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Original article (Orijinal araştırma)

Diversity and plant interactions of aphids (Hemiptera: Aphidomorpha) adjacent to Çardak Lagoon with new aphid and host records for Turkey

Türkiye için yeni afit ve konukçu kayıtları ile birlikte Çardak Lagün alanındaki afitlerin (Hemiptera: Aphidomorpha) çeşitliliği ve bitki etkileşimleri

Şahin KÖK[1*]

Abstract

This study aimed to reveal the diversity of aphid species and aphid-plant interactions adjacent to Çardak Lagoon, which is close to agricultural areas in Çanakkale Province of Turkey. Twenty-seven aphid species belonging to 17 genera in three subfamilies from the Aphididae (Hemiptera) were identified. Of these, *Staticobium latifoliae* (Bozhko, 1950) is new record from the genus *Staticobium* Mordvilko, 1914 and *Aphis symphyti* Schrank, 1801 are new records for the aphid fauna of Turkey. With these new records, the number of the aphid fauna of Turkey has increased to 596 species from 149 genera in the infraorder Aphidomorpha (Hemiptera). Of the hosts, *Geranium pusillum* L., *Geranium columbinum* L. (Geraniaceae), *Anagallis arvensis* L. (Primulaceae), *Polygonum maritimum* L. (Polygonaceae), *Myosotis* sp. (Boraginaceae), *Anthriscus caucalis* M. Bieb. (Apiaceae), *Raphanus raphanistrum* L. (Brassicaceae), *Anthemis* sp. (Asteraceae) and *Silene* sp. (Caryophyllaceae) are new hosts for the aphids in Turkey, respectively. Results of this detailed study conducted adjacent to the lagoon which has a diversity of hosts native to saline and sandy soils for the first time in Turkey provides important data on the diversity of aphids and the interactions with their hosts, and that this data will contribute a better understanding of aphid-plant interactions in agricultural and non-agricultural habitats as well as the biology and control strategies of host-alternate aphid pests.

Keywords: Aphid, Çanakkale, aphid-plant interactions, lagoon, Turkey

Öz

Bu çalışma 2020 ve 2021 yıllarında Nisan-Eylül arasında Türkiye'nin Çanakkale İli'nde tarım alanlarına yakın bir bölgede yer alan Çardak Lagününde bulunan afit türlerinin çeşitliliği ve afit-bitki etkileşimlerini ortaya çıkarmayı amaçlamaktadır. Aphididae (Hemiptera) familyasından üç altfamilya içerisinde 17 cinse ait 27 afit tespit edilmiştir. Bu türlerden, *Staticobium* Mordvilko, 1914 cinsinden yeni kayıt olan *Staticobium latifoliae* (Bozhko, 1950) ve *Aphis symphyti* Schrank, 1801 Türkiye afit faunası için yeni kayıtlardır. Bu yeni kayıtlar ile birlikte Türkiye afit faunası Aphidomorpha (Hemiptera) alttakımı içerisinde 149 cinse ait 596 türe yükselmiştir. Konukçulardan, *Geranium pusillum* L., *Geranium columbinum* L. (Geraniaceae), *Anagallis arvensis* L. (Primulaceae), *Polygonum maritimum* L. (Polygonaceae), *Myosotis* sp. (Boraginaceae), *Anthriscus caucalis* M. Bieb. (Apiaceae), *Raphanus raphanistrum* L. (Brassicaceae), *Anthemis* sp. (Asteraceae) ve *Silene* sp. (Caryophyllaceae) Türkiye'de afitler için yeni konukçu kayıtları olarak tespit edilmiştir. Türkiye'de ilk kez tuzlu ve kumlu topraklara özgü konukçu çeşitliliğine sahip bir lagünde yürütülen bu detaylı çalışmanın sonuçları afitlerin çeşitliliği ve onların konukçuları ile etkileşimleri üzerine önemli veriler sağlamaktadır. Bu veriler tarım ve tarımdışı habitatlardaki afit-bitki etkileşimlerinin daha iyi anlaşılmasının yanı sıra konukçu değişimi gösteren zararlı afitlerin biyoloji ve kontrol stratejilerine katkı sağlayacaktır.

Anahtar sözcükler: Afit, Çanakkale, afit-bitki etkileşimleri, lagün, Türkiye

[1] Çanakkale Onsekiz Mart University, Lapseki Vocational School, Department of Plant and Animal Production, 17800, Çanakkale, Turkey
* Corresponding author (Sorumlu yazar) e-mail: sahinkok@gmail.com
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Introduction

Aphids (Hemiptera: Aphidomorpha) are one of the most important pest groups that can cause serious economic losses on agricultural crops throughout the world. Aphids can damage crops by sucking plant sap, causing gall and deformities from toxins in their saliva, causing sooty mold due to secreted honeydew and by transmitting more than 270 plant viruses that cause serious economic damage to agricultural crops (Katis et al., 2007). All crops are known to be a host for at least one pest aphid (Peters et al., 1991). About 40% of aphid species live on trees, the other 55% prefer to feed on flowering herbaceous plants and shrubs (the host selection of the remaining 5% is unknown). Consequently, it is known that aphids feed on hosts in 300 families (Blackman & Eastop, 2021). Several studies, including Toros et al. (2002), Özdemir et al. (2005), Görür et al. (2012), Kanturski et al. (2014, 2018), Şenol et al. (2015), Kök et al. (2016), Kök & Kasap (2019), Özdemir (2020), have identified more species, hereby increasing the number of aphid species in Turkey to a total of 596 aphid species, 26 of which are subspecies, belonging to 149 genera (Kök & Özdemir, 2021; Patlar et al., 2021).

Aphids are an insect group commonly known to specialize on a particular host even if they have a range of possible hosts. Aphids can show different responses to different habitats such as agricultural, non-agricultural, urban and landscape areas in terms of their diversity, species richness, abundance, plant interactions and diversity of natural enemies (Janković et al., 2017; Kök et al., 2020; Barczak et al., 2021). Also, non-crop contexts such as stubble and pasture areas, roadsides, urban and landscape areas are important as refuge habitats for aphids with a migratory life cycle (Wilkaniec et al., 2015). Among these areas, lagoons are defined as semi-connected coastal ponds located on the edge of seas with a large coastal zone; they are also considered as geographical heritage due to their rare geomorphological formations (Kocataş, 1999; Doğaner, 2003). Lagoons are biological and economic rich at points where aquatic and terrestrial ecosystems converge (Viaroli et al., 2007). Çardak Lagoon in Çanakkale Province, Turkey, particularly, is of great importance as it is close to agricultural areas producing fruits, vegetables and cereal crops, and the plant diversity found there as potential secondary hosts to migrating aphids. Considering this situation, aphid diversity and aphid-plant interactions not only in agricultural areas, but also in non-agricultural areas should be examined in detail.

Aphids have a rich diversity and distribution in both agricultural and non-agricultural areas due to their host and non-host-alternating life cycles. Today, about 15% of aphids, most of which are polyphagous pest species, have a host-alternating life cycle (Blackman & Eastop, 2007). Detailed examination of host-alternating aphid species and their plant interactions within agricultural and nearby non-agricultural areas is important in terms of understanding the biology, damage and population densities of such aphids as well as their control strategies on agricultural crops. In this study, it is hypothesized that the vegetation adjacent to a coastal lagoon, consisting mostly halophytic and dune plants, and close to agricultural areas can contribute to the local diversity and number of aphid fauna of Turkey and it can contain secondary hosts for migrating aphid pests. In this context, this study aimed to reveal the diversity of aphid species and aphid-plant interactions adjacent to Çardak Lagoon, which is close to agricultural areas producing fruit, vegetables and cereal crops in Çanakkale Province, Turkey.

Materials and Methods

Sampling site

Çardak Lagoon is located on the northeastern shore of the Dardanelles Strait, which separates the European and Asian continents. Coordinates of this lagoon are 40°22'36"-40°23'36" N and 26°42'45"-26°44'18" E. The sampling area generally consists of a spit and a lagoon lake between it and the mainland. The soil structure of the sampling area consists of alluviums, brown forest soils and coastal sand soils. Also, the sampling area has a transitional character between Mediterranean and Black Sea climate types.

The lagoon and its surroundings, including the sampling area, are windy throughout the year. Considering the vegetation of the sampling area, there are reeds along the mainland shore of the lagoon. Also, there are more trees to the east of the lagoon and dune plants are distributed on the surface of the spit (Çalışkan & Tosunoğlu, 2010).

Figure 1. Map showing the sampling area adjacent to Çardak Lagoon in the Çanakkale Province of northwest Turkey (Anonymous, 2021).

Collection, preparation and identification of aphids

Aphid sampling was conducted from their hosts including flower herbaceous plants, shrubs and trees found adjacent to Çardak Lagoon in Çanakkale Province of northwest Turkey between April-September from 2020 to 2021. The apterous and alate aphids collected from hosts were transferred with a soft brush (#00) into the Eppendorf tubes containing 70% ethanol and brought to the laboratory for the identification. The preparation of the aphid specimens followed the method of Hille Ris Lambers (1950). The identification of aphids was done by the author using a LEICA DM 2500 microscope with a mounted HD camera and LAS 4.1 version software according to Blackman & Eastop (2006; 2021). Current taxonomic status and names of the identified aphid species were stated as in Favret (2021). For new aphid species to the fauna of Turkey, detailed measurements of morphological characters, ratios of different body parts and chaetotaxy were also examined. Abbreviations of morphological characters for apterous and alatae aphids used in this study are: BL, body length; HW, head width; ANT, whole antenna length; ANT I, ANT II, ANT III, ANT IV, ANT V and ANT VI, antennal segments lengths; ANT III BD, antennal segment III basal diameter; LsH on ANT III, antennal segment III longest hair length; ANT VI base, antennal segment VI base length; ANT VI PT, processus terminalis of antennal segment VI; Urs (R IV+V), ultimate rostral segment length; HFem, hind femur length; HTib, hind tibia length; Ht I, hind tibia first segment length; Ht II, hind tibia second segment length; Siph, siphinculi; hairs on ABD Tergite III, abdominal tergite segment III hair length; LFh, length of frontal hairs; and DFf, deeper frontal furrow. The slides of the identified aphid specimens were deposited in the Systematic Laboratory in the Department of Plant Protection of Çanakkale Onsekiz Mart University.

Aphid-plant interactions

The graphs of bipartite network interactions were constructed based on the data of aphid and host relative abundances for aphid-plant interactions for all years using functions of bipartite in R version 3.6.1 (R Core Team, 2021).

Results and Discussion

Diversity of aphids adjacent to Çardak Lagoon and new records for the aphid fauna of Turkey

Twenty-seven aphid species belonging to 17 genera in three subfamilies from family Aphididae (Hemiptera: Aphidomorpha) were identified from the study area. The identified aphid species and their hosts according to current taxonomic status follow. Also, for new aphids of the aphid fauna of Turkey, detailed description, measurements of morphological characters, number of setae on different body parts and chaetotaxy, ratio of different body parts, preparation figures, distribution and short biology are provided.

Order Hemiptera

Infraorder Aphidomorpha

Family Aphididae

Subfamily Aphidinae

***Acyrthosiphon malvae* (Mosley, 1841)**

Material examined. Çanakkale, Çardak, 19.V.2020, apt. 7♀♀, alt. 2♀♀, *Geranium pusillum* L. (Geraniaceae); 27.V.2021, apt. 4♀♀, alt. ♀, *Geranium columbinum* L. (Geraniaceae).

***Aphis fabae* Scopoli, 1763**

Material examined. Çanakkale, Çardak, 11.VI.2020, apt. 5♀♀, alt. 3♀♀, *Chenopodium* sp. (Amaranthaceae); 16.V.2021, apt. 4♀♀, alt. ♀, *Galium aparine* L. (Rubiaceae); 10.VII.2020, apt. 5♀♀, alt. 3♀♀, *Rumex* sp. (Polygonaceae).

***Aphis nasturtii* Kaltenbach, 1843**

Material examined. Çanakkale, Çardak, 10.V.2020, apt. 6♀♀, alt. 2♀♀, *Anagallis arvensis* L. (Primulaceae).

***Aphis polygonata* (Nevsky, 1929)**

Material examined. Çanakkale, Çardak, 19.VI.2020, apt. 6♀♀, alt. 2♀♀, *Polygonum maritimum* L. (Polygonaceae).

***Aphis ruborum* (Börner, 1931)**

Material examined. Çanakkale, Çardak, 21.VI.2021, apt. 4♀♀, alt. 2♀♀, *Rubus sanctus* Schreb. (Rosaceae).

***Aphis solanella* Theobald, 1914**

Material examined. Çanakkale, Çardak, 24.V.2020, apt. 4♀♀, *Papaver rhoeas* L. (Papaveraceae); 14.IV.2021, apt. 6♀♀, *Capsella rubella* Reut. (Brassicaceae).

***Aphis symphyti* Schrank, 1801**

A. symphyti is a new species record for the aphid fauna of Turkey.

Material examined. Çanakkale, Çardak, 11.V.2020, apt. 4♀♀, alt. 2♀♀, *Anchusa hybrida* Ten. (Boraginaceae).

Description. Color of apterous viviparous female specimens on slide; ANT I dark brown, ANT II paler brown, ANT III and IV pale, ANT V pale with brown apices, ANT VI wholly brown or dark brown; head dark; coxa dark or dusky, trochanter dusky, femur and tibia dusky with dark brown apices, hind tibia I and II dark brown, rostrum pale in base, III and URS brown or dark brown; siph wholly dark, and cauda usually paler

than siph. Body of apterous viviparous female more rounded or elliptical (Figure 2b). HW about 0.24 x BL. ANT PT 2.08-2.58 x ANT VI base (Figure 2e). Antennal tubercle weakly developed (Figure 2c). ANT III of alate female with 8-9, ANT IV 5 and ANT V 2-3 secondary rhinaria. The number of hairs of antennal segments of apterous females: ANT I 5-6, ANT II 3-5 and ANT III 10-11. Longest hairs on ANT III about 0.01-0.02 mm, and 0.45-0.67 x ANT BD III. Rostrum reach to the hind coxa and URS 1.24-1.36 x HT II, and generally two hairs present on URS (Figure 2f). Dorsal abdomen without dark markings and dorsal hairs on ABD tergites about 0.02-0.03 mm. Siph wholly dark and without reticulated zone (Figure 2h). Siph 1.59-1.79x cauda, and 0.16-0.21 x body length. Tongue-shaped cauda paler than siph, and bearing 6-7 hairs (Figure 2i), and its length 1.56-1.71 x width (Table 1). *A. symphyti* is difficult to distinguish morphologically from *Aphis* (*Aphis*) *gossypii* Glover, especially on the hosts belonging to the Boraginaceae. Considering the host difference, it is known that *A. symphyti* living under leaves, stems and inflorescence of *Symphytum officinale* L. (Boraginaceae) (Stroyan, 1984). Also, *A. symphyti* has a monoecious holocyclic life cycle, which is only known to be completed on *S. officinale* (Blackman & Eastop, 2021).

Key for identification of *Aphis symphyti* of apterous females on the hosts, *Anchusa* sp. (Boraginaceae) and *Symphytum* sp. (Boraginaceae) (Blackman & Eastop, 2021)

1. ANT VI PT/Base less than 1. Siph absent…….....*Geoica* sp.

- ANT VI PT/Base more than 1. Siph present……......2

2. ANT tubercles undeveloped or weakly developed.....3

- ANT tubercles well developed.....*Macrosiphum* spp., *Ovatomyzus* spp., other polyphagous aphids

3. Cauda helmet shaped.....*Brachycaudus* spp.

- Cauda tongue shaped.....4

4. Cauda and siph black, and bearing 11-24 hairs.....*Aphis fabae*

- Cauda usually paler than siph, and bearing 4-8 hairs.....5

5. R IV+V 0.120-0.160 mm (more than 0.135 mm) and siph 0.330-0.380 mm.....*Aphis symphyti*

- R IV+V 0.075-0.135 mm and siph 0.330-0.440 mm.....*Aphis gossypii*

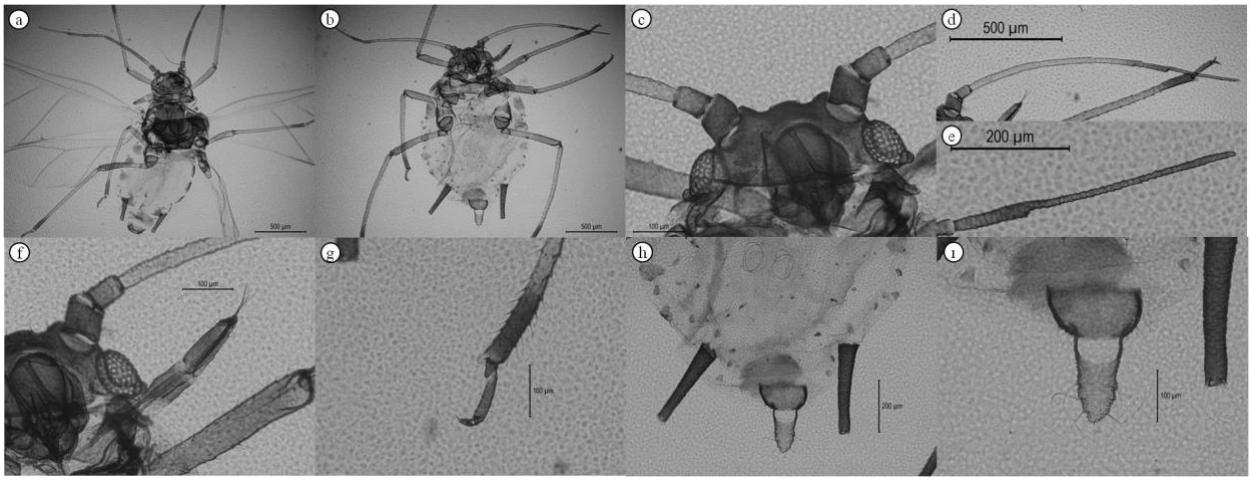

Figure 2. *Aphis symphyti*: a) body of alatae viviparous female; b) body of apterous viviparous female; c) antennal tubercle of apterous female; d) wholly antenna of apterous female; e) ANT VI PT of apterous female; f) URS (R IV+V) of apterous female; g) Ht I and Ht II of apterous female; h) siph of apterous female; and i) cauda of apterous female.

Table 1. Morphometric data (mm) for *Aphis symphyti* from Çanakkale

	Morphometric characters (mm)	*Aphis symphyti*	
		Apterous female (n=4)	Alate female (n=2)
Length of body parts	BL	1.711 (1.578-2.001)	1.649 (1.674-1.625)
	HW	0.410 (0.393-0.436)	0.388 (0.396-0.380)
	ANT	1.379 (1.358-1.436)	1.334 (1.328-1.340)
	ANT I	0.074 (0.067-0.084)	0.065 (0.061-0.070)
	ANT II	0.069 (0.066-0.071)	0.067 (0.070-0.065)
	ANT III	0.329 (0.307-0.345)	0.323 (0.325-0.320)
	ANT III BD	0.028 (0.027-0.029)	0.026 (0.022-0.030)
	LsH on ANT III	0.016 (0.013-0.018)	0.013 (0.011-0.014)
	ANT IV	0.238 (0.235-0.243)	0.215 (0.210-0.220)
	ANT V	0.223 (0.217-0.231)	0.208 (0.211-0.205)
	ANT VI	0.444 (0.425-0.481)	0.456 (0.451-0.460)
	ANT VI base	0.132 (0.122-0.156)	0.123 (0.126-0.120)
	ANT VI PT	0.312 (0.301-0.325)	0.333 (0.325-0.340)
	URS (R IV+V)	0.145 (0.139-0.153)	0.142 (0.139-0.145)
	HFem	0.513 (0.501-0.534)	0.415 (0.410-0.420)
	HTib	0.933 (0.892-0.979)	0.891 (0.883-0.900)
	Ht I	0.038 (0.036-0.041)	0.037 (0.034-0.040)
	Ht II	0.112 (0.107-0.116)	0.108 (0.105-0.110)
	Siph	0.365 (0.318-0.340)	0.223 (0.216-0.230)
	Cauda length	0.193 (0.182-0.203)	0.145 (0.142-0.148)
	Cauda width	0.118 (0.108-0.126)	0.109 (0.105-0.112)
	Hairs on ABD tergite III	0.030 (0.024-0.031)	0.016 (0.014-0.018)
Number of setae on different body parts	ANT I	6 (5-6)	7 (6-8)
	ANT II	4 (3-5)	5 (5-5)
	ANT III	10 (10-11)	9 (8-9)
	URS (R IV+V)	2 (2-2)	2 (2-2)
	Cauda	7 (6-7)	6 (5-7)
Number of secondary rhinaria on antennal segments	ANT III	0	9 (8-9)
	ANT IV	0	5 (5-5)
	ANT V	0	3 (2-3)
Ratio of different body parts	Whole antenna/body	0.811 (0.717-0.836)	0.808 (0.793-0.824)
	PT/base	2.392 (2.083-2.581)	2.817 (2.801-2.833)
	PT/ANT III	0.949 (0.891-1.000)	1.031 (1.000-1.062)
	URS/Ht II	1.297 (1.241-1.353)	1.320 (1.323-1.318)
	Siph/ANT III	0.987 (0.936-1.052)	0.691 (0.664-0.718)
	Siph/body length	0.190 (0.163-0.208)	0.135 (0.129-0.141)
	Siph/cauda	1.686 (1.591-1.791)	1.537 (1.520-1.556)
	Siph/hind femur	0.633 (0.604-0.664)	0.536 (0.526-0.547)
	Cauda length/cauda width	1.639 (1.563-1.705)	1.336 (1.352-1.321)
	LsH on ANT III/BD III	0.561 (0.448-0.666)	0.483 (0.500-0.466)

Distribution. *Aphis symphyti* is distributed throughout the European continent except for Scandinavia and Iberian Peninsula (Blackman & Eastop, 2021).

Biology. *Aphis symphyti* lives generally under leaves, stems and inflorescences of *Symphytum officinale* L. (Boraginaceae) and on other hosts in the Boraginaceae. This species has a monoecious

holocyclic life cycle with alate males and it completes its life cycle only on *S. officinale* (Stroyan, 1984; Blackman & Eastop, 2021).

***Brachycaudus amygdalinus* (Schouteden, 1905)**

Material examined. Çanakkale, Çardak, 19.V.2020, apt. 8♀♀, alt. 3♀♀, *Prunus dulcis* (Mill.) D.A. Webb (Rosaceae).

***Brachycaudus cardui* (Linnaeus, 1758)**

Material examined. Çanakkale, Çardak, 19.VIII.2021, apt. 7♀♀, Unknown plant species (Asteraceae).

***Brachycaudus helichrysi* (Kaltenbach, 1843)**

Material examined. Çanakkale, Çardak, 11.V.2020, apt. 4♀♀, alt. 3♀♀, *Anthemis* sp. (Asteraceae); 14.VI.2021, apt. 4♀♀, alt. ♀, *Artemisia santolina* Schrenk (Asteraceae); 14.VI.2020, apt. 5♀♀, alt. 2♀♀, *Myosotis* sp. (Boraginaceae); 16.IV.2021, apt. 5♀♀, alt. 2♀♀, *Senecio vulgaris* L. (Asteraceae); 12.VI.2021, apt. 4♀♀, alt. ♀, *Silybum marianum* (L.) Gaertn. (Asteraceae).

***Brevicoryne brassicae* (Linnaeus, 1758)**

Material examined. Çanakkale, Çardak, 16.VI.2020, apt. 6♀♀, alt. ♀, *Brassica nigra* (L.) K. Koch (Brassicaceae).

***Capitophorus similis* van der Goot, 1915**

Material examined. Çanakkale, Çardak, 11.VI.2021, apt. 7♀♀, *Elaeagnus angustifolia* L. (Elaeagnaceae).

***Hyadaphis foeniculi* (Passerini, 1860)**

Material examined. Çanakkale, Çardak, 23.IV.2020, apt. 4♀♀, *Anthriscus caucalis* M. Bieb. (Apiaceae)

***Hyalopterus pruni* (Geoffroy, 1762)**

Material examined. Çanakkale, Çardak, 13.VI.2021, apt. 3♀♀, alt. ♀, *Phragmites australis* (Cav.) Trin. Steud. (Poaceae).

***Hyperomyzus lactucae* (Linnaeus, 1758)**

Material examined. Çanakkale, Çardak, 14.V.2020, apt. 4♀♀, alt. 3♀♀, *Crepis* sp. (Asteraceae), 25.VI.2020; apt. 4♀♀, alt. 2♀♀, *Sonchus oleraceus* (L.) L. (Asteraceae), 15.VII.2021; apt. 5♀♀, alt. 2♀♀, *Sonchus* sp. (Asteraceae).

***Lipaphis pseudobrassicae* (Davis, 1914)**

Material examined. Çanakkale, Çardak, 11.V.2020, apt. 4♀♀, *Raphanus raphanistrum* L. (Brassicaceae).

***Macrosiphoniella tapuskae* (Hottes & Frison, 1931)**

Material examined. Çanakkale, Çardak, 19.V.2021, apt. 6♀♀, *Anthemis* sp. (Asteraceae).

***Macrosiphoniella pulvera* (Walker, 1848)**

Material examined. Çanakkale, Çardak, 15.V.2020, apt. 5♀♀, *Artemisia* sp. (Asteraceae).

***Myzus* sp.**

Material examined. Çanakkale, Çardak, 10.IX.2021, apt. 4♀♀, alt. 2♀♀, *Geranium molle* L. (Geraniaceae).

***Rhopalosiphum padi* (Linnaeus, 1758)**

Material examined. Çanakkale, Çardak, 24.V.2020, apt. 4♀♀, *Hordeum murinum* L. (Poaceae).

***Staticobium latifoliae* (Bozhko, 1950)**

S. latifoliae is a new species record for the aphid fauna of Turkey.

Material examined. Çanakkale, Çardak, 11.V.2020, apt. 4♀♀, alt. ♀, *Limonium narbonense* Mill. (Plumbaginaceae); 14.VI.2021, apt. 2♀♀, alt. ♀, *Limonium* sp. (Plumbaginaceae).

The genus *Staticobium* Mordvilko, 1914 contains 12 aphid species associated with the hosts in the Plumbaginaceae in salt-marsh and coastal habitats. The aphids in this genus are morphologically close to the genus *Macrosiphoniella* Del Guercio (Blackman & Eastop, 2021).

Description. Color of apterous viviparous female specimens on slide; ANT I and II dark brown or dark, ANT III and IV dusky with dark apices, ANT V wholly dark brown, base of ANT VI dark brown and PT of ANT VI dusky with paler apices; head dusky brown; coxa dark, trochanter dusky or pale, femur and tibia mostly pale with dark brown apices, hind tibia I and II dusky, rostrum generally pale and URS paler brown; siph dark with paler base, and cauda wholly pale. Body of apterous viviparous female mainly elliptical (Figure 3c); HW about 0.25 x BL. ANT PT 3.57-4.05 x ANT VI base (Figure 3f). Antennal tubercle well developed with diverging apices (Figure 3d). Length of frontal hairs 0.04-0.06 mm (Figure 3d). ANT III of apterous female with 0-3 secondary rhinaria mainly in base, ANT IV and V without secondary rhinaria while ANT III of alate female with 4-5 secondary rhinaria, ANT IV and V without secondary rhinaria (Figure 3h,i). The number of hairs of antennal segments of apterous females: ANT I 6-8, ANT II 4-6 and ANT III 11-14. Longest hairs on ANT III about 0.02-0.04 mm, and 0.68-0.94 x ANT BD III. Rostrum exceeds the middle coxa and URS 0.97-1.13 x HT II, and 4-6 hairs present on URS (Figure 3g). ABD tergites I-VI with dorsal hairs mostly arising from dark scleroites, and about 0.02-0.05 mm (Figure 3j). Siph dark with paler base, and reticulated zone of it (%) 37.24-51.36 (Figure 3k). Siph 1.30-2.30 x cauda, and 0.20-0.27 x body length. Cauda with 7-10 hairs (Figure 3l), and its length 1.45-2.29 x width (Table 2). On *S. latifoliae*, depth of frontal grove 0.15-0.28 (on average 0.21) x distance between apices of antennal tubercle, on *Staticobium smailovae* Kadyrbekov, 2004 which is morphologically a taxon between *S. latifoliae* and *Staticobium staticis* (Theobald, 1923) depth of frontal grove 0.14-0.18 x distance between apices of antennal tubercle. The apterous antennae of *S. latifoliae* are 1.0-1.3 times the body length and the apterous antennae of *S. staticis* are 0.6-0.9 times the body length.

Key for identification of *Staticobium latifoliae* of apterous females on the host, *Limonium* sp. (Plumbaginaceae) (Blackman & Eastop, 2021)

1. Siph dark in distally and pale in basal, polygonal reticulation of siph extending over distal 0.300-0.550 of length. Hairs on dorsal arising from small dark scleroites.....2

- Siph pale or dark, polygonal reticulation of siph extends only 0.130-0.200 of length. Hairs on dorsal not arising from small dark scleroites.....*Aphis* sp. and other polyphagous aphids

2. Hairs on dorsal very small, longest hairs on ANT III 0.200-0.300 × BD III.....*Staticobium gmelini*

- Hairs on dorsal evident, longest hairs on ANT III 0.500-1.500 × BD III.....3

3. Cauda bearing 4 (sometimes 5) hairs.....*Staticobium loochooense*

- Cauda bearings 6-13 hairs.....4

4. Cauda 1.0-1.5 × its basal width and rounded at apex.....*Staticobium longisetosum*/*caucasicum*

- Cauda 1.4-2.4 × its basal width and pointed at apex.....5

5. Hairs on dorsal not arising from scleroites, R IV+V 0.730-0.900 × HT II…*Staticobium otolepidis*/*suffruticosum*

- Hairs on dorsal arising from dark scleroites, R IV+V 0.900-1.300 × HT II.....6

6. ANT VI PT/Base 3.100-3.700 mm. R IV+V 1.000-1.100 × HT II.....*Staticobium* sp.

- ANT VI PT/Base 3.500-5.500 mm. R IV+V 0.900-1.300 × HT II.....7

7. Siph 0.290-0.370 × BL, siph 1.000-1.200 × ANT III; reticulation over 0.350-0.420 of length….*Staticobium limonii*

- Siph 0.140-0.300 × BL, siph 0.580-1.150 × ANT III; reticulation over distal 0.350-0.550 of length.....8

8. Siph 0.140-0.230 × BL, siph 0.900-1.500 × cauda, which bearing 6-11 (usually 7-8) hairs....*Staticobium staticis*

- Siph 0.230-0.300 × BL, siph 1.250-2.00 × cauda, which bearing 7-14 (usually 8-11) hairs.....*Staticobium latifoliae*

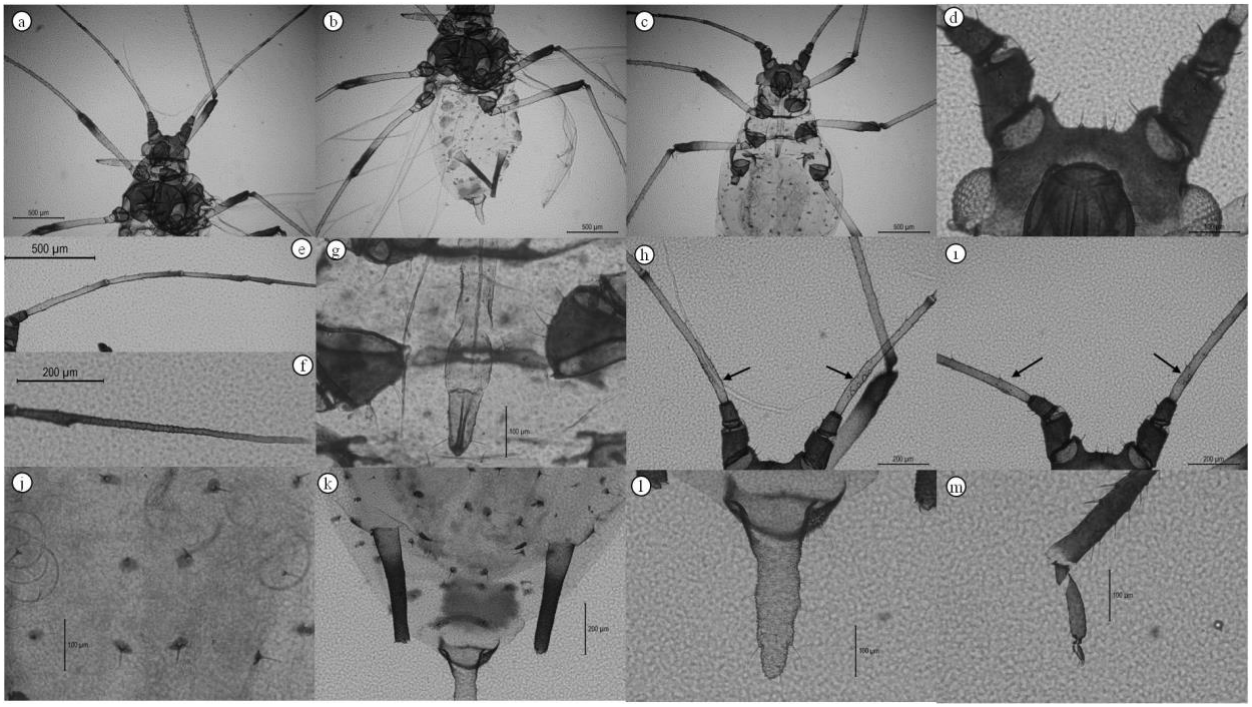

Figure 3. *Staticobium latifoliae*: a,b) body of alatae viviparous female; c) body of apterous viviparous female; d) antennal tubercle and frontal hairs of apterous female; e) wholly antenna of apterous female; f) ANT VI PT of apterous female; g) URS (R IV+V) of apterous female; h) secondary rhinaria on antennal segments of alatae female; i) secondary rhinaria on antennal segments of apterous female; j) dorsal hairs on ABD tergites of apterous female; k) siph of apterous female; l) cauda of apterous female; and m) Ht I and Ht II of apterous female.

Distribution. *S. latifoliae* is distributed in Bulgaria, Greece, Hungary, Iran, Italy, Kazakhstan, Lebanon, Pakistan, Russia, Romania, Tajikistan and Ukraine (Blackman & Eastop, 2021).

Biology. *S. latifoliae* feed on undersides of leaves and flower stalks of *Limonium* spp. (Blackman & Eastop 2021).

Table 2. Morphometric data (mm) for *Staticobium latifoliae* from Çanakkale

	Morphometric characters (mm)	*Staticobium latifoliae*	
		Apterous female (n=6)	Alate female (n=2)
Length of body parts	BL	2.082 (1.938-2.335)	1.965 (1.806-2.124)
	HW	0.523 (0.450-0.557)	0.481 (0.475-0.488)
	ANT	2.222 (1.972-2.510)	2.537 (2.438-2.637)
	ANT I	0.144 (0.140-0.150)	0.126 (0.116-0.136)
	ANT II	0.096 (0.088-0.101)	0.102 (0.100-0.103)
	ANT III	0.519 (0.459-0.562)	0.566 (0.530-0.603)
	ANT III BD	0.035 (0.030-0.040)	0.036 (0.035-0.037)
	LsH on ANT III	0.029 (0.024-0.036)	0.029 (0.028-0.030)
	ANT IV	0.425 (0.368-0.487)	0.490 (0.475-0.506)
	ANT V	0.345 (0.299-0.378)	0.421 (0.410-0.432)
	ANT VI	0.690 (0.594-0.844)	0.837 (0.817-0.857)
	ANT VI base	0.145 (0.130-0.168)	0.141 (0.136-0.146)
	ANT VI PT	0.545 (0.464-0.676)	0.696 (0.681-0.711)
	URS (R IV+V)	0.148 (0.142-0.157)	0.148 (0.147-0.148)
	HFem	0.806 (0.733-0.867)	0.797 (0.722-0.872)
	HTib	1.443 (1.270-1.568)	1.498 (1.352-1.645)
	Ht I	0.046 (0.041-0.050)	0.043 (0.041-0.045)
	Ht II	0.141 (0.127-0.155)	0.135 (0.135-0.135)
	Siph	0.486 (0.440-0.607)	0.457 (0.418-0.488)
	Cauda length	0.287 (0.243-0.350)	0.255 (0,222-0.289)
	Cauda width	0.152 (0.130-0.175)	0.119 (0.100-0.138)
	Hairs on ABD tergite III	0.036 (0.022-0.050)	0.037 (0.030-0.048)
	LFh	0.050 (0.039-0.061)	0.030 (0.027-0.035)
	DFf	0.053 (0.042-0.065)	0.054 (0.052-0.059)
Number of setae on different body parts	ANT I	7 (6-8)	6 (5-6)
	ANT II	5 (4-6)	4 (3-4)
	ANT III	13 (11-14)	14 (12-15)
	URS (R IV+V)	5 (4-6)	7 (6-8)
	Cauda	9 (7-10)	8 (8-8)
Number of secondary rhinaria on antennal segments	ANT III	2 (0-3)	5 (4-5)
	ANT IV	0	0
	ANT V	0	0
Ratio of different body parts	Whole antenna/body	1.060 (0.960-1.286)	1.295 (1.241-1.349)
	PT/Base	3.755 (3.569-4.050)	4.934 (4.869-5,000)
	PT/ANT III	1.047 (0.965-1.202)	1.231 (1.179-1.284)
	URS/Ht II	1.050 (0.974-1.125)	1.092 (1.088-1.096)
	Siph/ANT III	0.939 (0.782-1.089)	0.807 (0.784-0,847)
	Siph/body length	0.233 (0.197-0.265)	0.232 (0.222-0.248)
	Siph/cauda	1.734 (1.302-2.290)	1.807 (1.636-2.022)
	Siph/hind femur	0.602 (0.534-0.700)	0.575 (0.542-0.621)
	Cauda length/cauda width	1.890 (1.446-2.291)	4.314 (2.094-2.220)
	LsH on Ant III/BD III	0.825 (0.675-0.939)	0.805 (0.800-0.810)
	Depth of frontal grove / distance between apices of antennal tubercle	0.204 (0.150-0.275)	0.235 (0.227-0.253)
	Reticulated zone of siph (%)	42.71 (37.24-51.36)	45.042 (41.86-47.60)

***Uroleucon aeneum* (Hille Ris Lambers, 1939)**

Material examined. Çanakkale, Çardak, 11.VI.2020, apt. 4♀♀, *Carduus pycnocephalus* L. (Asteraceae), 12.VI.2020; apt. 4♀♀; 15.V.2021, apt. 5♀♀, *Carduus* sp. (Asteraceae).

***Uroleucon jaceae* (Linnaeus, 1758)**

Material examined. Çanakkale, Çardak, 23.IV.2020, apt. 6♀♀, *Centaurea spinosa* L. (Asteraceae).

***Uroleucon sonchi* (Linnaeus, 1767)**

Material examined. Çanakkale, Çardak, 11.VII.2020, apt. 4♀♀, alt. 2♀♀, *Sonchus oleraceus* (L.) L. (Asteraceae); 14.VI.2021, apt. 5♀♀, alt. ♀, *Sonchus* sp. (Asteraceae).

***Volutaphis schusteri* (Börner, 1939)**

Material examined. Çanakkale, Çardak, 19.IV.2020, apt. 6♀♀, *Silene* sp. (Caryophyllaceae).

Subfamily Chaitophorinae

Chaitophorus salicti (Schrank, 1801)

Material examined. Çanakkale, Çardak, 27.V.2021, apt. 7♀♀, *Salix alba* L. (Salicaceae).

Subfamily Eriosomatinae

***Pemphigus immunis* Buckton, 1896**

Material examined. Çanakkale, Çardak, 14.VI.2020, alt. 7♀, *Populus canadensis* Moench (Salicaceae).

Considering the taxonomic diversity of the aphids in this study, 25 of the identified species are in the subfamily Aphidinae. The subfamily Aphidinae, with 361 species belonging to 74 genera, is the largest subfamily of the Aphididae in Turkey and constitute about 61% of all aphid species (Kök & Özdemir, 2021). About 93% of the identified species are in the Aphidinae subfamily. Also, of the 27 identified aphids in this study, six species (about 22% of species) belong to the genus *Aphis* which is one of the largest genera with 90 species among 148 genera from the Aphididae in Turkey.

Of the identified aphids, *A. fabae*, *B. helichrysi* and *H. lactucae* were as most common aphid species in the study area. *Aphis fabae*, black bean aphid, is one of the most commonly distributed aphid species; it has been reported from almost 50 provinces in Turkey. Similarly, *B. helichrysi*, known as the leaf-curling plum aphid, was reported in more than 30 provinces and *H. lactucae* in more than 20 provinces in Turkey (Kök & Özdemir, 2021). Some aphid species identified from this study area are rarely recorded in Turkey. For example, *L. pseudobrassicae*, an important worldwide pest of brassica crops, and *V. schusteri*, widely distributed in continental Europe, were previously only recorded from Samsun Province in Turkey (Remaudière et al., 2006). Similarly, *M. pulvera* was previously only recorded from Ankara, Eskişehir and Erzurum Provinces of Turkey (Tuatay, 1990). In terms of aphid diversity, the results of this study significantly contribute to the regional diversity of aphids in Turkey. *Aphis symphyti* on *A. hybrida* and *S. latifoliae* on *Limonium* sp. and *L. narbonense* are reported for the first time for the aphid fauna of Turkey. Also, *S. latifoliae* is the first aphid species of the genus *Staticobium* to be identified in Turkey.

Aphid-plant interactions adjacent to Çardak Lagoon and new host records for aphids in Turkey

In this study, 37 host species belonging to 16 families, viz., Apiaceae, Amaranthaceae, Asteraceae, Brassicaceae, Boraginaceae, Caryophyllaceae, Elaeagnaceae, Geraniaceae, Papaveraceae, Plumbaginaceae, Poaceae, Polygonaceae, Primulaceae, Rubiaceae, Rosaceae and Salicaceae, were revealed as hosts of aphids adjacent to Çardak Lagoon of Çanakkale. From these plant families, Asteraceae, with 15 species

in the sampling area, provided the highest number of host species for the aphids. In contrast, the Amaranthaceae, Apiaceae, Caryophyllaceae, Elaeagnaceae, Rubiaceae and Primulaceae had only one host species each. In the case of the aphids, *B. helichrysi* feeding on five host species was the aphid species that had the highest number of host species. Similarly, it was determined that *A. fabae* and *H. lactucae* feed on two host species (Figure 4).

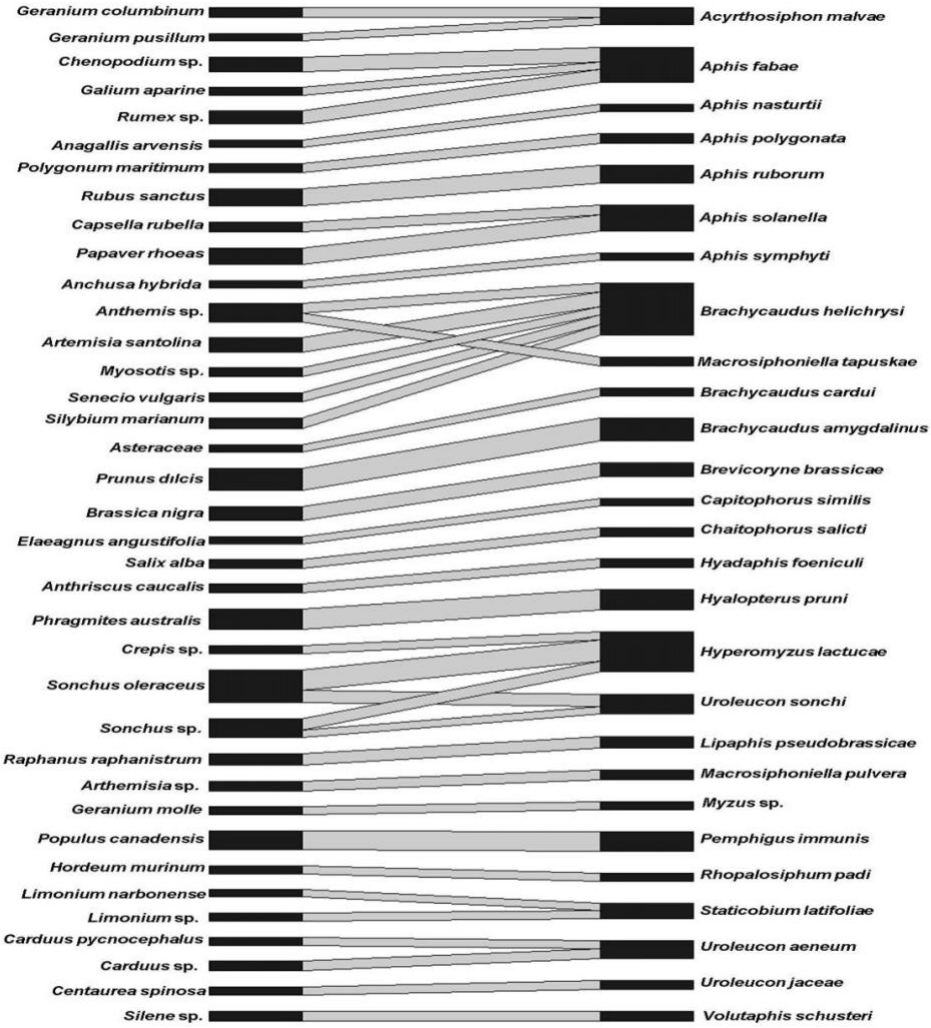

Figure 4. Bipartite network interaction between aphids (right) and hosts (left) species adjacent to Çardak Lagoon in Çanakkale Province, Turkey. Black bars represent the abundance of the species and gray bars represent interactions.

Also, a large number of new host records for aphids in Turkey were determined from the sampling area. Of these, *G. pusillum* and *G. columbinum* for *A. malvae*, *A. arvensis* for *A. nasturtii*, *P. maritimum* for *A. polygonata*, *Myosotis* sp. for *B. helichrysi*, *A. caucalis* for *H. foeniculi*, *R. raphanistrum* for *L. pseudobrassicae*, *Anthemis* sp. for *M. tapuskae* and *Silene* sp. for *V. schusteri* were revealed for the first time as new hosts of aphids in Turkey.

With this study, the important results were obtained confirming the hypothesis presented. With this study, *A. symphyti* distributed throughout European and *S. latifoliae* distributed in salt-marsh and coastal habitats of European, Middle and North Asia were introduced in to the aphid fauna of Turkey. With these new records, the number of the aphid fauna of Turkey has reached to 596 species from 149 genera in the infraorder Aphidomorpha (Hemiptera). Also, some aphid species, which are rarely reported in Turkey such

as *L. pseudobrassicae*, *M. pulvera* and *V. schusteri*, were identified with this study and these results contribute significantly to the local diversity of the aphid fauna of Turkey. The new hosts reported for some aphid species such as *A. malvae*, *A. nasturtii*, *A. polygonata*, *B. helichrysi*, *H. foeniculi*, *L. pseudobrassicae*, *M. tapuskae* and *V. schusteri* provide significant contributions to the emergence of new data on the biology and control of aphid pests, which are economically harmful in agricultural areas.

A remarkable finding was that *B. helichrysi*, a cosmopolitan pest on *Prunus* spp. (Rosaceae) (especially *Prunus domestica* L. and *Prunus persica* (L.) Batsch) worldwide and in Turkey, was the most common aphid species in the sampling area. So far, *B. helichrysi* has been reported on *Achillea* sp. (Asteraceae), *A. millefolium* L. (Asteraceae), *A. nobilis* L. (Asteraceae), *Anchusa* sp. (Boraginaceae), *A. leptophylla* Roem. & Schult. (Boraginaceae), *A. pusilla* Gusul. (Boraginaceae), *Anthemis* sp. (Asteraceae), *Calendula* spp. (Asteraceae), *C. arvensis* M. Bieb. (Asteraceae), *C. officinalis* L. (Asteraceae), *Caltha* sp. (Ranunculaceae), *Campsis* sp. (Bignoniaceae), *Carduus* sp. (Asteraceae), *C. pycnocephalus*, *Carlina* sp. (Asteraceae), *Carthamus dentatus* Wahl (Asteraceae), *C. tinctorius* L. (Asteraceae), *Centaurea* sp. (Asteraceae), *C. solstitialis* L. (Asteraceae), *Cerasus* sp. (Rosaceae), *Chrysanthemum* sp. (Asteraceae), *C. frutescens* L. (Asteraceae), *C. nivellei* Braun-Blanq. & Maire (Asteraceae), *Cineraria* sp. (Asteraceae), *Cirsium arvense* (L.) Scop. (Asteraceae), *C. cephalotes* Boiss. (Asteraceae), *Cucurbita pepo* L. (Cucurbitaceae), *Cydonia* sp. (Rosaceae), *Cynoglossum* sp. (Boraginaceae), *Eryngium* sp. (Apiaceae), *Euphorbia* spp. (Euphorbiaceae), *Gazania* sp. (Asteraceae), *Helianthus* sp. (Asteraceae), *H. annuus* L. (Asteraceae), *Hyacinthus* sp. (Asparagaceae), *Leucanthemum vulgare* (Vaill.) Lam. (Asteraceae), *Lycopersicum esculentum* L. (Solanaceae), *Matricaria* sp. (Asteraceae), *M. chamomilla* L. (Asteraceae), *Onopordum* sp. (Asteraceae), *Pulicaria dysenterica* (L.) Gaertn. (Asteraceae), *Pyrus* sp. (Rosaceae), *Rubus* sp. (Rosaceae), *Rumex crispus* L. (Polygonaceae), *Sambucus nigra* L. (Adoxaceae), *Senecio* sp. (Asteraceae), *S. vernalis* Waldst. & Kit. (Asteraceae), *Silene* sp. (Caryophyllaceae), *Sorbus* sp. (Rosaceae), *Spirea* spp. (Rosaceae), *Symphytum asperum* Lepech. (Boraginaceae), *Taraxacum officinale* L. (Asteraceae), *Tripleurospermum inodorum* (L.) Sch.Bip. (Asteraceae), *Urtica dioica* L. (Urticaceae), *Verbascum* sp. (Scrophulariaceae), *Veronica anagallis-aquatica* L. (Plantaginaceae) and *Vinca minor* L. (Apocynaceae) in Turkey (Toros et al., 2002; Özdemir, 2004; Aslan & Uygun, 2005; Görür et al., 2009; Görür, 2014; Kök et al., 2016; Öztürk & Muştu, 2017; Kök & Kasap, 2019; Akyıldırım Beğen & Görür, 2021; Başer & Tozlu, 2020). *Brachycaudus helichrysi* has a heteroecious holocyclic life cycle with sexual phase on *Prunus* spp. (especially *P. domestica*) in colder climates. This aphid, which uses *Prunus* species as the primary host on which sexual reproduction occurs during the autumn, migrates to secondary host on which parthenogenetic reproduction occurs throughout the spring and the summer period (Blackman & Eastop, 2021). *Brachycaudus helichrysi* is highly polyphagous on its secondary hosts and it was reported linked with more than 300 herbaceous plant genera in the Palearctic region (Holman, 2009). In this respect, the secondary hosts are vital for this aphid pest to complete its life cycle. This study clearly revealed that the secondary hosts of this aphid pest is important in terms of the better understanding of the biology and control strategies of the aphid in the Çanakkale Province, where plums and peaches are produced in high quantities.

Plant interactions are a major driver of reproductive isolation in aphids in different habitats (Peccoud et al*.,* 2010). In this regard, it is important that faunal and biological studies are conducted on hosts in different habitats to contribute to aphid diversity in the world and in our country. This phenomenon appears in the results of this study which was conducted in a small area with different habitats and is close to agricultural areas. Therefore, it is believed that a detailed examination of aphid-plant interactions not only in agricultural areas but also non-agricultural areas with different habitats as in this study will enhance understanding of the diversity of aphids and their hosts in Turkey. Also, uncovering the secondary hosts of migrating aphids, which have continually increasing distributions due to global warming and climate change, and their interactions with these plants will provide important data for the cultural and biological control of these aphid pests in crops.

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