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Aphidophagous coccinellid and parasitoid species determined in the Çanakkale Province with a new record for the parasitoid fauna of Turkey

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ÖZ

Türkiye parazitoit faunası için yeni bir kayıt ile birlikte Çanakkale ilinde belirlenen afidofag coccinellid ve parazitoit türler

Bu çalışma 2013 ve 2015 yılları arasında Çanakkale ilinde afidofag coccinellid ve parazitoit türleri ile onların çeşitlilikleri ve birbirleri arasındaki tritrofik ilişkilerin (parazitoit/predatör-konukçu yaprakbiti-konukçu bitki) belirlenmesi amacıyla yürütülmüştür. Çalışma boyunca Aphidiinae (Hymenoptera: Braconidae) altfamilyasına ait altı cinse bağlı 10 parazitoit tür ve Coccinellidae (Coleoptera) familyasına ait 10 cinse bağlı 12 predatör tür tespit edilmiştir. Parazitoit türlerden *Aphidius hortensis* Marshall, 1896 Türkiye parazitoit faunası için yeni kayıttır. *Lysiphlebus testaceipes* (Cresson, 1880) (%32.9) ve *Lysiphlebus fabarum* (Marshall, 1896) (%23.0) türleri diğer parazitoit türlerden daha yoğun tespit edilmiştir. Benzer şekilde *Coccinella septempunctata* Linnaeus, 1758 (%35.1) ve *Adalia bipunctata* (Linnaeus, 1758) (%22.8) türleri predatör türler içerisinde en yaygın türler olarak belirlenmiştir. *Aphis fabae* Scopoli 1763 parazitoit türlerin konukçusu olarak en yaygın çeşitliliğe (Shannon-Wiener H = 0.658) sahip iken *Cinara pini* (Linnaeus, 1758) ise predatör türlerin konukçusu olarak en yaygın çeşitliliğe sahiptir (Shannon-Wiener H = 1.386). Bu çalışmada 14 farklı konukçu bitki üzerinde 18 parazitoit-yaprakbiti ilişkisi ve 19 farklı bitki üzerinde 28 predatör-yaprakbiti ilişkisi belirlenmiştir. *Berberis* sp. (Berberidaceae) üzerinde *A. hortensis* - *Liosomaphis berberidis* (Kaltenbach, 1843) ilişkisi Türkiye'de ilk kez bu çalışma ile kayıt edilmiştir.

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Mevcut çalışma ile Çanakkale ilinde afidofag coccinellid ve parazitoit türler ilk kez tespit edilmiştir.

Anahtar kelimeler: Yaprakbiti, coccinellid, parazitoit, *Aphidius hortensis*, Çanakkale

ABSTRACT

This study was conducted between 2013 - 2015 to determine aphidophagous coccinellid and parasitoid species of aphids, their diversity and tritrophic associations (parasitoid/predator-host aphid-host plant) in the Çanakkale Province. In the course of the investigations, 10 species belonging to six genera of the subfamily Aphidiinae (Hymenoptera: Braconidae) were determined, in addition to 12 species belonging to 10 genera of the family Coccinellidae (Coleoptera). Among the parasitoids, *Aphidius hortensis* Marshall, 1896 is a new record for the Turkish parasitoid fauna. *Lysiphlebus testaceipes* (Cresson, 1880) (32.9%) and *Lysiphlebus fabarum* (Marshall, 1896) (23.0%) were more extensively found compared to other parasitoid species. Similarly, *Coccinella septempunctata* Linnaeus, 1758 (35.1%) and *Adalia bipunctata* (Linnaeus, 1758) (22.8%) were recorded as the most common predator species. *Aphis fabae* Scopoli 1763 had the greatest diversity among the parasitoids (Shannon-Wiener $H = 0.658$), while *Cinara pini* (Linnaeus, 1758) had the greatest diversity among the predators (Shannon-Wiener $H = 1.386$). As for tritrophic associations, 18 parasitoid-aphid associations on 14 host plants and 28 predator-aphid associations on 19 host plants were determined. The *A. hortensis* - *Liosomaphis berberidis* (Kaltenbach, 1843) association on *Berberis* sp. (Berberidaceae) is here newly recorded from Turkey. With the present study, the aphidophagous coccinellid and parasitoid species are determined for the first time in the Çanakkale Province of Turkey.

Keywords: Aphid, coccinellid, parasitoid, *Aphidius hortensis*, Çanakkale

INTRODUCTION

Aphids (Hemiptera: Aphididae) are one of the most important pests causing damage to different plants in cultivated and uncultivated areas throughout the world. Aphids are responsible for direct damage to plants such as leaf curling, twisting of shots, yellowing of leaves and stunting by sucking plant sap. In addition they also produce galls and deformities on plants by secreting toxic saliva during feeding. Moreover, they cause indirect damage by excreting honeydew on plant leaves and transmitting phytopathogenic viral diseases (Blackman and Eastop 2006, Jouraeva et al. 2006, van Emden and Harrington 2007). Recently, aphids have become more important in cultivated and uncultivated areas because they, winged aphids, migrate over greater distances and can produce several generations per annum (Gilabert et al. 2009, Kavallieratos et al. 2005, Posada-Flórez et al. 2014).

Aphid populations have a large number and various categories of specific and nonspecific natural enemies (parasitoids and predators) throughout the world. Among these natural enemies, parasitoid species belonging to the subfamilies Aphidiinae (Hymenoptera: Braconidae) and Aphelininae (Hymenoptera: Aphelinidae) are specialized to parasitize aphids and could play an important role in

biological control of aphids feeding on different plants (Aziza et al. 2014, Darsouei et al. 2011, Hagvar and Hofsvang 1991, Hughes 1989, Starý 2006, van Emden 1995, van Emden and Harrington 2007). Among aphid parasitoids, species belonging to the subfamily Aphidiinae are solitary wasp endoparasitoids of aphid populations, and they usually have a body length of 1-4 mm (Kavallieratos et al. 2001, Starý 1970, 1988). The subfamily Aphidiinae contains more than 400 species belonging to 60 genera and subgenera worldwide (Starý 1988). Many studies conducted in recent years, has led to the identification of a great number of new parasitoid species have in Southeast Europe, including Turkey (Akar and Çetin Erdoğan 2017, Çetin Erdoğan et al. 2008, 2010, Kavallieratos et al. 2003, Kavallieratos and Tomanović 2003, Tomanović and Starý 2001, Tomanović and Kavallieratos 2002, Tomanović et al. 2002, 2003a, 2003b). Predator species belonging to the family Coccinellidae (Coleoptera) are among the most important natural enemies of aphids and play a major role in control of aphid populations worldwide. Most of these species, generally known as ladybugs or ladybird beetles, feed as predators on both adult and immature stages of aphids and other pests. Also, some of these predators survive by phytophagy or mycethophagy (Chinery 1993, Tezcan and Uygun 2003). Predator species of the family Coccinellidae have been successfully used in biological control of many insect pests including aphids (Hemiptera: Aphididae), scale insects (Hemiptera: Coccoidea), whiteflies (Hemiptera: Aleyrodidae), thrips (Thysanoptera), mealybugs (Hemiptera: Pseudococcidae), leaf hoppers (Hemiptera: Cicadellidae) and other soft bodied insect pests worldwide (Magro et al. 2010).

Recently, synthetic pesticides have been heavily used in the control of aphid populations damaging different crops in Turkey and worldwide. These pesticides have caused serious harm to the environment (including beneficial insects) and human health (Desneux et al. 2004, 2006, 2007). Determining parasitoid and predator species as potential agents of biological control of aphid populations is therefore very important. The aim of the present study was to determine the species of parasitoids (Hymenoptera: Braconidae: Aphidiinae) and predator coccinellid (Coleoptera: Coccinellidae) of aphids feeding on different crops in cultivated and uncultivated areas of the Çanakkale Province, Turkey.

MATERIALS AND METHODS

Aphid specimens, mummified aphids and predators were collected from herbaceous plants, shrubs and trees growing in cultivated and uncultivated areas from 2013 to 2015 in the Çanakkale Province (especially City Centre and Ayvacık, Bayramiç, Biga, Çan, Lapseki, Yenice), Turkey. Sampling was carried out aperiodically during spring and summer. The plant specimens colonized with aphids, mummified aphids and predators were brought to the laboratory in a plastic bag. Plants were pressed, herbarized and identified. Both apterous and alate aphids were collected from their host plants using a soft brush and put in an Eppendorf tube containing 70% alcohol to identify its species. Collection and preparation of aphids followed the method of

Hille Ris Lambers (1950), while identification of aphids was conducted according to Heie (1986), Bodenheimer and Swirski (1957) and Blackman and Eastop (2006, 2016). In the present study, the aphid species were determined by Kök et al. (2016).

For parasitoid emergence, mummified aphids and plant samples were put in plastic bottles inside a growth chamber (22.5 °C, 65% humidity, 16:8 L:D photoperiod). The lid of the plastic bottles had a circular opening covered with muslin cloth for ventilation purpose (Kavallieratos et al. 2004). After their emergence, the parasitoids were identified. Coccinellid species were collected from aphid-infested plant parts using a mouth aspirator in field conditons. Immature stages of the predators were brought to the laboratory and put in plastic bottles to complete their development. Preparation and identification of coccinellid species were done according to Uygun (1981).

All aphid, parasitoid and coccinellid specimens identified in the study were collected by the first author in the Çanakkale Province, Turkey. In the present study, the parasitoid and coccinellid species were identified by second and third author, respectively. Specimens of aphids and coccinellids were deposited in the insect collection of the Department of Plant Protection, Agricultural Faculty, Çanakkale Onsekiz Mart University, Turkey. Parasitoid specimens were deposited in that of the Institute of Zoology, Faculty of Biology, University of Belgrade, Belgrade, Serbia. Coordinates where we collected parasitoid and coccinellid species were recorded by GPS (Magellan Triton 500). The Shannon-Wiener *H* index was used to determine diversity of parasitoids and coccinellids of each aphid species in the Çanakkale Province. The nomenclature of diagnostified parasitoid species new for Turkey follows Sharkey and Wharton (1997).

RESULTS AND DISCUSSION

This study was conducted between 2013 - 2015 to determine parasitoids and coccinellids of aphids, their diversity and tritrophic associations (parasitoid/coccinellid-host aphid-host plant) in the Çanakkale Province. During the study, 10 species belonging to six genera of the subfamily Aphidiinae (Hymenoptera: Braconidae) were determined, in addition to 12 species belonging to 10 genera of the family Coccinellidae (Coleoptera). Among the parasitoids, *Aphidius hortensis* Marshall, 1896 reared from *Liosomaphis berberidis* (Kaltenbach, 1843) feeding on *Berberis* sp. (Berberidaceae) is a new record for the Turkish parasitoid fauna. In the survey of parasitoid species, 18 associations of parasitoids-aphids occurring on 14 host plants were recorded. In the survey of coccinellid species, 28 associations of predators-aphids occurring on 19 host plants were reported. Moreover, the *A. hortensis* - *L. berberidis* association on *Berberis* sp. (Berberidaceae) was found as new record from Turkey. Specialized parasitoids of aphids of the genus *Liosomaphis* (Kavallieratos et al. 2004), the indicated species are of Palaearctic origin and were probably introduced into the USA and Canada (Smith 1944). It should be noted that parasitoids and predators of aphids are

determined for the first time in the Çanakkale Province. The taxonomy, host aphids, host plants and coordinates (Figure 1) are given below, along with the collection dates, the sex ratio and distribution of genera and species of parasitoids and coccinellids.

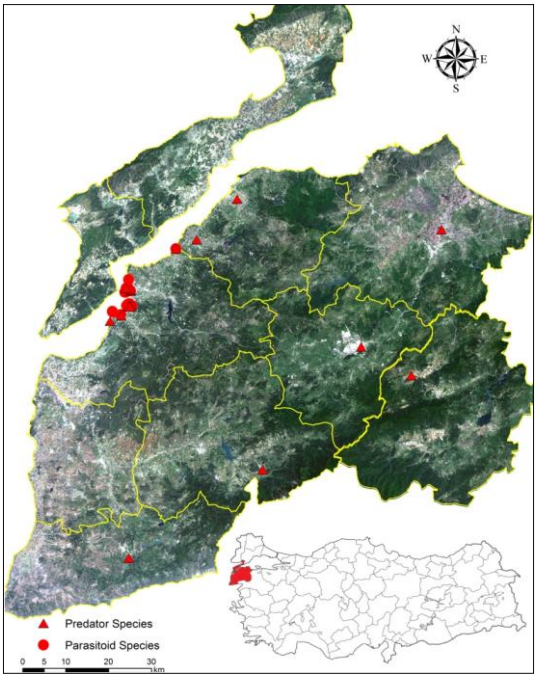

Figure 1. Location of sites where aphid parasitoids and coccinellids were sampled in the Çanakkale, Turkey.

List of the species

Order Hymenoptera

Family Braconidae

Subfamily Aphidiinae

***Adialytus salicaphis* (Fitch, 1855)**

Distribution: Andorra, Bulgaria, Canada, China, Croatia, Czech Republic, Finland, France, Georgia, Germany, Greece, Hungary, India, Iran, Iraq, Italy, Japan, Kazakhistan, Mexico, Moldova, Pakistan, Poland, Romania, Russia, Slovakia, Spain, Sweden, Tajikistan, Turkey, USA, United Kingdom, Uzbekistan, Yugoslavia, Serbia (Yu et al. 2012).

Material examined: *Chaitophorus leucomelas* Koch 1854, *Populus* sp. (Salicaceae), 40°08'25.3" N 26°24'03.7" E, Çanakkale, City Centre, 10.VI.2015, 7♀♀, 2♂♂.

***Aphidius colemani* Viereck, 1912**

Distribution: Algeria, Angola, Argentina, Australia, Brazil, Bulgaria, Chile, China, Colombia, Costa Rika, Cyprus, Czech Republic, Egypt, France, Georgia, Germany, Greece, Hungary, India, Iran, Iraq, Israel, Italy, Japan, Jordan, Kenya, Lebanon, Libya, Madagascar, Morocco, Mozambique, Norway, Pakistan, Peru, Poland, Portugal, Russia, South Africa, Spain, Syria, Turkey, USA (Yu et al. 2012).

Material examined: *Aphis nerii* Boyer de Fonscolombe 1841, *Nerium* sp. (Apocynaceae), 40°06'58.3" N 26°24'47.4" E, Çanakkale, City Centre, 12.VI.2015, 11♀♀, 2♂♂; *Aphis punicae* Passerini 1863, *Punica granatum* L. (Lythraceae), 40°08'24.7" N 26°24'10.8" E, Çanakkale, City Centre, 10.VI.2015, 4♀♀, 2♂♂.

****Aphidius hortensis* Marshall, 1896**

Distribution: Bulgaria, Canada, Czech Republic, Estonia, Finland, France, Georgia, Germany, Hungary, India, Italy, Moldova, the Netherlands, Poland, Slovakia, Spain, USA, Ukraine, United Kingdom, Yugoslavia, Serbia (Yu et al. 2012).

Material examined: *Liosomaphis berberidis* (Kaltenbach 1843), *Berberis* sp. (Berberidaceae), 40°06'39.8" N 26°24'59.5" E, Çanakkale, City Centre, 27.VI.2015, 3♀♀.

A. hortensis is a new record for the aphid parasitoid fauna of Turkey. Also, the *A. hortensis* - *L. berberidis* association is a new record from Turkey. *A. hortensis* characterize short antennae with 14-15 antennal segments, elongated stigma, two-segmented labial palpomeres and short metacarpus (Figure 2). It is specialized parasitoids of *L. berberidis*.

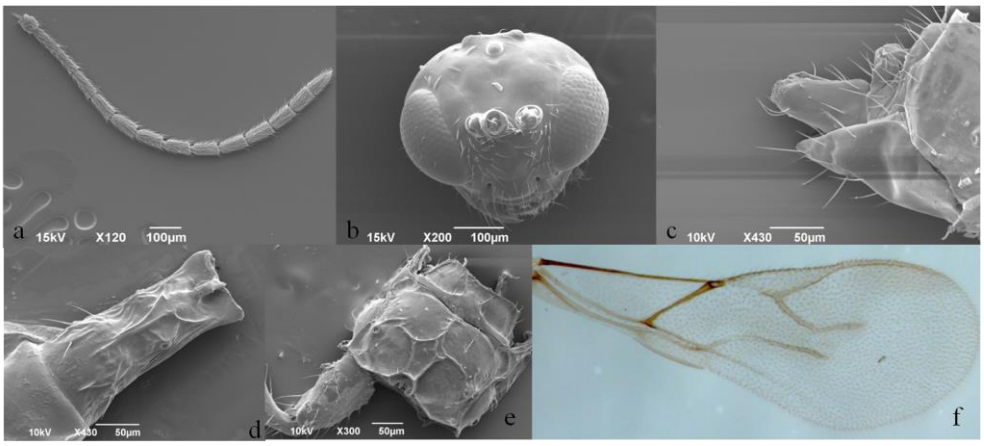

Figure 2. *Aphidius hortensis* Marshall, 1896 (a) antennae, (b) head, frontal view, (c) ovipositor sheaths, lateral view, (d) petiole, dorsal view, (e) propodeum, dorsal view, (f) forewing.

***Aphidius matricariae* Haliday, 1834**

Distribution: Algeria, Andorra, Argentina, Belgium, Bulgaria, Canada, Chile, China, Cyprus, Czech Republic, Egypt, Finland, France, Germany, Hungary, India, Iran, Iraq, Israel, Italy, the Netherlands, Norway, Poland, Portugal, Serbia, Slovakia, Slovenia, Spain, Turkey, USA, Ukraine, United Kingdom, Yugoslavia (Yu et al. 2012).

Material examined: *Brachycaudus helichrysi* (Kaltenbach 1843), *Anthemis* sp. (Asteraceae), 40°08'36.5" N 26°25'01.4" E, Çanakkale, City Centre, 31.V.2015, 19♀♀, 20♂♂; *Brachycaudus helichrysi* (Kaltenbach 1843), *Helianthus annuus* L. (Asteraceae), 40°06'55.5" N 26°24'37.2" E, Çanakkale, City Centre, 15.V.2015, 3♀♀, 3♂♂.

***Aphidius rosae* Haliday, 1834**

Distribution: Andorra, Belarus, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Finland, France, Germany, Greece, Hungary, India, Iran, Iraq, Ireland, Israel, Italy, the Netherlands, Norway, Pakistan, Poland, Portugal, Romania, Russia, Slovakia, Spain, Switzerland, Turkey, USA, Ukraine, United Kingdom, Yugoslavia, Serbia (Yu et al. 2012).

Material examined: *Macrosiphum rosae* (Linnaeus 1758), *Rosa* sp. (Rosaceae), 40°05'59.6" N 26°22'03.3" E, Çanakkale, Kepez, 05.VI.2015, 23♀♀, 4♂♂.

***Binodoxys acalephae* (Marshall, 1896)**

Distribution: Andorra, Bulgaria, Canada, China, Czech Republic, Finland, France, Georgia, Germany, Hungary, India, Iran, Iraq, Italy, Kazakhistan, Moldova, Morocco, the Netherlands, Poland, Portugal, Russia, Serbia, Slovakia, Slovenia, Spain, Turkey, United Kingdom, Yugoslavia (Yu et al. 2012).

Material examined: *Aphis craccivora* Koch 1854, *Robinia pseudoacacia* L. (Fabaceae), 40°06'41.0" N 26°25'00.4" E, Çanakkale, City Centre, 06.VI.2015, ♀; *Aphis fabae* Scopoli 1763, *Robinia pseudoacacia* L. (Fabaceae), 40°06'41.0" N 26°25'00.4" E, Çanakkale, City Centre, 06.VI.2015, 5♀♀, 6♂♂.

***Lipolexis gracilis* Foerster, 1862**

Distribution: Algeria, Andorra, Bulgaria, China, Czech Republic, Finland, France, Georgia, Germany, Greece, Hungary, India, Italy, Japan, Kazakhistan, Lebanon, Moldova, the Netherlands, Pakistan, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Thailand, Turkey, Uzbekistan, Yugoslavia, Serbia (Yu et al. 2012).

Material examined: *Aphis gossypii* Glover 1877, *Abelmoschus esculentus* (L.) Moench (Malvaceae), 40°13'56.1" N 26°32'25.4" E, Çanakkale, City Centre, 06.VI.2015, ♀.

***Lysiphlebus fabarum* (Marshall, 1896)**

Distribution: Afghanistan, Algeria, Andorra, Australia, Azerbaijan, Belgium, Bulgaria, China, Czech Republic, Egypt, Finland, France, Georgia, Germany, Greece, Hungary, India, Iran, Iraq, Israel, Italy, Japan, Kazakhistan, Korea, Lebanon, Moldova, Morocco, the Netherlands, Pakistan, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Switzerland, Syria, Turkey, Ukraine, United Kingdom, Uzbekistan, Yugoslavia, Serbia (Yu et al. 2012).

Material examined: *Aphis fabae* Scopoli 1763, *Phaseoulus vulgaris* L. (Fabaceae), 40°05'57.6" N 26°22'03.1" E, Çanakkale, Kepez, 05.VI.2015, 43♀♀; *Aphis fabae* Scopoli 1763, *Spartium junceum* L. (Fabaceae), 40°06'43.1" N 26°25'16.0" E, Çanakkale, University Campus, 23.V.2014, 4♀♀; *Aphis umbrella* (Börner 1950), *Malva* sp. (Malvaceae), 40°05'35.7" N 26°23'25.3" E, Çanakkale, Kepez, 25.IV.2014, 10♀♀; *Aphis gossypii* Glover 1877, *Abelmoschus esculentus* (L.) Moench (Malvaceae), 40°13'56.1" N 26°32'25.4" E, Çanakkale, Yapıldak, 06.VI.2015, 10♀♀.

***Lysiphlebus testaceipes* (Cresson, 1880)**

Distribution: Algeria, Argentina, Australia, Belgium, Brazil, Canada, Chile, China, Costa Rika, Croatia, Cuba, Czech Republic, France, Greece, India, Iran, Italy, Korea, Mexico, Pakistan, Peru, Portugal, South Africa, Spain, Turkey, USA, Uzbekistan, Yugoslavia, Serbia (Yu et al. 2012).

Material examined: *Aphis nerii* Boyer de Fonscolombe 1841, *Nerium* sp. (Apocynaceae), 40°08'56.4" N 26°24'17.9" E, Çanakkale, City Centre, 11.VII.2014, 8♀♀, ♂; *Aphis nerii* Boyer de Fonscolombe 1841, *Nerium* sp. (Apocynaceae), 40°06'59.3" N 26°24'49.0" E, Çanakkale, University Campus, 12.VI.2015, 13♀♀, 11♂♂; *Aphis nerii* Boyer de Fonscolombe 1841, *Nerium* sp. (Apocynaceae), 40°10'00.1" N 26°24'40.4" E, Çanakkale, Esenler, 17.VI.2015, 2♀♀, ♂; *Aphis fabae* Scopoli 1763, *Vicia faba* L. (Fabaceae), 40°06'44.7" N 26°24'22.9" E, Çanakkale, Kepez, 14.V.2014, ♀, 2♂♂; *Aphis punicae* Passerini 1863, *Punica granatum* L. (Lythraceae), 40°05'55.5" N 26°22'04.1" E, Çanakkale, Kepez, 05.VI.2015, 10♀♀, 7♂♂; *Aphis punicae* Passerini 1863, *Punica granatum* L. (Lythraceae), 40°08'24.9" N 26°24'12.8" E, Çanakkale, City Centre, 10.VI.2015, 3♀♀, 6♂♂; *Aphis punicae* Passerini 1863, *Punica granatum* L. (Lythraceae), 40°09'03.0" N 26°24'29.6" E, Çanakkale, City Centre, 01.VI.2014, 14♀♀, 17♂♂.

***Pauesia* sp. Quilis Perez, 1931**

Distribution: Afrotropical, East and West Palaearctic, European, Nearctic, Neotropical and Oriental regions (Yu et al. 2012).

Material examined: *Cinara pini* (Linnaeus 1758), *Pinus* sp. (Pinaceae), 40°06'37.7" N 26°24'37.1" E, Çanakkale, Kepez, 14.V.2014, 11♀♀, ♂.

Order Coleoptera

Family Coccinellidae

Subfamily Coccinellinae

***Adalia bipunctata* (Linnaeus, 1758)**

Distribution: Middle Africa (Bielawski 1975), USA (Gordon 1985), Canada (Larson 2013), Palaearctic region, North Africa, North Asia and North China (Uygun 1981, Kovar 2007).

Material examined: *Aphis punicae* Passerini 1863, *Punica granatum* L. (Lythraceae), 40°13'56.1" N 26°32'25.4" E, Çanakkale, Yapıldak, 06.VI.2015, (2); *Brachycaudus helichrysi* (Kaltenbach), *Anthemis* sp. (Asteraceae), 40°08'36.5" N 26°25'01.4" E, Çanakkale, City Centre, 31.V.2015, (2); *Chaitophorus leucomelas* Koch, *Populus* sp. (Salicaceae), 40°06'32.9" N 26°24'59.3" E, Çanakkale, University Campus, 11.IV.2013, (4); *Cavariella aegopodii* (Scopoli), *Salix* sp. (Salicaceae), 40°06'48.9" N 26°25'14.2" E, Çanakkale, University Campus, 24.IV.2015, (2); *Cinara pini* (Linnaeus 1758), *Pinus* sp. (Pinaceae), 40°06'37.7" N 26°24'37.1" E, Çanakkale, Kepez, 14.V.2014 (1); *Hyalopterus pruni* (Geoffroy 1762), *Prunus persic*a L. (Batsch) (Rosaceae), 40°01'38.1" N 27°02'54.2" E, Çanakkale, Çan, 07.VI.2013, (2).

***Adalia fasciatopunctata revelieri* Mulsant, 1866**

Distribution: South Palaearctic region (Horion 1961).

Material examined: *Chaitophorus leucomelas* Koch, *Populus* sp. (Salicaceae), 40°06'32.9" N 26°24'59.3" E, Çanakkale, University Campus, 11.IV.2013, (3); *Cinara pini* (Linnaeus 1758), *Pinus* sp. (Pinaceae), 40°06'37.7" N 26°24'37.1" E, Çanakkale, Kepez, 14.V.2014, (1); *Aphis nerii* Boyer de Fonscolombe 1841, *Nerium* sp. (Apocynaceae), 40°08'56.4" N 26°24'17.9" E, Çanakkale, City Centre, 11.VII.2014, (1); *Hyalopterus pruni* (Geoffroy 1762), *Prunus persica* L. (Batsch) (Rosaceae), 40°01'38.1" N 27°02'54.2" E, Çanakkale, Çan, 07.VI.2013, (1).

***Chilocorus bipustulatus* (Linnaeus, 1758)**

Distribution: Mongolia (Bielawski 1975), USA (Gordon 1985), Palaearctic (especially Mediterranean region) (Uygun 1981, Kovar 2007), Sudan (Yousof et al. 2013),

Material examined: *Macrosiphum rosae* (Linnaeus 1758), *Rosa* sp. (Rosaceae), 40°08'44.2" N 26°24'59.6" E, Çanakkale, City Centre, 21.IV.2013, (5).

***Coccinella septempunctata* Linnaeus, 1758**

Distribution: USA (Gordon 1985), Canada (Larson 2013), Sri Lanka (Ashfaquae 2012), Pakistan (Poorani 2004); Palaearctic and Afrotropical region (Horion 1961, Kovar 2007).

Material examined: *Aphis rumicis* Linnaeus 1758, *Rumex* sp. (Polygonaceae), 40°15'04.9" N 26°35'49.5" E, Çanakkale, Umurbey, 31.III.2013, (4); *Brevicoryne brassicae* (Linnaeus 1758), *Brassica oleracea* L. (Brassicaceae), 40°20'12.2" N 26°42'28.3" E, Lapseki, Beyçayırı, 31.III.2013, (4); *Aphis fabae* Scopoli 1763, *Vicia faba* L. (Fabaceae), 40°05'27.1" N 26°23'29.7" E, Çanakkale, Kepez, 14.III.2013, (5); *Hyperomyzus lactucae* (Linnaeus 1758), *Sonchus* sp. (Asteraceae), 40°6'40.6" N 26°24'53.1" E, Çanakkale, University Campus, 11.IV.2013, (1); *Aphis fabae solanella* Theobald 1914, *Solanum nigrum* L. (Solanaceae), 39°34'56.7 N 26°25'0.2" E, Çanakkale, Ayvacık, 10.IX.2013, (1); *Acyrthosiphon gossypii* Mordvilko 1914, *Sonchus asper* (L.) Hill 1769 (Asteraceae), 40°16'21.8" N 27°16'07.2" E, Çanakkale, Biga, 02.IV.2013, (5).

***Coccinella quatuordecimpustulata* (Linnaeus, 1758)**

Distribution: South Palaearctic region (Horion 1961).

Material examined: *Aphis fabae* Scopoli 1763, *Artemisia* sp. (Asteraceae), 40°4'46.30" N 26°21'41.6" E, Çanakkale, Dardanos campus, 18.IV.2013, (2).

***Exochomus (Parexochomus) nigromaculatus* Goeze, 1777**

Distribution: USA (Gordon 1985), Palaearctic region (Uygun 1981, Kovar 2007).

Material examined: *Hyperomyzus lactucae* (Linnaeus 1758), *Sonchus* sp. (Asteraceae), 40°6'40.6" N 26°24'53.1" E, Çanakkale, University Campus, 11.IV.2013, (1).

***Hippodamia variegata* Goeze, 1777**

Distribution: Palaearctic (especially western) region, Middle and North Africa, Europe, Arabia, India and China (Horion 1961, Kovar 2007).

Material examined: *Liosomaphis berberidis* (Kaltenbach), *Berberis* sp. (Berberidaceae), 40°06'39.8" N 26°24'59.5" E, Çanakkale, University Campus, 27.VI.2015, (2); *Aphis nerii* Boyer de Fonscolombe 1841, *Nerium* sp. (Apocynaceae), 40°08'56.4" N 26°24'17.9" E, Çanakkale, City Centre, 11.VII.2014, (1).

***Nephus (Bipunctatus) nigricans* Weise, 1879**

Distribution: Albania, France, Greece, Italy (Kovar 2007), Mediterranean region (Fursch 1965).

Material examined: *Aphis pomi* De Geer 1773, *Malus pumila* Miller, 1768 (Rosaceae), 39°46'7.9"N 26°46'45.7" E, Çanakkale, Bayramiç, 25.IV.2013, (1).

***Oenopia conglobata* (Linnaeus, 1758)**

Distribution: North America (Ashfaquae 2012), Europe, North Africa, Anatolia, Syria, Middle Asia and Siberia (Horion 1961).

Material examined: *Cinara pini* (Linnaeus 1758), *Pinus* sp. (Pinaceae), 40°06'37.7" N 26°24'37.1" E, Çanakkale, Kepez, 14.V.2014, (1); *Eucallipterus tiliae* (Linnaeus), *Tilia* sp. (Malvaceae), 40°06'36.4" N 26°24'49.5" E, Çanakkale, University Campus, 06.VI.2015, (1).

***Psyllobora vigintiduopunctata* (Linnaeus, 1758)**

Distribution: South Palaearctic region, Europe, North Africa, Anatolia, Armenia and Siberia (Horion 1961, Kovar 2007).

Material examined: *Myzus* (*Nectarosiphon*) *persicae* Sulzer 1776, *Capsicum* sp. (Solanaceae), 39°58'00.3" N 27°11'06.5" E, Çanakkale, Yenice, 04.IX.2013, (1).

***Scymnus pallipediformis* Gunther, 1958**

Distribution: Palaearctic region (Audisio and Canepari 2016).

Material examined: *Tinocallis (Sarucallis) kahawaluokalani* (Kirkaldy), *Lagerstroemia indica* L. Pers. (Lythraceae), 40°06'37.1" N 26°24'47.1" E, Çanakkale, University Campus, 27.VI.2015, (1).

***Scymnus (Pullus) subvillosus* (Goeze, 1777)**

Distribution: East Palaearctic, North Africa, Turkey, Russia, Georgia, Armenia, Azerbaijan, Syria, Israel, Iran, Iraq, Jordan, Arabian Peninsula (Audisio and Canepari 2016).

Material examined: *Cinara pini* (Linnaeus 1758), *Pinus* sp. (Pinaceae), 40°06'37.7" N 26°24'37.1" E, Çanakkale, Kepez, 14.V.2014, (1); *Chaitophorus leucomelas* Koch, *Populus* sp. (Salicaceae), 40°06'32.9" N 26°24'59.3" E, Çanakkale, University Campus, 11.IV.2013, (1).

In the present study, *Lysiphlebus testaceipes* (Cresson, 1880) (32.9%) and *Lysiphlebus fabarum* (Marshall, 1896) (23.0%) were found more extensively than the other parasitoid species. Similarly, *Coccinella septempunctata* Linnaeus, 1758 (35.1%) and *Adalia bipunctata* (Linnaeus, 1758) (22.8%) are recorded as the most common predator species. Interestingly, we did not find the widespread invasive species *Harmonia axyridis* Pallas, 1773. The diversity of parasitoids and predators associated with different host aphids was determined in all areas of the Çanakkale Province. The study revealed that the *Aphis fabae* Scopoli 1763 had the greatest diversity of parasitoids (Shannon-Wiener $H = 0.658$) whereas *Cinara pini* (Linnaeus, 1758) had the greatest diversity of predators (Shannon-Wiener $H = 1.386$) (Table 1).

Table 1. Diversity and occurrence of parasitoids and predators on their host aphids in the Çanakkale Province, Turkey

Host Aphid Species	Parasitoid Species											Predator Coccinellid Species											
	A. salicaphis	*A. colemani*	*A. hortensis*	*A. matricariae*	*A. rosae*	*B. acalephae*	*L. gracilis*	*L.fabarum*	*L. testaceipes*	*Pauesia*sp.	Shanon-Weiner H	*A. bipunctata*	*A. f. revelieri*	*C. bipustulatus*	*C. septempunctata*	*C. quatuordecimpustulata*	*E. nigromaculatus*	*H. variegate*	*N. nigricans*	*O. conglobata*	*P. vigintiduopunctata*	*S. pallipediformis*	*S. subvillosus*	Shanon-Weiner H
A. craccivora	-	-	-	-	-	1	-	-	-	-	0.000	-	-	-	-	-	-	-	-	-	-	-	0.000
A. fabae	-	-	-	-	-	11	-	47	3	-	0.658	-	-	-	5	2	-	-	-	-	-	-	0.598
A. fabaesolanella	-	-	-	-	-	-	-	-	-	-	0.000	-	-	-	1	-	-	-	-	-	-	-	0.000
A. gossypii	-	-	-	-	-	-	1	10	-	-	0.305	-	-	-	-	-	-	-	-	-	-	-	0.000
Acyr. gossypii	-	-	-	-	-	-	-	-	-	-	0.000	-	-	-	5	-	-	-	-	-	-	-	0.000
A. nerii	-	13	-	-	-	-	-	-	36	-	0.579	-	1	-	-	-	-	1		-	-	-	0.693
A. pomi	-	-	-	-	-	-	-	-	-	-	0.000	-	-	-	-	-	-	-	1	-	-	-	0.000
A. punicae	-	6	-	-	-	-	-	-	57	-	0.314	2	-	-	-	-	-	-	-	-	-	-	0.000
A. rumicis	-	-	-	-	-	-	-	-	-	-	0.000	-	-	-	4	-	-	-	-	-	-	-	0.000
A. umbrella	-	-	-	-	-	-	-	10	-	-	0.000	-	-	-	-	-	-	-	-	-	-	-	0.000
B. helichrysi	-	-	-	45	-	-	-	-	-	-	0.000	2	-	-	-	-	-	-	-	-	-	-	0.000
B. brassicae	-	-	-	-	-	-	-	-	-	-	0.000	-	-	-	4	-	-	-	-	-	-	-	0.000
C. aegopodii	-	-	-	-	-	-	-	-	-	-	0.000	2	-	-	-	-	-	-	-	-	-	-	0.000
C. leucomelas	9	-	-	-	-	-	-	-	-	-	0.000	4	3	-	-	-	-	-	-	-	-	1	0.974
C. pini	-	-	-	-	-	-	-	-	-	12	0.000	1	1	-	-	-	-	-	1	-	-	1	1.386
E. tiliae	-	-	-	-	-	-	-	-	-	-	0.000	-	-	-	-	-	-	-	1	-	-	-	0.000
H. pruni	-	-	-	-	-	-	-	-	-	-	0.000	2	1	-	-	-	-	-	-	-	-	-	0.637
H. lactucae	-	-	-	-	-	-	-	-	-	-	0.000	-	-	-	1	-	1		-	-	-	-	0.693
L. berberidis	-	-	3	-	-	-	-	-	-	-	0.000	-	-	-	-	-	-	2	-	-	-	-	0.000
M. rosae	-	-	-	-	27	-	-	-	-	-	0.000	-	-	5	-	-	-	-	-	-	-	-	0.000
M. persicae	-	-	-	-	-	-	-	-	-	-	0.000	-	-	-	-	-	-	-	-	1	-	-	0.000
T. kahawaluokalani	-	-	-	-	-	-	-	-	-	-	0.000	-	-	-	-	-	-	-	-	-	1	-	0.000
Occurrence ratio (%)	3.0	6.5	1.0	15.5	9.3	4.1	0.3	23.0	32.9	4.1		22.8	10.5	8.8	35.1	3.5	1.8	5.3	1.8	3.5	1.8	1.8	3.5
	Total number of parasitoids: 291 specimens											Total number of predators: 57 specimens											

A great number of local studies have been conducted to identify aphid parasitoids and predators in cultivated and uncultivated areas of Turkey. Ölmez and Ulusoy (2003) reported that 16 parasitoid species belonging to nine genera of the subfamily Aphiidinae (Hymenoptera: Braconidae) were determined in the Diyarbakır Province. Among these parasitoid species, *Monoctonus mali* van Achterberg 1989 was a new record for the aphid parasitoid fauna of Turkey. Aslan et al. (2004) investigated aphid parasitoids in the Kahramanmaraş Province. They reported 19 aphid parasitoid species belonging to the subfamily Aphiidinae (Hymenoptera: Braconidae) and family Aphelinidae (Hymenoptera) on different plants. A list of the aphid hosts of parasitoid species was given in the indicated study, and the finding of *Pauesia picta* (Haliday, 1834) was a new record for the aphid parasitoid fauna of Turkey. Güz and Kılınçer (2005) reported 10 aphid parasitoid species belonging to six genera of the family Braconidae (Hymenoptera) family in the Ankara Province. Çetin Erdoğan et al. (2008) announced that 17 species of Aphiidinae parasitoids were identified from region of Marmara including Provinces of Adapazarı, Balıkesir, Bursa, Bilecik, Çanakkale, Edirne, İstanbul, İzmit, Tekirdağ and Yalova. Tomanović et al. (2008) conducted a study to identify aphid parasitoids in the Marmara and Black Sea regions of Turkey. In this study, they recorded eight species new for the aphid parasitoid fauna of Turkey. Akar and Çetin Erdoğan (2017) reported that 27 species belongs to Aphiidinae were determined in eight different habitats in the Province of Edirne. Among these, seven species were new records for the Turkish Aphiidinae fauna. Baştuğ and Kasap (2015) surveyed species of the family Coccinellidae (Coleoptera) on different plants in cultivated and uncultivated areas of the province investigated in our study (the Çanakkale Province). They reported 20 coccinellid species by focusing only on the existence of coccinellid species in the Çanakkale Province, but not investigated aphid-coccinellid associations. Aslan and Uygun (2005) identified 33 predator coccinellid species associated with 59 aphids feeding on different plants in cultivated and uncultivated areas of the Kahramanmaraş Province. Many studies have been carried out to identify species of aphid parasitoids and predators in different districts of Turkey (Aslan and Karaca 2005, Ayyıldız and Atlıhan 2006, Güncan et al. 2010, Şahbaz and Uysal 2006). Although many local areas in Turkey have been investigated to determine parasitoids and predators of aphids, the number of their natural enemies is still quite limited.

In view of the negative effects of pesticides used to control of aphids and other pests on the environment and human health, parasitoids and predators of these pests have become more important in biological control studies. Protecting and supporting the native parasitoids and predators of aphids will increase the success of biological control efforts in field and greenhouse conditions. In addition to determining natural enemies of aphids feeding on plants in agricultural fields, aphid-parasitoid-predator associations on plants in uncultivated areas should also be investigated. With the present study, parasitoids and predators of aphids are determined for the first time in cultivated and uncultivated areas of the Çanakkale Province in Turkey. It is recommended that local fauna studies of parasitoids and predators of aphids be

conducted so that these natural enemies can be used more effectively in biological control studies. More comprehensive studies will contribute to knowledge of the fauna of natural enemies of aphids in Turkey.

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