)	0	0.00	2	0.04	0	0.00	2	0.02
18	*Cinara* (*Cinara*) *pinihabitans* (Mordvilko, 1894)	0	0.00	2	0.04	0	0.00	2	0.02
19	*Cinara* (*Cinara*) *piniphila* (Ratzeburg, 1844)	0	0.00	9	0.17	0	0.00	9	0.10
20	*Cinara* (*Cinara*) *pinivora* (Wilson, 1919)	0	0.00	30	0.58	12	0.31	42	0.45
21	*Cinara* (*Cinara*) *schimitscheki* Börner, 1940	1	0.61	7	0.13	17	0.44	25	0.27
22	*Cinara* (*Cinara*) sp. (on *Pinus nigra* and *P. brutia*)	2	1.21	37	0.71	16	0.41	55	0.59
23	*Cinara* (*Cinara*) sp. (on *Cedrus libani*)	0	0.00	16	0.31	15	0.39	31	0.34
24	*Cinara* (*Cinara*) sp. (on *Juniperus* spp.)	1	0.61	69	1.33	39	1.00	109	1.18
25	*Cinara* (*Cinara*) sp. (on *Abies cilicica*)	0	0.00	0	0.00	3	0.08	3	0.03
26	*Cinara* (*Cinara*) *wahluca* Hottes, 1952	2	1.21	251	4.82	185	4.77	438	4.73
27	*Cinara* (*Cinara*) *watanabei* Inouye, 1970	0	0.00	16	0.31	0	0.00	16	0.17
28	*Cinara* (*Cupressobium*) *tujafilina* (Del Guercio, 1909)	0	0.00	2	0.04	0	0.00	2	0.02
29	*Cinara* (*Schizolachnus*) *obscura* (Börner, 1940)	0	0.00	37	0.71	126	3.25	163	1.76
30	*Cinara* (*Schizolachnus*) *orientalis* (Takahashi, 1924)	23	13.9	163	3.13	**280**	**7.21**	466	5.04
31	*Cinara* (*Schizolachnus*) *pineti* (Fabricius, 1781)	0	0.00	192	3.69	80	2.06	272	2.94
32	*Cinara* (*Schizolachnus*) sp.	0	0.00	28	0.54	26	0.67	54	0.58
33	*Eulachnus agilis* (Kaltenbach, 1843)	0	0.00	42	0.81	6	0.15	48	0.52
34	*Eulachnus cembrae* Börner, 1950	0	0.00	7	0.13	0	0.00	7	0.08
35	*Eulachnus nigricola* (Pasek, 1953)	2	1.21	212	4.07	184	4.74	398	4.30
36	*Eulachnus pumilae* Inouye, 1939	0	0.00	19	0.37	14	0.36	33	0.36
37	*Eulachnus rileyi* (Williams, 1911)	7	4.24	**639**	**12.28**	**393**	**10.12**	**1039**	**11.23**
38	*Eulachnus* sp.	8	4.85	153	2.94	245	6.31	406	4.39
39	*Eulachnus thunbergi* Wilson, 1919	0	0.00	9	0.17	0	0.00	9	0.10

Table 1. Continued

No	Species	2018		2019		2020		Total	
		No	%	No	%	No	%	No	%
40	*Eulachnus tuberculostemmatus* Theobald, 1915	2	1.21	180	3.46	170	4.38	352	3.80
41	*Hoplocallis picta* (Ferrari, 1872)	0	0.00	1	0.02	3	0.08	4	0.04
42	*Hoplochaetaphis zachvatkini* (Aizenberg & Moravskaya, 1959)	0	0.00	0	0.00	75	1.93	75	0.81
43	*Hoplochaitophorus dicksoni* Quednau, 1999	0	0.00	5	0.10	0	0.00	5	0.05
44	*Lachnus crassicornis* Hille Ris Lambers, 1948	0	0.00	106	2.04	0	0.00	106	1.15
45	*Lachnus pallipes* (Hartig, 1841)	1	0.61	0	0.00	0	0.00	1	0.01
46	*Lachnus roboris* (L., 1758)	11	6.67	72	1.38	12	0.31	95	1.03
47	*Lachnus* sp.	0	0.00	6	0.12	8	0.21	14	0.15
48	*Lachnus swirskii* Hille Ris Lambers, 1954	13	7.88	1	0.02	0	0.00	14	0.15
49	*Lachnus tuataye* Remaudière, 2005	7	4.24	10	0.19	11	0.28	28	0.30
50	*Macrosiphum* sp.	0	0.00	0	0.00	1	0.03	1	0.01
51	*Mindarus abietinus* Koch, 1857	0	0.00	2	0.04	0	0.00	2	0.02
52	*Mindarus kinseyi* Voegtlin, 1995	0	0.00	0	0.00	114	2.94	114	1.23
53	*Mindarus* sp.	0	0.00	0	0.00	6	0.15	6	0.06
54	*Myzocallis* (*Myzocallis*) *boerneri* Stroyan, 1957	0	0.00	**835**	**16.0**	9	0.23	**844**	**9.12**
55	*Myzocallis* (*Myzocallis*) *glandulosa* Hille Ris Lambers, 1948	15	9.09	67	1.29	191	4.92	273	2.95
56	*Myzocallis* (*Pasekia*) *komareki* (Pašek. 1953)	0	0.00	0	0.00	20	0.52	20	0.22
57	*Myzocallis* (*Pasekia*) *mediterranea* Quednau & Remaudière, 1994	0	0.00	300	5.76	146	3.76	446	4.82
58	*Myzocallis* sp.	15	9.09	99	1.90	197	5.07	311	3.36
59	*Phylloxera quercina* (Ferrari, 1872)	0	0.00	22	0.42	0	0.00	22	0.24
60	*Phylloxera quercus* Boyer de Fonscolombe, 1834	0	0.00	0	0.00	6	0.15	6	0.06
61	*Phylloxera* sp.	0	0.00	0	0.00	7	0.18	7	0.08
62	*Pseudessigella brachychaeta* Hille Ris Lambers. 1966	2	1.21	11	0.21	26	0.67	39	0.42
63	*Thelaxes* sp.	1	0.61	0	0.00	1	0.03	2	0.02
64	*Thelaxes suberi* (Del Guercio, 1911)	**38**	**23.0**	302	5.80	79	2.04	419	4.53
65	*Thelaxes valtadorosi* Remaudière, 1983	0	0.00	0	0.00	6	0.15	6	0.06
66	*Tuberculatus* (*Tuberculoides*) *annulatus* (Hartig, 1841)	0	0.00	0	0.00	27	0.70	27	0.29
67	*Tuberculatus* (*Tuberculoides*) *borealis* (Krzywiec, 1971)	5	3.03	76	1.46	3	0.08	84	0.91
68	*Tuberculatus* sp.	0	0.00	18	0.35	3	0.08	21	0.23
	Total	**165**	**100**	**5205**	**100**	**3882**	**100**	**9252**	**100**

Although the most common species in 2019 were *M*. *boerneri*, *Eulachnus rileyi* (Williams, 1911) and *Cinara cedri* Mimeur, 1936 with 835 (16.0%), 639 (12.3) and 542 (10.4%) specimens, respectively, the least common species were *Acyrthosiphon gossypii* Mordvilko, 1914, *Aphis* sp., *Cinara matsumurana* Hille Ris Lambers, 1966, *Hoplocallis picta* (Ferrari, 1872) and *Lachnus tuataye* Remaudière, 2005 with only one specimen for each species. In 2020, the most common species were *E*. *rileyi*, *A*. *robiniae* and *Cinara orientalis* (Takahashi, 1924), with 393 (10.1%), 360 (9.3%) and 280 (7.2%) specimens respectively. However, at the end of the study the most common species were *E*. *rileyi* (1039), *M*. *boerneri* (844), and *C*. *cedri* (685). In 2020, it is notable that the detection of the most common species (*A*. *robiniae* with 360 specimens) on the host plant *R*. *pseudoacacia*, was from only two sampling areas using systematic sampling. It is concluded that *A*. *robiniae* was among the highest detected species as a result of its host plant-specific nature (Görür et al., 2014, 2020; Oğuzoğlu & Avcı, 2019; Kök et al., 2020, 2022; Kök & Özdemir, 2021; Patlar et al., 2021).

Studies in Türkiye have been conducted in both forest and non-forest areas, but few studies have reported aphid fauna for forest areas alone. The first studies on aphids determined in forest areas in Türkiye were made by Çanakçıoğlu (1966, 1967). Later, Tosun (1976) found five aphid species in Western Mediterranean Region. Özkazanç & Yücel (1985) species in Western Mediterranean Region. Özkazanç & Yücel (1985) detected 14 aphid species in *Pinus*, *Cedrus* and *Quercus* species in their semiarid zone plantations in Ankara. Cebeci (2003) stated that *Pineus pini* (Goeze, 1778) dried needles and shoots of

Pinus sylvestris L. in afforestation areas in Istanbul. Aytar (2006), *C*. *cedri* and *Cinara laportei* (Remaudiere, 1954) species identified on *Cedrus libani* in the forests in Eastern Mediterranean Region. Finally, Oğuzoğlu & Avcı (2019) determined the distribution, damage and natural enemies of *C*. *cedri* in the cedar forests of Isparta and Burdur Provinces. When looking at other studies, eighteen aphid species were detected in the Gölcük Nature Park in Isparta Province (Barjadze et al., 2014), 58 aphid species on *P*. *nigra*, *Quercus* spp., *Juniperus* spp., *C*. *libani* and *A*. *cilicica* were detected in Central Anatolia (Afyonkarahisar, Kütahya and Uşak Provinces) (Görür et al., 2014), 48 aphid species were detected in city parks in Burdur Province (Patlar et al., 2021) and 54 aphid species were detected in Antalya Province (Güleç, 2011). Comparing the number of aphid species to the number of host plants in the regions close to the study area, it was evident that the number of aphid species was high. Also, 68 aphid species from different host plants including some forest trees have been reported in Kahramanmaraş in Eastern Mediterranean Region (Aslan & Uygun, 2005). In Central Anatolian Region, 11 aphid species on *Pinus* spp., *Abies* spp., *Cedrus* spp. and *Picea* spp. were detected in city parks (Ülgentürk et al., 2010).

In Türkiye, to date *Aphis craccivora*, *A*. *craccivora* subsp. *pseudacaciae* Takahashi, 1966, *A*. *fabae* Scopoli, 1763, *A*. *gossypii* Glover, 1877, *A*. *spiraecola* Patch, 1914, *A*. *nasturtii* Kaltenbach, 1843, *A*. *sambuci*, *Brachycaudus* (*Brachycaudus*) *helichrysi* and *Therioaphis riehmi* (Börner, 1949) have been found on *R*. *pseudoacacia* (Schimitscheki, 1944; Yüksel, 1998; Bayhan et al., 2014; Aslan & Uygun, 2005; Toper Kaygın et al., 2008; Akyürek, 2013; Görür et al., 2014, 2018; Kök et al., 2016; Patlar et al., 2021). The feeding of *Appendiseta robiniae* on the *R*. *pseudoacacia* is a new record for Turkish aphid fauna, thus the Turkish aphid fauna reached 615 species (Figure 2) (Görür et al., 2022).

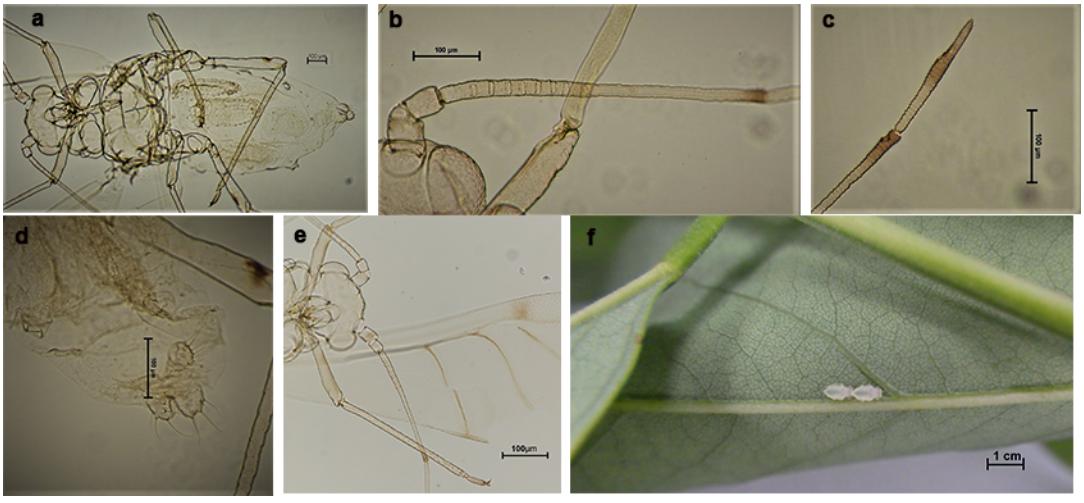

Figure 2. The taxonomic characteristics of *Appendiseta robiniae*: a) body of alate viviparous female; b) secondary rhinaria on antenna segment III; c) last segment of the antenna (base + processus terminalis); d) siphinculi and cauda; e) antenna and front wing) and f) *A*. *robiniae* alate viviparous female on the underside of a host plant leaf.

Appendiseta robiniae is an alien species in Türkiye and Europe being a Nearctic species (Borowiak-Sobkowiak & Durak, 2012). It is considered that it was introduced to the Neotropic and West Palearctic regions with host plants. It was recorded in Argentina, Chile, England, Germany, Hungary, Iran, Italy, Jordan, Netherlands, Poland, Russia, South America, Spain and Sweden (Borowiak-Sobkowiak & Durak, 2012; Entezari et al., 2016; Blackman & Eastop, 2022). This species was detected on *R*. *pseudoacacia*, *Robinia neomexicana* A. Gray, *Vitex agnus-castus* L. and *Sophora japonica* L. (Entezari et al., 2016; Blackman & Eastop, 2022). With the entry of this new alien aphid, the number of alien aphid species in Türkiye has reached 58 species (Kök & Özdemir, 2021). Also, it is assumed that this species was introduced to Türkiye some time ago given it having the highest number with a total of 538 specimens collected in 2019 and 2020. The distribution of aphid sampling numbers based on host species in the sampling area is given in Figure 3.

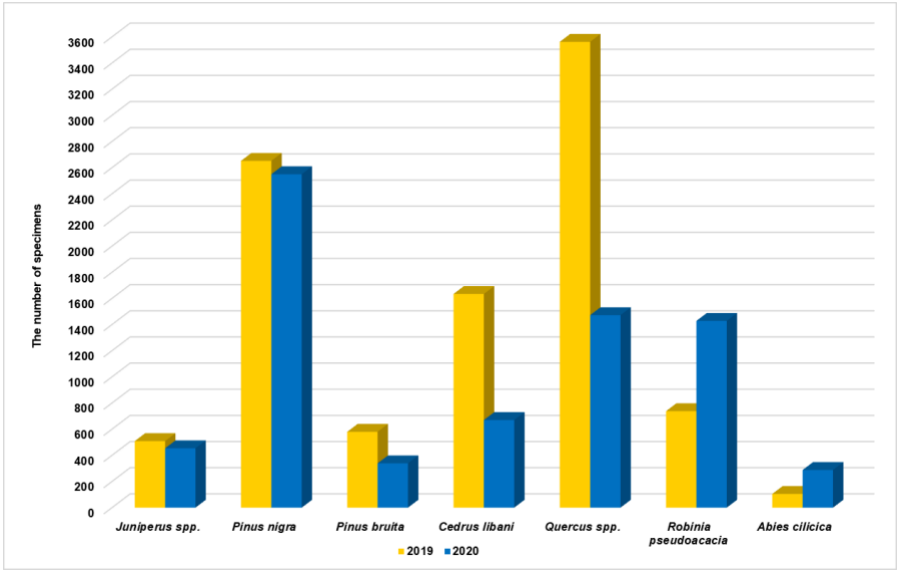

Figure 3. Number of aphid specimens collected from host trees in 2019 and 2020.

The highly infested host plants were the *C*. *libani*, *P*. *nigra*, *R*. *pseudoacacia* and *Quercus* spp. and the least infested tree species were the *A*. *cilicica*, *P*. *brutia* and *Juniperus* spp. in 2019 and 2020. Considering the aphid species distribution at genus level, the results show that the most infested host plant genus was *Cinara* with a 38% infestion rate, followed by the *Eulachnus* and *Lachnus*. However, only one aphid species was detected on the *Appendiseta*, *Hoplocallis*, *Hoplochaetaphis*, *Hoplochaitophorus*, *Macrosiphum*, and *Pseudessigella* (Figure 4).

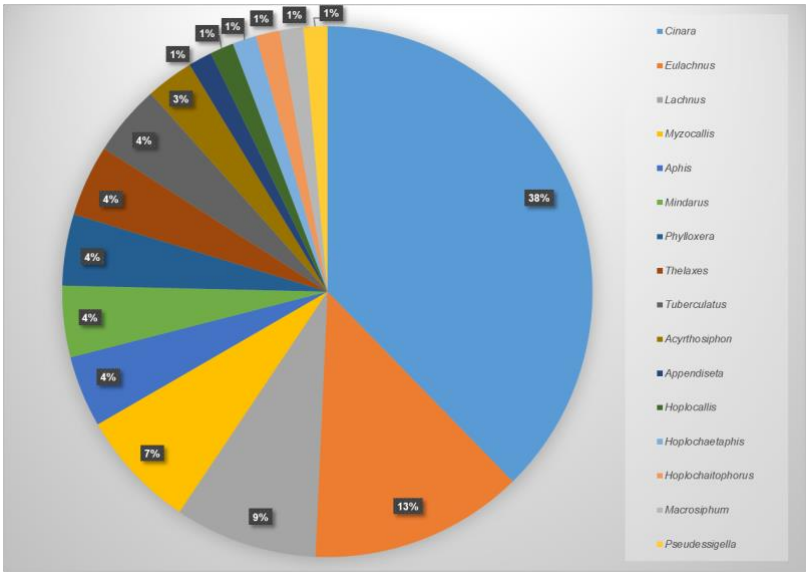

Figure 4. Aphid species distributions at genus level.

Aphids have been detected on plants in nearly 300 families and many are specific to certain host plant genera or families (Jaouannet et al., 2014; Blackman & Eastop, 2022). Therefore, aphid host-plant associations were considered in this study, and 68 aphid species were detected on 14 host species. In areas of the *Juniperus* spp., five aphid species were detected and the highest number of aphid species was detected on the most common species in this genus, namely the *Juniperus excelsa* (4 aphid species). Twenty-three aphid species were detected on the *Pinus* spp., and the highest number of aphid species

were detected on the *P*. *nigra*. Four aphid species were detected in areas of *C*. *libani* and six aphid species were detected in areas of *A*. *cilicica*. Görür et al. (2015) reported that *C*. *curvipes* feeds on both the *C*. *libani* and *A*. *cilicica*, and *C*. *curvipes* was also observed in this study on both these host plant members. In total, 22 aphid species were detected on *Quercus* with *Q*. *cerris* infested by the highest number of aphid species (15 species) and *M*. *glandulosa* was collected from all oak trees. *Robinia pseudoacacia* was included in the study due its importance as a forest tree with seven aphid species detected on this host. The aphid species composition was determined using systematic sampling in different forest habitats (Table 2).

Table 2. The relationships between aphid species and host trees

Host plants species	**Aphid species**
Robinia pseudoacacia	*Acyrthosiphon* (*Acyrthosiphon*) *gossypii*
	Acyrthosiphon (*Acyrthosiphon*) *pisum*
	Aphis (*Aphis*) *craccivora*
	Aphis (*Aphis*) *spiraecola*
	Aphis sp.
	Appendiseta robiniae
	Macrosiphum sp.
Abies cilicica	*Cinara* (*Cinara*) *matsumurana*
	Cinara (*Cinara*) *pectinatae*
	Cinara (*Cinara*) sp.
	Mindarus abietinus
	Mindarus kinseyi
	Mindarus sp.
Juniperus excelsa, *J. foetidissima*, *J. oxycedrus*	*Cinara* (*Cinara*) sp., *C*. (*Cinara*) *juniperensis*, *C*. (*Cinara*) *wahluca*
Juniperus excels	*Cinara* (*Cupressobium*) *tujafilina*
Cedrus libani	*Cinara* (*Cinara*) *cedri*
	Cinara (*Cinara*) *curvipes*
	Cinara (*Cinara*) *laportei*
	Cinara (*Cinara*) sp.
Pinus nigra	*Cinara* (*Cinara*) *acutirostris*, *C*. (*Cinara*) *brauni*, *C*. (*Cinara*) *intermedia*, *C*. (*Cinara*) *pini*, *C*. (*Cinara*) *pinihabitans*, *C*. (*Cinara*) *piniphila*, *C*. (*Cinara*) *schimitscheki*, *C*. (*Cinara*) *watanabei*, *Eulachnus agilis*, *E*. *cembrae*, *E*. *thunbergi*
Pinus nigra, *P*. *brutia*	*Cinara* (*Cinara*) sp., *C*. (*Cinara*) *maghrebica*, *C*. (*Cinara*) *pinivora*, *C*. (*Schizolachnus*) *obscura*, *C*. (*Schizolachnus*) *orientalis*, *C*. (*Schizolachnus*) *pineti*, *C*. (*Schizolachnus*) sp., *Eulachnus* sp., *E*. *nigricola*, *E*. *pumilae*, *E*. *rileyi*, *E*. *tuberculostemmatus*, *Pseudessigella brachychaeta*
Quercus cerris, *Q*. *trojana*, *Q*. *infectoria*, *Q*. *ithaburensis*	*Hoplocallis picta*
Quercus cerris, *Q*. *trojana*, *Q*. *vulcanica*	*Hoplochaetaphis zachvatkini*
Quercus ithaburensis	*Hoplochaitophorus dicksoni*
Quercus coccifera, *Q*. *vulcanica*, *Q*. *trojana*, *Q*. *cerris*	*Lachnus crassicornis*
Quercus cerris	*Lachnus pallipes*, *Phylloxera quercina*
Quercus coccifera, *Q*. *cerris*	*Lachnus roboris*, *Lachnus tuataye*
Quercus ithaburensis, *Q*. *coccifera*, *Q*. *cerris*	*Lachnus* sp.
Quercus coccifera	*Lachnus swirskii*, *Thelaxes valtadorosi*
Quercus ithaburensis, *Q*. *infectoria*, *Q*. *vulcanica*, *Q*. *trojana*, *Q*. *cerris*	*Myzocallis* (*Myzocallis*) *boerneri*
Quercus robur, *Q*. *coccifera*, *Q*. *ithaburensis*, *Q*. *infectoria*, *Q*. *vulcanica*, *Q*. *trojana*, *Q*. *cerris*	*Myzocallis* (*Myzocallis*) *glandulosa*
Quercus ithaburensis, *Q*. *infectoria*, *Q*. *cerris*	*Myzocallis* (*Pasekia*) *komareki*
Quercus robur, *Q*. *coccifera*, *Q*. *ithaburensis*, *Q*. *vulcanica*, *Q*. *trojana*, *Q*. *cerris*	*Myzocallis* (*Pasekia*) *mediterranea*
Quercus ithaburensis, *Q*. *infectoria*, *Q*. *vulcanica*, *Q*. *cerris*	*Myzocallis* sp.
Quercus infectoria	*Phylloxera quercus*, *Phylloxera* sp.
Quercus coccifera, *Q*. *infectoria*	*Thelaxes* sp.

Table 2. Continued

Host plants species	Aphid species
Quercus coccifera, *Q. ithaburensis*, *Q. infectoria*, *Q. vulcanica*, *Q. cerris*	*Thelaxes suberi*
Quercus infectoria, *Q. vulcanica*	*Tuberculatus* (*Tuberculoides*) *annulatus*
Quercus infectoria, *Q. vulcanica*, *Q. cerris*	*Tuberculatus* (*Tuberculoides*) *borealis*
Quercus vulcanica	*Tuberculatus* sp.

Considering the distribution of aphid species by host species, it was found that more than half of the species were detected on *P. nigra* (30%) and *Quercus* spp. (28%), followed by *Pinus brutia* these host with 17% of species (Figure 5). Comparing coniferous and broadleaved trees, it was observed that more than half of the aphid species were on coniferous trees (58%). The fact that coniferous tree species sampled in the study were higher than the broadleaved ones could be affected by the distribution of aphid species.

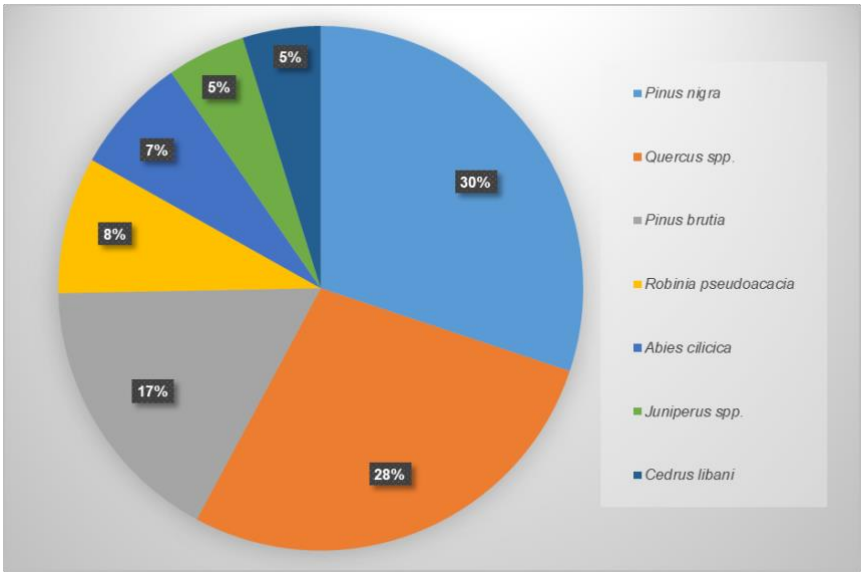

Figure 5. Distribution of aphid species detected on host trees.

During the study, the most infested host tree was *P. nigra* (Figure 6), followed by the *Quercus coccifera* and *P. brutia*. Considering the number of host species, aphids were observed on eight species in 2018 and on 15 species in 2019 and 2020. Over the three years, the greatest aphid species diversity was mostly found on *Q. cerris* with 15 aphid species. It was noted that this aphid on the endemic oak, *Q. vulcanica*, was a first record in Türkiye with 10 aphid species detected on this host. Forty-two aphid species have been detected on oak trees in Türkiye (Çanakçıoğlu, 1975; Düzgüneş et al., 1980; Özkazanç & Yücel, 1985; Tuatay, 1999; Uygun et al., 2000; Aslan & Uygun, 2005; Eser et al., 2009; Görür et al., 2009, 2014, 2018; Tepecik, 2010; Çalışkan et al., 2012; Akyürek, 2013; Kanturski et al., 2014; Öztürk, 2017; Kök, 2019; Patlar et al., 2021) and 23 (55%) of these species were detected in the present study. *Cinara curvipes*, *C. matsumurana*, *C. pectinatae* and *Mindarus kinseyi* Voegtlin, 1995 were observed on the *A. cilicica* in the present study. Also, two aphid species [*Cinara juniperensis* (Gillette & Palmer, 1925) and *C. wahluca*] on the *Juniperus foetidissima* Willd. 1806 was detected for the first time in Türkiye. Seven aphid species have previously been found on *Juniperus communis*, *J. oxycedrus*, *J. excelsa*, *J. nana*, *J. sabina* and *Juniperus* spp. in Türkiye (Çanakçıoğlu, 1975; Tosun, 1976; Tuatay, 1999; Görür et al., 2009, 2014; Ülgentürk et al., 2010; Akyürek, 2013; Şenol et al., 2015; Oğuzoğlu et al., 2021).

Sixty-eight aphid species were detected using random and systematic sampling in this study, with 65% of these detected by systematic sampling and 35% by random sampling. The highest number of species found by random sampling was in 2018 with 22 (39%) specimens, followed by 20 (36%) specimens

in 2020 and finally 14 (25%) specimens in 2019. *Lachnus swirskii* Hille Ris Lambers, 1954, *L. pallipes*, *Thelaxes valtadorosi* Remaudière, 1983 and *Phylloxera quercus* Boyer de Fonscolombe, 1834 were detected on *Quercus* spp. and *Cinara pini* was detected on *P. nigra* only by random sampling.

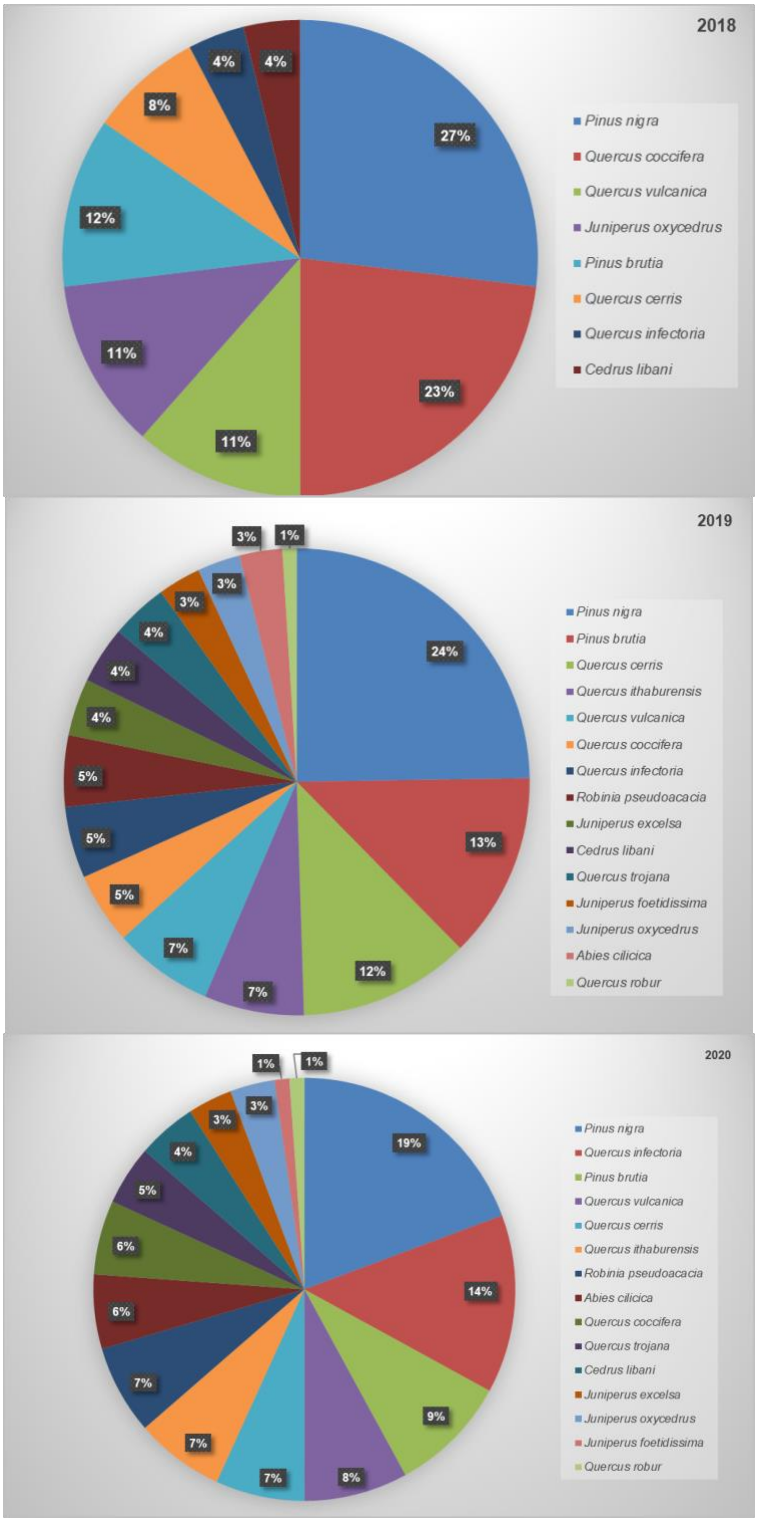

Figure 6. Associations between aphid species and host trees between 2018 and 2020.

Barjadze et al. (2014) detected *T*. *suberi* on a rock in the Gölcük Nature Park and there are no aphid records on oak trees except for this finding in study area. However, in Bitlis-Tatvan (Eastern Anatolia Region) *T*. *suberi* was recorded on *Quercus conferta* (synonym of *Quercus frainetto* Ten.) as *Thelaxes confertae* Börner, 1942 (synonym of *T*. *suberi* see Favret, 2022) (Tuatay & Remaudière, 1964). Ten aphid species on the endemic oak *Q*. *vulcanica* was recorded for the first time during the present study, so the aphid species except for the *T*. *suberi* are new records for Isparta aphid fauna. *Hoplochaitophorus dicksoni* Quednau, 1999, *Myzocallis mediterranea*, *Phylloxera quercina*, *Thelaxes valtadorosi*, *Tuberculatus borealis*, *Mindarus kinseyi*, *C*. *curvipes*, *C*. *piniphila*, *C*. *intermedia*, *C*. *orientalis*, *Eulachnus cembrae* and *E*. *thunbergii* were new records for the Turkish aphid fauna in the last 10 years (Görür et al., 2014; Görür et al., 2015; Görür et al., 2018) and were also collected in the present study. Forty-two aphid species were detected on oak trees and 35 aphid species have been detected on pine trees in Türkiye. In Isparta Province, 23 (55% of all records in Türkiye) and 21 (62% of all records in Türkiye) aphid species have been detected on oak trees and pine trees respectively (Görür et al., 2014, 2018).

Aphids do not directly cause the death of trees, but when aphid populations increase on young trees intense needle loss can be observed. In literature, it was reported that when the aphid's density, particularly with *C*. *cedri*, occasionally increase with climate changes, they can cause to death of their host plants (Çanakçıoğlu, 1975; Düzgüneş et al., 1980; Usta & Keskin, 1992; Núñez-Pérez & Tizado, 1996; Çanakçıoğlu & Mol, 1998; Tuatay, 1999; Ünal & Özcan, 2005; Binazzi et al., 2015; Mendel et al., 2016; Oğuzoğlu & Avcı, 2019). It is suggested that monitoring populations of *M*. *boerneri* and *E*. *rileyi* which had high population densities in the study area, will be useful for predicting and responding to the risk of future damage.

The detection and monitoring of harmful species are key to ensure the proper biological control of these species, the conservation of ecological balance in the forestry areas, and sustainable management. Thus, the protection and increase of biological diversity will be support continued forestry in Türkiye. Over recent years, new records of many new aphid species in Türkiye are increasing the possibility of there being other unknown aphid species in Turkish forests, which have a rich biodiversity and a high endemism rate. The fact that only a few studies on aphids have been conducted in forest areas also supports this conclusion. It has been reported that 10% of the Turkish aphid fauna consist of alien species (Akyıldırım et al., 2013; Görür et al., 2017; Oğuzoğlu et al., 2021; Kök & Özdemir, 2021). It is predicted that *A*. *robiniae*, which was detected for the first time in Türkiye, may increase in distribution due to the host distribution of this species, which is an economically important and ecologically valuable species, being frequently used in parks, gardens and forests, and for roadside plantings, erosion control and soil improvement in Türkiye (Bridgen, 1992; Li et al., 2014; Okulu, 2019).

Aphids are important in the ecosystems both directly as a prey resource of predators and parasitoids, and indirectly by secreting a honeydew, which provides nutrition for many organisms such as ants and bees. The identification of 68 aphid species on 14 host plants indicated that the species diversity was high and when considering that the aphids supply a nutrient to many organisms, this aphid diversity in the study area is significant. This study, which was conducted in Isparta Province in the Lake District, which is among the areas rich in biodiversity, concludes that the detection of aphids will contribute to forestry studies and the field of science in Türkiye.

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