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Original article (Orijinal araştırma)

Interactions of aphids (Hemiptera: Aphididae) with their primary and secondary host plants in orchards in Çanakkale Province, Turkey[1]

Türkiye'nin Çanakkale İli'ndeki bahçelerde afitler (Hemiptera: Aphididae) ile ana ve ara konukçu bitkilerinin etkileşimleri

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Abstract

This study aimed to reveal the interactions of aphids with their primary hosts (pome and stone fruit trees) and secondary hosts (herbaceous plants) in and around orchards in the Çanakkale Province in northwestern Turkey between April-September from 2020 to 2021. Thirty-eight aphid species belonging to 18 genera from two subfamilies, Aphidinae and Calaphidinae, of Aphididae in the order Hemiptera were identified on 53 host plants. Also, 92 aphid-primary-secondary host plant interactions, including several new host plant records for some aphid species in Turkey were revealed in the orchards. Of these hosts, *Ballota* sp. (Lamiaceae), *Carduus pycnocephalus* L. (Asteraceae), *Conyza* sp. (Asteraceae), *Diplotaxis* sp. (Brassicaceae), *Echium plantagineum* L. (Boraginaceae), *Galium* sp. (Rubiaceae), *Geranium columbinum* L. (Geraniaceae), *Papaver rhoeas* L. (Papaveraceae), *Ranunculus muricatus* L. (Ranunculaceae) and *Scandix pecten-veneris* L. (Apiaceae) are determined as new host plants for some aphids in Turkey. It is believed that the new data on the interactions of aphids with their primary and secondary hosts in orchards will support both a better understanding of the biology of fruit pest aphids and the development of new strategies for the control of aphid pests.

Keywords: Aphid, fruit tree, herbaceous plant, interaction, Turkey

Öz

Bu çalışma 2020 ve 2021 yıllarında Nisan ve Eylül ayları arasında Türkiye'nin kuzeybatısında yer alan Çanakkale İli'ndeki meyve bahçelerinde afitler ile ana konukçuları olan yumuşak ve sert çekirdekli meyve ağaçları ve bahçelerin içinde ve etrafında bulunan ara konukçuları olan yabancı otlar arasındaki etkileşimlerin ortaya çıkarılmasını amaçlamaktadır. Teşhislerin sonucunda, 53 konukçu üzerinde Hemiptera takımı Aphididae familyasından Aphidinae ve Calaphidinae altfamilyalarına ait 18 cins içerisinde toplam 38 afit türü belirlenmiştir. Ayrıca, meyve bahçelerinde Türkiye'de bazı afit türleri için çok sayıda yeni konukçu bitki kaydını içeren 92 afit-ana-ara konukçu bitki etkileşimi ortaya çıkarılmıştır. Bu konukçulardan, *Ballota* sp. (Lamiaceae), *Carduus pycnocephalus* L. (Asteraceae), *Conyza* sp. (Asteraceae), *Diplotaxis* sp. (Brassicaceae), *Echium plantagineum* L. (Boraginaceae), *Galium* sp. (Rubiaceae), *Geranium columbinum* L. (Geraniaceae), *Papaver rhoeas* L. (Papaveraceae), *Ranunculus muricatus* L. (Ranunculaceae) ve *Scandix pecten-veneris* L. (Apiaceae) Türkiye'de afitler için yeni konukçu bitki kayıtları olarak belirlenmiştir. Sonuç olarak, meyve bahçelerindeki afitler ile ana ve ara konukçu bitkilerinin etkileşimleri üzerine sunulan bu yeni verilerin hem meyve zararlısı afitlerin biyolojilerinin daha iyi anlaşılmasını hem de zararlı afitler için yeni mücadele stratejilerinin geliştirilmesini destekleyeceğine inanılmaktadır.

Anahtar sözcükler: Afit, meyve ağacı, yabancı ot, etkileşim, Türkiye

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Introduction

Agricultural areas in Turkey have many fruit species due to the range of geographical and climatic characteristics of these areas. More than half of the 138 fruit species cultivated in the world can be grown economically in Turkey (Ağaoğlu et al., 2015). In 2020, about 8.7 Mt of pome and stone fruits was produced on 540 kha in Turkey. Çanakkale Province, where this study was conducted, is one of the important agricultural regions located in northwestern Turkey produces about 360 kt of pome and stone fruit on 15 kha (Anonymous, 2020).

Many diseases and pest species affect fruit production around the world and cause economically significant losses in yield. Of these pests, aphids (Hemiptera: Aphididae) are one of the most important agricultural pests that damage a large number of crop and forest plants as a result of the suck of plant sap and the secreting of honeydew. They are also vector more than 270 phytopathogenic viruses that cause serious economic damage to agricultural crops (Katis et al., 2007).

Some aphid species have more complex life cycles with host alternation, known as heteroecy. The haploid and fertilized eggs of these aphids occur on tree and shrub plants which serve as primary hosts, and later regularly migrate to other unrelated plants including flowering herbaceous plants which serve as secondary hosts (Blackman & Eastop, 2021). About 10% of aphids, mostly from the subfamily Aphidinae, are heteroecious species that spend seasons like winter, spring and autumn on their primary host plants including trees or shrubs and then switch to unrelated secondary hosts including herbaceous host plants during summer. It is an important that the majority of heteroecious aphids are highly specialized on both primary and secondary host plants (Dixon, 1987). Also, certain heteroecious aphids such as the green peach aphid, *Myzus* (*Nectarosiphon*) *persicae* (Sulzer, 1776) (Hemiptera: Aphididae) transmit plum pox virus (Potyviridae), which is one of the most significant and devastating pathogens of plants, among primary host plants [*Prunus persica* (L.) Batsch (Rosaceae)] and secondary host plants [herbaceous plants including *Centaurea* sp. (Asteraceae), *Matricaria* sp. (Asteraceae), *Papaver* sp. (Papaveraceae) and *Trifolium* sp. (Leguminosae)] (Manachini et al., 2007).

Many uncultivated herbaceous flowering plants occur in and around orchards and are neighbors of fruit trees in these orchards, the interactions of fruit pest aphids with their primary and secondary host plants need to be investigated in more detail. This study aimed to provide basic data on the interactions of aphids with their primary and secondary host plants in pome and stone fruit trees and herbaceous host plants in and around orchards in the Çanakkale Province in northwestern Turkey.

Materials and Methods

Collection, preparation and identification of aphids and their host plants

To reveal the interactions of aphids and primary and secondary hosts, aphid sampling was conducted from pome and stone fruit trees such as quince, apple, plum, cherry, and peach, and herbaceous host plants in and around orchards in the Çanakkale Province between April-September from 2020 to 2021 (Figure 1). Different plant parts, including as trunk, branches, shoots and leaves, of all fruit trees were visually checked and aphid sampling was done from infested fruit trees. To reveal secondary herbaceous hosts of aphids in these orchards, the flowering herbaceous plants in and around the orchards were also examined and aphids collected.

To identify the aphids, apterous and alate individuals from the colonies on infested fruit trees and herbaceous hosts were put into with a brush (#00) into the Eppendorf tubes containing 70% ethyl alcohol and then brought to the laboratory for preparation and identification. The preparation of collected aphids were conducted according to the method of Hille Ris Lambers (1950). The aphids were identified by the corresponding author according to the identification keys of Blackman & Eastop (2006; 2021) using a light microscope (Leica DM 2500) with HD camera and LAS software (version 4.1). The current taxonomic status and names of identified aphid are given as in Favret (2021). The specimens of identified aphids were deposited in the Department of Plant Protection, Faculty of Agriculture, Çanakkale Onsekiz Mart University, Turkey.

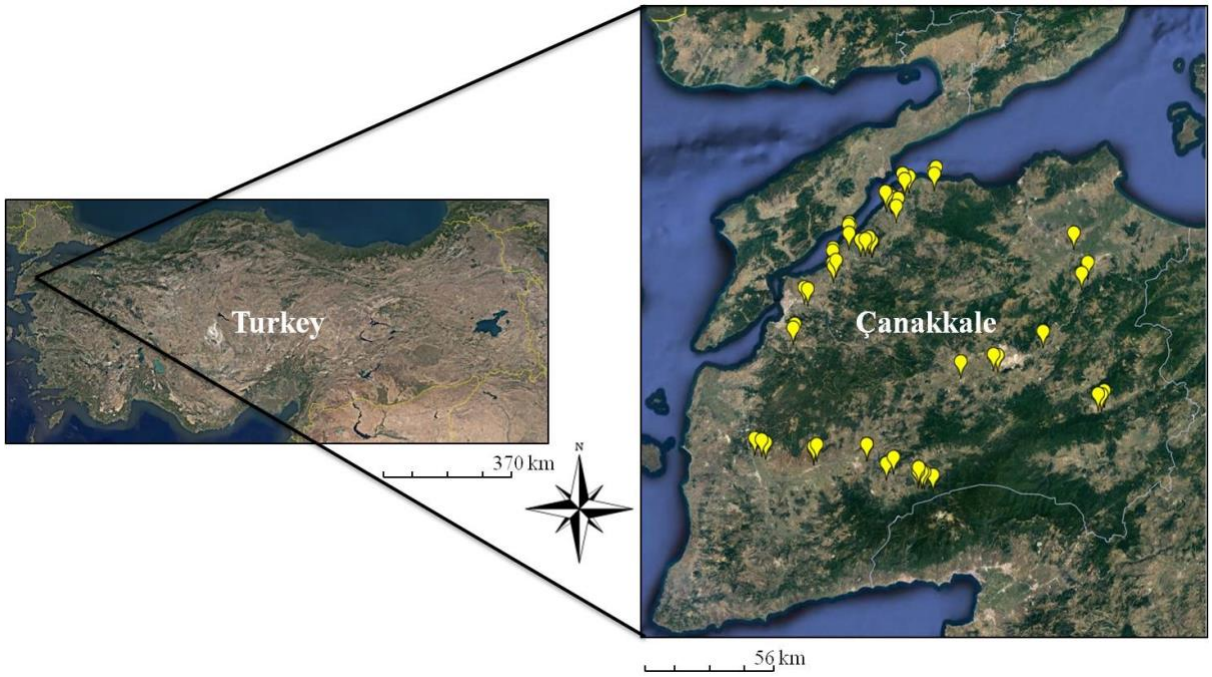

Figure 1. Satellite image showing the sampling area including the orchards in Çanakkale Province, Turkey (Google, 2022).

Plant samples determined to be hosts of aphids were prepared as herbarium specimens for identification. The host plants associated with aphids were identified by Assoc. Prof. Dr. Ersin Karabacak (Department of Biology, Faculty of Arts and Sciences, Çanakkale Onsekiz Mart University, Turkey).

Aphid - Primary and Secondary Host Plant Interactions

To visualize the structural patterns of the aphid - primary and secondary host plant interaction networks in orchards in Çanakkale Province, graphs of bipartite interactions were constructed on the basis of data on aphid, primary and secondary host plant relative abundances using the *plotweb* function in R package "bipartite" under R version 2.04 (Dormann et al., 2014; R Core Team, 2021).

Results and Discussion

Thirty-eight aphid species belonging to 18 genera from two subfamilies, Aphidinae and Calaphidinae, of Aphididae in the order Hemiptera were identified on 53 host plants. Of these, 15 aphids belonging to seven genera were determined on the fruit trees and 29 aphids belonging to 17 genera on the herbaceous hosts in the orchards. Taxonomic status, locality, collection date, the number of apterous and alatae individuals, and host plants of aphids on the fruit trees and herbaceous host plants in the orchards are presented below:

Order Hemiptera

Infraorder Aphidomorpha

Family Aphididae Latreille, 1802

Subfamily Aphidinae Latreille, 1802

***Acyrthosiphon* (*Acyrthosiphon*) *ilka* Mordvilko, 1914**

Material examined. Çanakkale, Lâpseki, Subaşı Village, 17.V.2020, apt. 5♀♀, *Papaver rhoeas* L. (Papaveraceae).

Comments. *Papaver rhoeas* is recorded for the first time as a new host for *A.* (*A.*) *ilka* in Turkey.

Hosts in Turkey. *Glaucium corniculatum* (L.) Rudolph (Papaveraceae), *Lactuca sativa* L. (Asteraceae), *Papaver somniferum* L. (Papaveraceae) (Tuatay & Remaudière, 1964; Tuatay et al., 1972; Tuatay, 1988; Aslan & Uygun, 2005; Islamoğlu & Tarla, 2018; Alaserhat et al., 2020).

***Acyrthosiphon* (*Acyrthosiphon*) *pisum* (Harris, 1776)**

Material examined. Çanakkale, Bayramiç, 15.VII.2020, apt. 4♀♀, alt. 2♀♀, *Trifolium spumosum* L. (Fabaceae); Lâpseki, Çardak, 23.IV.2021, apt. 5♀♀, alt. 2♀♀, *Vicia* sp. (Leguminosae).

***Aphis* (*Aphis*) *acetosae* L., 1767**

Material examined. Çanakkale, Bayramiç, 10.V.2020, apt. 5♀♀, *Rumex* sp. L. (Polygonaceae).

***Aphis* (*Aphis*) *ballotae* Passerini, 1860**

Material examined. Çanakkale, Lâpseki, Subaşı Village, 10.IV.2020, apt. 4♀♀, alt. 2♀♀, *Ballota* sp. (Lamiaceae).

Comments. *Ballota* sp. is recorded for the first time as a new host for *A.* (*A.*) *ballotae* in Turkey.

Hosts in Turkey. *Marrubium* sp. (Lamiaceae) (Tuatay & Remaudière, 1964).

***Aphis* (*Aphis*) *craccae* L., 1758**

Material examined. Çanakkale, Lâpseki, Çardak, 23.IV.2021, apt. 6♀♀, *Vicia* sp.

***Aphis* (*Aphis*) *craccivora* Koch, 1854**

Material examined. Çanakkale, Ezine, Akköy Village, 6.V.2020, apt. 3♀♀, alt. 2♀♀, *Anthemis* sp. (Asteraceae); Bayramiç, 19.V.2020, apt. 4♀♀, *Vicia* sp.; 21.V.2020, apt. 5♀♀, alt. 2♀♀, *Diplotaxis* sp. (Brassicaceae); 20.VI.2020, apt. 3♀♀, alt. 2♀♀, *Vicia* sp.; 15.VII.2020, apt. 5♀♀, alt. 3♀♀, *T. spumosum*; Umurbey, 2.IX.2020, apt. 5♀♀, alt. 2♀♀, *Melilotus* sp. (Leguminosae); 10.X.2020, apt. 3♀♀, alt. 2♀♀, *Malus* sp. (Rosaceae); Lâpseki, 25.V.2021, apt. 4♀♀, *Trifolium purpureum* Loisel. (Leguminosae); Musaköy Village, 25.VI.2021, apt. 5♀♀, alt. 2♀♀, *Trifolium* sp.; Lâpseki, Çardak, 10.VII.2021, apt. 4♀♀, alt. 3♀♀, *T. purpureum*.

Comments. *Diplotaxis* sp. is recorded for the first time as a new host for *A.* (*A.*) *craccivora* in Turkey.

Hosts in Turkey. *Aphis* (*Aphis*) *craccivora* is a polyphagous aphid species. In Turkey, it has been recorded on numerous host plants in many plant families, especially Leguminosae and Fabaceae (Düzgüneş & Tuatay, 1956; Bodenheimer & Swirski, 1957; Tuatay & Remaudière, 1964; Çanakçıoğlu, 1966, 1975; Tuatay, 1993; Toros et al., 1996, 2002; Ölmez Bayhan et al., 2003; Görür, 2004; Aslan & Uygun, 2005; Görür et al., 2009; Güçlü et al., 2015; Öztürk & Muştu, 2017; Kök & Kasap, 2019; Başer & Tozlu, 2020).

***Aphis* (*Aphis*) *fabae* Scopoli, 1763**

Material examined. Çanakkale, Lâpseki, Subaşı Village, 2.IV.2020, apt. 4♀♀, *Galium aparine* L. (Rubiaceae); Bayramiç, Evciler Village, 10.IV.2021, apt. 5♀♀, *Chenopodium album* L. (Amaranthaceae); 17.IV.2021, apt. 5♀♀, alt. 2♀♀, *Rumex* sp.; 25.IV.2021, apt. 4♀♀, alt. 2♀♀, *Rumex* sp.; Lâpseki, 19.V.2021, apt. 3♀♀, alt. 2♀♀, *Galium* sp. (Rubiaceae); 2.VI.2021, apt. 5♀♀, alt. 2♀♀, *C. album*; 5.VI.2021, apt. 4♀♀, *Rumex* sp.; 15.VI.2021, apt. 3♀♀, alt. 2♀♀, *Rumex* sp.; 21.VI.2021, apt. 5♀♀, alt. 2♀♀, *Chenopodium* sp. (Amaranthaceae); Lâpseki, Çardak, 15.VII.2021, apt. 3♀♀, *C. album*.

***Aphis* (*Aphis*) *frangulae* Kaltenbach, 1845**

Material examined. Çanakkale, Ezine, Akköy Village, 25.IV.2020, apt. 4♀♀, *Lamium amplexicaule* L. (Lamiaceae).

***Aphis* (*Aphis*) *gossypii* Glover, 1877**

Material examined. Çanakkale, Ezine, Akköy Village, 18.IV.2020, apt. 5♀♀, *Capsella rubella* Reut. (Brassicaceae); 21.IV.2020, apt. 7♀♀, *Carduus pycnocephalus* L. (Asteraceae); 21.IV.2020, apt. 5♀♀, alt. 2♀♀, *Scandix pecten-veneris* L. (Apiaceae); 21.IV.2020, apt. 6♀♀, *Galium* sp.; 29.IV.2020, apt. 6♀♀, *C. rubella*; Central, Saraycık Village, 21.V.2020, apt. 7♀♀, *Geranium columbinum* L. (Geraniaceae); 2.VI.2020, apt. 3♀♀, alt. 2♀♀, *Malus* sp.; Bayramiç, Evciler Village, 10.VI.2020, apt. 4♀♀, alt. 2♀♀, *Malus domestica* Borkh. (Rosaceae); Umurbey, 10.X.2020, apt. 4♀♀, alt. 2♀♀, *Malus* sp.; Umurbey, 16.VI.2020, apt. 5♀♀, *Punica*

granatum L. (Lythraceae); Yapıldak Village, 5.V.2021, apt. 3♀♀, alt. 2♀♀, *Prunus armeniaca* L. (Rosaceae); Musaköy Village, 16.V.2021, apt. 7♀♀, alt. 2♀♀, *M. domestica*.

Comments. *Carduus pycnocephalus* and *S. pecten-veneris* are recorded for the first time as new hosts for *A.* (*A.*) *gossypii* in Turkey.

Hosts in Turkey. *Aphis* (*Aphis*) *gossypii* is a highly polyphagous aphid species on a very wide range of host plants. In Turkey, it has been recorded on numerous host plants (Iyriboz, 1937; Çanakçıoğlu, 1967, 1975; Tuatay, 1993; Toros et al., 1996, 2002; Ölmez Bayhan et al., 2003; Görür, 2004; Aslan & Uygun, 2005; Ayyıldız & Atlıhan, 2006; Özdemir et al., 2006; Alaserhat & Kaplan, 2017; Kuloğlu & Özder, 2017; Öztürk & Muştu, 2017; Bayındır Erol et al., 2018).

***Aphis* (*Aphis*) *lamiorum* (Börner, 1950)**

Material examined. Çanakkale, Lâpseki, Subaşı Village, 16.IV.2020, apt. 8♀♀, *Lamium purpureum* L. (Lamiaceae).

***Aphis* (*Aphis*) *pomi* De Geer, 1773**

Material examined. Çanakkale, Bayramiç, Evciler Village, 6.IX.2020, apt. 5♀♀, *M. domestica*.

***Aphis* (*Aphis*) *rumicis* L., 1758**

Material examined. Çanakkale, Lâpseki, Subaşı Village, 1.IV.2020, apt. 5♀♀, *Rumex* sp.; Kepez, 10.IV.2020, apt. 5♀♀, *Rumex* sp.; 12.IV.2020, apt. 3♀♀, *Rumex* sp.; Biga, Aziziye Village, 13.V.2020, apt. 5♀♀, alt. 2♀♀, *Rumex* sp.; Çan, 20.V.2020, apt. 4♀♀, alt. 2♀♀, *Rumex* sp.; Central, Saraycık Village, 27.V.2020, apt. 5♀♀, *Rumex* sp.; 29.V.2020, apt. 3♀♀, alt. 2♀♀, *Rumex* sp.; Bayramiç, 19.VI.2020, apt. 3♀♀, alt. 2♀♀, *Rumex* sp.; 3.VII.2020, apt. 5♀♀, *Rumex* sp.

***Aphis* (*Aphis*) *solanella* Theobald, 1914**

Material examined. Çanakkale, Bayramiç, 5.VI.2020, apt. 5♀♀, *C. pycnocephalus*; Lâpseki, 10.VI.2021, apt. 4♀♀, *Ranunculus muricatus* L. (Ranunculaceae).

Comments. *Carduus pycnocephalus* and *R. muricatus* are recorded for the first time as new hosts for *A.* (*A.*) *solanella* in Turkey.

Hosts in Turkey. *Arctium minus* (Hill) Bernh. (Asteraceae), *C. album*, *C. rubella*, *Centaurea iberica* Trevir. ex Spreng. (Asteraceae), *Cirsium* sp. (Asteraceae), *Matricaria* sp., *P. rhoeas*, *Persicaria hydropiper* (L.) Spach (Polygonaceae), *Prunus cerasifera* Ehrh. (Rosaceae), *Rumex* sp., *Solanum americanum* Mill. (Solanaceae), *Solanum dulcamara* L. (Solanaceae), *Spirea* spp. (Rosaceae), *Urtica urens* L. (Urticaceae), *Vitis vinifera* L. (Vitaceae) and *Yucca glauca* Nutt. (Asparagaceae) (Giray, 1974; Çanakçıoğlu, 1975; Düzgüneş et al., 1982; Görür et al., 2009; Güleç, 2011; Kök & Kasap, 2019; Kök, 2021).

***Aphis* (*Aphis*) *spiraecola* Patch, 1914**

Material examined. Çanakkale, Ezine, Akköy Village, 29.IV.2020, apt. 7♀♀, *Cydonia oblonga* Mill. (Rosaceae); 15.V.2020, apt. 5♀♀, alt. 2♀♀, *C. oblonga*.

***Aulacorthum* (*Aulacorthum*) *solani* (Kaltenbach, 1843)**

Material examined. Çanakkale, Ezine, Akköy Village, 29.IV.2020, apt. 4♀♀, *C. oblonga*; 6.V.2020, apt. 5♀♀, *Galium* sp.; 8.V.2020, apt. 5♀♀, *Anthemis* sp.; 21.IV.2020, apt. 4♀♀, *S. pecten-veneris*; Çan, 13.V.2020, apt. 5♀♀, *Senecio* sp. (Asteraceae); Central, Saraycık Village, 25.V.2020, apt. 5♀♀, *G. columbinum*; 29.V.2020, apt. 3♀♀, *G. columbinum*.

Comments. *Galium* sp., *S. pecten-veneris* and *G. columbinum* are recorded for the first time as new host plants for *A.* (*A.*) *solani* in Turkey.

Hosts in Turkey. *Acer* sp. (Sapindaceae), *Achillea* sp. (Asteraceae), *Ajuga orientalis* L. (Lamiaceae), *Antirrhinum* sp. (Plantaginaceae), *Ballota* sp., *Begonia cucullata* Willd. (Begoniaceae), *Tecoma capensis* (Thunb.)

Lindl. (Bignoniaceae), *Calendula* sp. (Asteraceae), *Canna indica* L. (Cannaceae), *Convolvulus arvensis* L. (Convolvulaceae), *C. oblonga*, *Dianthus anatolicus* Boiss. (Caryophyllaceae), *Dianthus barbatus* L. (Caryophyllaceae), *Digitalis* sp. (Plantaginaceae), *Helianthus annuus* L. (Asteraceae), *Hibiscus rosa-sinensis* L. (Malvaceae), *Hydrangea macrophylla* (Thunb.) Ser. (Hydrangeaceae), *Hyoscyamus* sp. (Solanaceae), *L. sativa*, *Ligustrum vulgare* L. (Oleaceae), *Ocimum* sp. (Lamiaceae), *Populus nigra* L. (Salicaceae), *Prunus laurocerasus* L. (Rosaceae), *Pyrus communis* L. (Rosaceae), *Quercus* sp. (Fagaceae), *Robinia pseudoacacia* L. (Leguminosae), *Rubus* sp. (Rosaceae), *Russelia equisetiformis* Schltdl. & Cham. (Plantaginaceae), *Solanum lycopersicum* L. (Solanaceae), *Solanum tuberosum* L. (Solanaceae), *Taraxacum scaturiginosum* G.E. Haglund (Asteraceae), *Trifolium* sp., *Tulipa gesneriana* L. (Liliaceae), *Veronica anagalloides* Guss. (Plantaginaceae), *Viburnum opulus* L. (Adoxaceae), *Yucca filamentosa* L. (Asparagaceae) (Bodenheimer & Swirski, 1957; Tuatay, 1988; Ölmez Bayhan et al., 2003; Görür, 2004, 2014; Görür et al., 2009; Güleç, 2011; Kök et al., 2016; Kuloğlu & Özder, 2017; Öztürk & Muştu, 2017; Kök & Kasap, 2019; Oner et al., 2021; Patlar et al., 2021).

***Brachycaudus* (*Appelia*) *tragopogonis* (Kaltenbach, 1843)**

Material examined. Çanakkale, Bayramiç, 6.VI.2020, apt. 5♀♀, *Tragopogon dubius* Scop. (Asteraceae); Lâpseki, 10.VI.2021, apt. 5♀♀, *Tragopogon* sp. (Asteraceae); 14.VI.2021, apt. 6♀♀, *Tragopogon* sp.

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

Material examined. Çanakkale, Lâpseki, Subaşı Village, 4.IV.2020, apt. 5♀♀, *Prunus domestica* L. (Rosaceae); 7.IV.2020, apt. 7♀♀, *P. domestica*; Lâpseki, 11.IV.2020, apt. 6♀♀, *P. domestica*; Umurbey, 15.IV.2020, apt. 4♀♀, *P. domestica*; Ezine, Akköy Village, 18.IV.2020, apt. 5♀♀, *Cynoglossum creticum* Mill. (Boraginaceae); 21.IV.2020, apt. 7♀♀, alt. 2♀♀, *C. pycnocephalus*; 8.V.2020, apt. 5♀♀, *Anthemis* sp.; 11.V.2020, apt. 6♀♀, alt. 2♀♀, *C. creticum*; 19.V.2020, apt. 5♀♀, *P. domestica*; Biga, Aziziye Village, 22.V.2020, apt. 7♀♀, alt. 2♀♀, *Senecio vulgaris* L. (Asteraceae); 24.V.2020, apt. 5♀♀, alt. 2♀♀, *Matricaria* sp.; Biga, 24.V.2020, apt. 5♀♀, alt. 2♀♀, *P. domestica*; 28.V.2020, apt. 5♀♀, alt. 2♀♀, *P. domestica*; Central, Saraycık Village, 29.V.2020, apt. 6♀♀, alt. 2♀♀, *Conyza* sp. (Asteraceae); 1.VI.2020, apt. 3♀♀, alt. 2♀♀, *Anthemis* sp.; Bayramiç, 10.VI.2020, apt. 6♀♀, alt. 2♀♀, *Echium plantagineum* L. (Boraginaceae); 18.VI.2020, apt. 4♀♀, alt. 3♀♀, *C. creticum*; 2.VII.2020, apt. 3♀♀, alt. 2♀♀, *Anthemis* sp.; 11.VII.2020, apt. 3♀♀, alt. 2♀♀, *Anthemis* sp.

Comments. *Conyza* sp. and *E. plantagineum* are recorded for the first time as new hosts for *B.* (*B.*) *helichrysi* in Turkey.

Hosts in Turkey. *Brachycaudus* (*Brachycaudus*) *helichrysi* is a polyphagous aphid species. In Turkey, it has been recorded on numerous host plants in many plant families, especially Asteraceae and Boraginaceae (Tuatay & Remaudière, 1964; Giray, 1974; Tuatay, 1988; Toros et al., 2002; Ölmez Bayhan et al., 2003; Görür, 2004, 2014; Aslan & Uygun, 2005; Görür et al., 2009; Güleç, 2011; Öztürk & Muştu, 2017; Kök & Kasap, 2019).

***Brachycaudus* (*Prunaphis*) *cardui* (L., 1758)**

Material examined. Çanakkale, Lâpseki, Subaşı Village, 11.IV.2020, apt. 5♀♀, *C. pycnocephalus*; Lâpseki, 14.V.2021, apt. 4♀♀, *C. pycnocephalus*; Central, Musaköy Village, 21.V.2021, apt. 5♀♀, *C. pycnocephalus*.

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

Material examined. Çanakkale, Bayramiç, Ahmetçeli Village, 28.V.2020, apt. 7♀♀, alt. 2♀♀, *Prunus dulcis* (Mill.) D. A. Webb (Rosaceae).

***Brevicoryne brassicae* (L., 1758)**

Material examined. Çanakkale, Biga, Aziziye Village, 10.V.2020, apt. 5♀♀, *Raphanus raphanistrum* L. (Brassicaceae).

***Corylobium avellanae* (Schrank, 1801)**

Material examined. Çanakkale, Bayramiç Evciler Village, 27.V.2021, apt. 5♀♀, alt. 2♀♀, *Corylus* sp. (Betulaceae).

***Dysaphis* (*Pomaphis*) *plantaginea* (Passerini, 1860)**

Material examined. Çanakkale, Çan, 15.IV.2020, apt. 6♀♀, *M. domestica*; Saraycık Village, 24.IV.2020, apt. 5♀♀, *M. domestica*; Bayramiç, Ahmetçeli Village, 18.IV.2020, apt. 4♀♀, *M. domestica*; Bayramiç, Evciler Village, 29.V.2020, apt. 5♀♀, *M. domestica*; Central, Musaköy Village, 16.V.2021, apt. 6♀♀, *M. domestica*; Bayramiç, 26.V.2021, apt. 5♀♀, alt. 2♀♀, *M. domestica*; Evciler Village, 2.IX.2021, apt. 5♀♀, *M. domestica*; Ayvacık, Kösedere Village, 5.IX.2021, apt. 6♀♀, *M. domestica*.

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

Material examined. Çanakkale, Umurbey, 25.VI.2020, apt. 4♀♀, alt. 5♀♀, *Phragmites australis* (Cav.) Trin. ex Steud. (Poaceae); 10.VII.2021, apt. 4♀♀, alt. 2♀♀, *P. australis*.

***Hyperomyzus* (*Hyperomyzus*) *lactucae* (L., 1758)**

Material examined. Çanakkale, Lâpseki, Subaşı Village, 4.IV.2020, apt. 5♀♀, *Sonchus oleraceus* (L.) L. (Asteraceae); Çan, 11.IV.2020, apt. 4♀♀, *Sonchus* sp. (Asteraceae); Lâpseki, Alpagut Village, 18.IV.2020, apt. 4♀♀, *Sonchus* sp.; 24.IV.2020, apt. 5♀♀, alt. 2♀♀, *Sonchus* sp.; Central, Saraycık Village, 27.IV.2020, apt. 4♀♀, alt. 2♀♀, *Sonchus* sp.; 4.V.2020, apt. 4♀♀, alt. 2♀♀, *Sonchus* sp.; 17.V.2020, apt. 4♀♀, alt. 2♀♀, *Sonchus* sp.; 28.V.2020, apt. 5♀♀, alt. 3♀♀, *Sonchus* sp.; 29.V.2020, apt. 5♀♀, *G. columbinum*; Bayramiç, 3.VI.2020, apt. 5♀♀, alt. 2♀♀, *Sonchus* sp.; Central, Musaköy Village, 11.VI.2021, apt. 5♀♀, alt. 2♀♀, *Sonchus* sp.; Lâpseki, Çardak, 16.VI.2021, apt. 4♀♀, *Sonchus* sp.

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

Material examined. Çanakkale, Lâpseki, Subaşı Village, 11.IV.2020, apt. 4♀♀, *Moricandia arvensis* (L.) DC. (Brassicaceae); Ezine, Akköy Village, 23.IV.2020, apt. 7♀♀, alt. 2♀♀, *C. rubella*; 29.IV.2020, apt. 5♀♀, *C. rubella*; 30.IV.2020, apt. 5♀♀, alt. 3♀♀, *Raphanus* sp. (Brassicaceae); 3.V.2020, apt. 4♀♀, *Brassica* sp. (Brassicaceae); Biga, Aziziye Village, 15.V.2020, apt. 6♀♀, alt. 3♀♀, *C. rubella*; Bayramiç, 29.V.2020, apt. 7♀♀, alt. 2♀♀, *Bunias erucago* L. (Brassicaceae).

***Macrosiphum* (*Macrosiphum*) *euphorbiae* (Thomas, 1878)**

Material examined. Çanakkale, Biga, 20.V.2020, apt. 5♀♀, *P. communis*; Biga, Aziziye Village, 15.V.2020, apt. 5♀♀, alt. 2♀♀, *C. rubella*; 22.V.2020, apt. 5♀♀, alt. 2♀♀, *S. vulgaris*; Bayramiç, 10.VI.2020, apt. 6♀♀, *E. plantagineum*.

***Myzus* (*Myzus*) *cerasi* (Fabricius, 1775)**

Material examined. Çanakkale, Biga, 18.V.2020, apt. 7♀♀, *Prunus avium* (L.) L. (Rosaceae); Bayramiç, Evciler Village, 6.VI.2020, apt. 5♀♀, alt. 3♀♀, *P. avium*; Umurbey, 25.IV.2021, apt. 4♀♀, *P. avium*; Central, Musaköy Village, 29.IV.2021, apt. 5♀♀, *P. avium*; Bayramiç, Evciler Village, 20.V.2021, apt. 6♀♀, *P. avium*; 2.VI.2021, apt. 4♀♀, alt. 3♀♀, *P. avium*; 8.VI.2021, apt. 3♀♀, alt. 3♀♀, *P. avium*.

***Myzus* (*Myzus*) *lythri* (Schrank, 1801)**

Material examined. Çanakkale, Ezine, Akköy Village, 10.V.2020, apt. 5♀♀, alt. 2♀♀, *P. armeniaca*.

***Myzus* (*Myzus*) *varians* Davidson, 1912**

Material examined. Çanakkale, Çan, 27.V.2020, apt. 4♀♀, alt. 3♀♀, *P. persica*.

***Myzus* (*Nectarosiphon*) *persicae* (Sulzer, 1776)**

Material examined. Çanakkale, Lâpseki, Subaşı Village, 14.IV.2020, apt. 7♀♀, *Euphorbia helioscopia* L. (Euphorbiaceae); Ezine, Akköy Village, 21.IV.2020, apt. 6♀♀, alt. 2♀♀, *S. pecten-veneris*; Saraycık Village, 14.V.2020, apt. 5♀♀, *P. persica*; 16.V.2020, apt. 3♀♀, *P. persica*; Bayramiç, 17.V.2020, apt. 5♀♀, alt. 2♀♀, *P. persica*; 21.V.2020, apt. 4♀♀, alt. 2♀♀, *Diplotaxis* sp.; 24.V.2020, apt. 4♀♀, alt. 2♀♀, *P. persica*; Bayramiç, Evciler Village, 27.V.2020, apt. 5♀♀, alt. 2♀♀, *P. persica*; Bayramiç, 29.V.2020, apt. 5♀♀, alt. 3♀♀, *B. erucago*; 10.VI.2020, apt. 5♀♀, alt. 2♀♀, *E. plantagineum*; 19.VI.2020, apt. 4♀♀, alt. 3♀♀, *Rumex* sp.; 2.VII.2020, apt.

5♀♀, alt. 2♀♀, *Anthemis* sp.; Umurbey, 2.V.2021, apt. 5♀♀, alt. 2♀♀, *P. persica*; Central, Yapıldak Village, 5.V.2021, apt. 3♀♀, alt. 2♀♀, *P. armeniaca*; Lâpseki, 26.V.2021, apt. 6♀♀, alt. 3♀♀, *Prunus avium*.

***Myzus* sp.**

Material examined. Çanakkale, Lâpseki, Subaşı Village, 15.IV.2020, alt. 6♀♀, Poaceae.

***Ovatus* (*Ovatus*) *insitus* (Walker, 1849)**

Material examined. Çanakkale, Lâpseki, 21.IV.2020, apt. 5♀♀, *C. oblonga*; Umurbey, 25.IV.2020, apt. 6♀♀, *C. oblonga*; Ezine, Akköy Village, 29.IV.2020, apt. 4♀♀, *C. oblonga*; Çanakkale, Umurbey, 10.X.2020, apt. 5♀♀, *Malus* sp.

***Phorodon* (*Phorodon*) *humuli* (Schrank, 1801)**

Material examined. Çanakkale, Ezine, Akköy Village, 19.V.2020, apt. 5♀♀, *P. domestica*; Çan, 3.VI.2021, apt. 6♀♀, *Prunus* sp. (Rosaceae).

***Semiaphis dauci* (Fabricius, 1775)**

Material examined. Çanakkale, Musaköy Village, 11.VI.2021, apt. 4♀♀, alt. 3♀♀, *Daucus* sp. (Apiaceae).

***Sitobion* (*Sitobion*) *avenae* (Fabricius, 1775)**

Material examined. Çanakkale, Musaköy Village, 14.VI.2021, apt. 5♀♀, Poaceae.

***Uroleucon* (*Uroleucon*) *sonchi* (L., 1767)**

Material examined. Çanakkale, Lâpseki, Alpagut Village, 18.IV.2020, apt. 5♀♀, *Sonchus* sp.; Central, Saraycık Village, 27.IV.2020, apt. 4♀♀, *Sonchus* sp.; Central, Saraycık Village, 4.V.2020, apt. 5♀♀, *Sonchus* sp.; 12.V.2020, apt. 5♀♀, *Sonchus* sp.; Bayramiç, 3.VI.2020, apt. 3♀♀, alt. 2♀♀, *Sonchus* sp.; Lâpseki, Çardak, 16.VI.2021, apt. 5♀♀, alt. 2♀♀, *Sonchus* sp.; 19.VI.2021, apt. 6♀♀, alt. 3♀♀, *Sonchus* sp.; 24.VI.2021, apt. 5♀♀, alt. 2♀♀, *Sonchus* sp.

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

Material examined. Çanakkale, Bayramiç, 23.V.2020, apt. 4♀♀, alt. 2♀♀, *C. pycnocephalus*; Lâpseki, 4.VI.2021, apt. 6♀♀, alt. 2♀♀, *Carduus* sp. (Asteraceae).

Subfamily Calaphidinae Oestlund, 1919

***Therioaphis* (*Pterocallidium*) *trifolii* (Monell, 1882)**

Material examined. Çanakkale, Bayramiç, 15.VII.2020, apt. 6♀♀, *T. spumosum*.

Ninety-two aphid-host plant interactions, including many new host plant records for some aphid species in Turkey, were determined from the orchards. Of these hosts, *P. rhoeas* for *A.* (*A.*) *ilka*, *Ballota* sp. for *A.* (*A.*) *ballotae*, *Diplotaxis* sp. for *A.* (*A.*) *craccivora*, *C. pycnocephalus* and *S. pecten-veneris* for *A.* (*A.*) *gossypii*, *C. pycnocephalus* and *R. muricatus* for *A.* (*A.*) *solanella*, *Galium* sp., *S. pecten-veneris* and *G. columbinum* for *A.* (*A.*) *solani*, *Conyza* sp. and *E. plantagineum* for *B.* (*B.*) *helichrysi* were recorded for the first time as new hosts of aphids in Turkey.

It was revealed that the identified aphid species have varying degrees of diversity on both the fruit trees that are primary hosts and the herbaceous plants that are secondary hosts. Fifteen aphid species were identified on fruit trees of which, *A.* (*A.*) *gossypi* with four fruit trees hosts and *M.* (*N.*) *persicae* with three fruit trees hosts were recorded as the most common aphids in the orchards. However, *B.* (*B.*) *helichrysi*, known as the leaf-curling plum aphid, and *D.* (*P.*) *plantaginea*, forming yellowish crumpled-leaf galls on apple, were determined only on *P. domestica* and *M. domestica*, respectively (Figure 2).

As for herbaceous plants that are secondary hosts, 29 aphid species were identified on these herbaceous plants in and around the orchards. Similarly, *A.* (*A.*) *craccivora*, *M.* (*N.*) *persicae* and *B.* (*B.*) *helichrysi* was found on seven herbaceous host species and *A.* (*A.*) *fabae* and *A.* (*A.*) *gossypii* on five herbaceous host species (Figure 3).

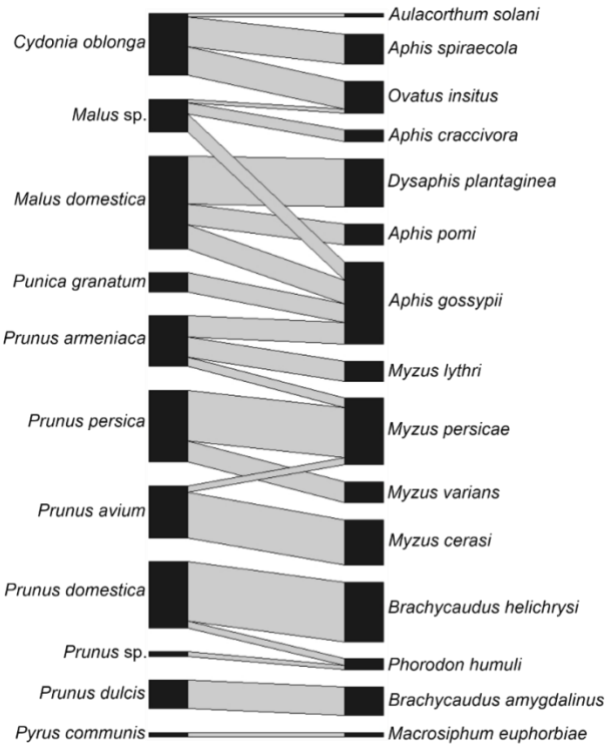

Figure 2. Quantitative bipartite network of interactions between host trees (left) and aphids (right) in orchards in Çanakkale Province, Turkey. Black bars show abundance of the plants and aphids, and gray bars shows their interactions (width of the bars indicates the intensity of interactions).

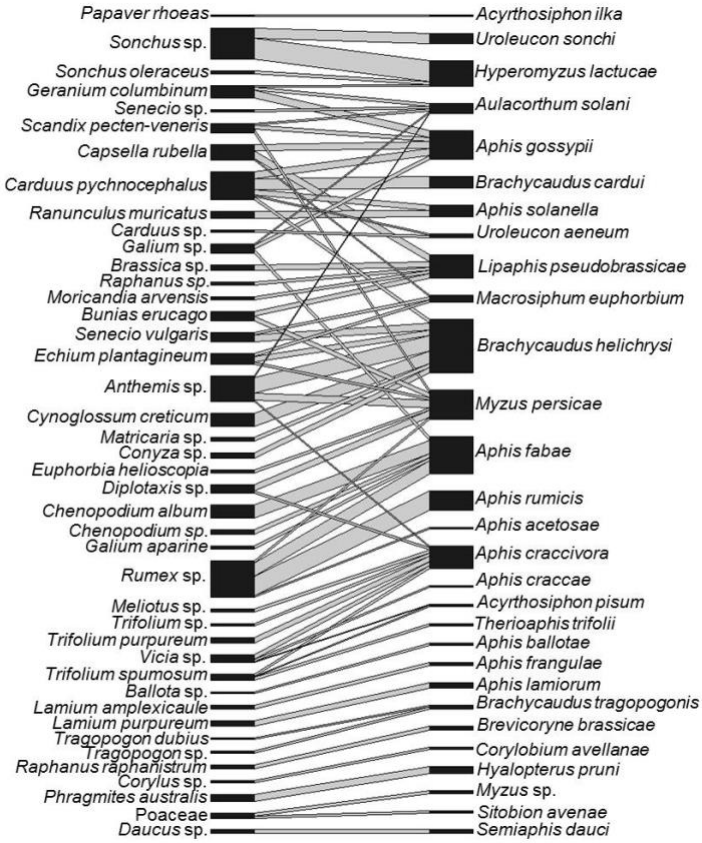

Figure 3. Quantitative bipartite network of interactions between host herbaceous plants (left) and aphids (right) in orchards in Çanakkale Province, Turkey. Black bars show abundance of the plants and aphids, and gray bars shows their interactions (width of the bars indicates the intensity of interactions).

Studies conducted in fruit fields in different regions of Turkey revealed that aphid pests have a significant diversity and density on both fruit trees and herbaceous host plants. Of these studies, Aslan & Karaca (2005) showed that *A.* (*A.*) *pomi*, *Dysaphis* (*Dysaphis*) *devecta* (Walker, 1849) (Hemiptera: Aphididae) and *D.* (*P.*) *plantaginea* are the most common aphids on fruit trees in the Isparta region because of the high amount of apple production. Aslan (2015) reported that *Hyalopterus amygdali* (Blanchard, 1840) (Hemiptera: Aphididae) and *M.* (*N.*) *persicae* are the most common species among the twelve identified species on fruit trees in Burdur. Also, other similar studies showed that many aphid species such as *A.* (*A.*) *craccivora*, *A.* (*A.*) *pomi*, *D.* (*D.*) *devecta*, *D.* (*P.*) *plantaginea*, *H. pruni* and *Rhopalosiphum oxyacanthae* (Schrank, 1801) (Hemiptera: Aphididae) are mostly distributed on trees in orchards in Antalya, Erzurum, Iğdır and Niğde Provinces of Turkey (Görür, 2004; Daşcı & Güçlü, 2008; Narmanlıoğlu & Güçlü, 2008; Saraç et al., 2015).

Determination of the primary and secondary hosts of aphids with heteroecious life cycles will make significant contributions to a clearer understanding of the biology and control strategies of these aphids. Unlike the studies mentioned above, we have revealed important data on herbaceous plants that are secondary hosts as well as fruit tree that are primary hosts of aphids in orchards. A study similar to ours conducted in orchards in Spain showed that 181 herbaceous host plants can serve as reservoirs for 27 aphid pests on fruit trees. In this study, the most common aphids, *M.* (*N.*) *persicae* and *B*. (*B.*) *helichrysi*, were reported on 30 and 13 secondary herbaceous host plants, respectively, in orchards (Tizado & Nunez Perez, 1998). Similarly, in our study, *M.* (*N.*) *persicae* and *B.* (*B.*) *helichrysi*, pests of fruit species, were found on seven herbaceous host species as secondary hosts the most in orchards (Figure 3). Ahmed et al. (2007) reported that *A.* (*A.*) *gossypii* is the most common aphid species on both fruit trees and herbaceous host plants in the areas of economic crops in Egypt. In contrast, the results of our study showed that *B.* (*B.*) *helichrysi* and *M.* (*N.*) *persicae* are common on secondary host plants, while *A.* (*A.*) *gossypii*, a polyphagous species, is one of the most common aphids on both fruit trees and secondary hosts in orchards.

As is clear from our study, and other studies conducted in orchards, aphid diversity is remarkable rich on fruit trees that are the primary hosts, as well as herbaceous plants that are the secondary hosts in orchards. Especially, considering that fruit pest aphids migrate to secondary hosts in summer, it is clear that revealing both primary-secondary hosts of pest aphids and their migration season in more detail will make significant contributions to the integrated pest management of aphids. In the context of these results, it is believed that the data presented in this study on the primary and secondary hosts and their interactions with aphids in orchards in northwestern Turkey will support both a better understanding of the biology of fruit aphids and the development of new strategies for the control of aphid pests.

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