

Reported Aphid (Hemiptera: Aphidoidea) and Ant (Hymenoptera: Formicidae) Species Associations from Samsun Province

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ABSTRACT

Mutualistic relationship between ants and aphids species are common phenomena. This association arise from honeydew excretion by aphids. Proportion of honeydew ingredient which is the most important point of this relationship is variable according to both plant and aphid species. In this study, it was determined that 13 ant species associated with 45 aphid species. The most tending ant species associated with many aphid species were *Lasius brunneus* (Latreille, 1798) (Hymenoptera: Formicidae), *Lasius turcicus* Santschi, 1921 (Hymenoptera: Formicidae), *Lasius alienus* (Foerster, 1850) (Hymenoptera: Formicidae), *Formica rufibarbis* Fabricius, 1793 (Hymenoptera: Formicidae) and *Formica cunicularia* Latreille, 1798 (Hymenoptera: Formicidae). The most aphid species associated with many ant species were *Aphis spiraeicola* Patch, 1914 (Hemiptera: Aphididae), *Aphis fabae* Scopoli, 1763 (Hemiptera: Aphididae) and *Brachycaudus cardui* (Linnaeus, 1758) (Hemiptera: Aphididae).

Key words: Aphid, ant, mutualism, Samsun.

INTRODUCTION

Many Hemipteran species produce a carbohydrate-rich excretion called honeydew. In temperate regions, aphids are the most important honeydew producers and many of them have developed a mutualistic relationship with ants (Völkl *et al.*, 1999; Katayama and Suzuki, 2003). Ants have colonized almost every landmass around the world. They can succeed in most ecosystems, and may form about 15-25% of the terrestrial animal biomass. There are about 12,000 species of ants and many ant species protect and cultivate flock of greenfly, coccids and aphids (Ülgentürk, 2001; Dixon, 2004; Keller and Gordon, 2010). Aphids have a various interactions with ant species such as antagonistic, facultatively mutualistic or obligately mutualistic (Stadler and Dixon, 2005). There are about 5000 aphid determined species worldwide (Blackman and Eastop, 2015) and they mostly feed on phloem sap, which is generally rich in sugars but low in nitrogen. Thus, aphids need to ingest large volumes of phloem sap most of which is excreted as honeydew (Dixon, 2004; Stadler and Dixon, 1998) to supply sufficient amount of protein. The proportion of sugars in aphid honeydews is variable related with both plant and aphid species. It depends on host plants (Fischer

and Shingleton, 2001; Fischer *et al.*, 2005), location of host plants, season and year (Beggs *et al.*, 2005; Vantaux *et al.*, 2011), parts of plant where aphids settle as well as on the different concentrations of nutrients of plant sap related to the different periods of the vegetative season. The more both phloem-sap and aphid honeydew are rich in sugars the ants are attracted by that honeydew (Binazzi and Scheurer, 2009). Although most aphid species produce honeydew, are susceptible to predation, and co-occur in the same ecological niches with ants (Bristow, 1991; Billick *et al.*, 2007), only 60% of aphid species have a relationship with ants in where 40% of the relations are obligatory (Stadler, 1997). Aphids are soft bodied and have very weak defense strategies against natural enemies. Therefore, it is likely that a major benefit of ant attendance for aphids is protection from their natural enemies. As a result of the mutualistic relationships between these two major insect groups, the ants obtain food and the aphids get protection from these mutualistic relations vice versa (DelClaro and Oliveira, 1993; Dixon, 1998; Kaplan and Eubanks, 2002). Previous studies have also shown that ant tending improves the survival and reproduction rate of aphid colonies as protection of aphids from enemies. Flatt and Weisser (2000) investigated the effects of ant tending on life history traits of aphids feeding on host plant in the absence of natural enemies. They showed that the presence of ant *Lasius niger* (Linnaeus, 1758) (Hymenoptera: Formicidae) had strong positive effect on the fitness of individuals of the aphid *Metopeurum fuscoviride* Stroyan, 1950 (Hemiptera: Aphididae), and ant-tended aphid individuals had a longer life span, matured earlier, had higher reproduction rate, higher number of offspring than aphids not tended by ants. In the similar studies, Stewart-Jones *et al.* (2008) studied the effects of ant-tending on population and natural enemies of *Dysaphis plantaginea* (Passerini, 1860) (Hemiptera: Aphididae) which is an important pest on apples in Europe. They reported decrease in population of *D. plantaginea* in the absence of ant-tending. It has been also proposed that the pattern of ant mutualism among aphids may be explained by differences in feeding position on their host plant (Dixon, 1998; Stadler *et al.*, 2003; Shingleton *et al.*, 2005). Depa *et al.* (2012) showed that aphid species feed on deeper located floem might have a more difficulty to escape from their natural enemies, so they might need to mutualistic relations with ant species compared with other aphid species feed on superficially located phloem.

Common ecologically and agriculturally important mutualistic relations between aphid and ant species have not been well studied in Turkey. Özdemir *et al.* (2008) determined 16 ant species associated with 19 aphid species on wild plants and indicated that the most tending ant species that associated with many aphid species were *Camponotus aethiops* (Latreille, 1978) (Hymenoptera: Formicidae), *Camponotus piceus* (Leach, 1825) (Hymenoptera: Formicidae), *Formica glauca* Ruzsky, 1896 (Hymenoptera: Formicidae), *Lasius paralienus* Seifert, 1992 (Hymenoptera: Formicidae) and *Crematogaster sordidula* (Nylander, 1849) (Hymenoptera: Formicidae) respectively. Recently Akyıldırım *et al.* (2014) reported 15 ant species associated with 45 aphid species from Far Eastern Black Sea Region of Turkey. The most encountered ant species, which interacted with different number of aphid species, were *Formica cinereofusca* Karawaiew, 1929, *Lasius turcicus* Santschi, 1921 and

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Lasius emarginatus (Olivier, 1792) respectively. Among determined aphid species *Aphis fabae* Scopoli, 1763, *Brachycaudus cardui* (Linnaeus, 1758), *Aphis gossypii* Glover, 1877, *Aphis spiraecola* Patch, 1914, *Cinara pilicornis* (Hartig, 1841) and *Toxoptera aurantii* Boyer de Fonscolombe, 1841 has higher ant attraction respectively. In this aspect, this aimed to find out possible ant-aphid mutualistic relation in Samsun Province where no similar study has been performed so far.

MATERIAL AND METHODS

The aphids and ants specimens were collected with a fine brush by sweeping from different herbaceous and woody plants in Samsun province (from all districts) of Turkey between 2009 and 2011. The most important point on aphid sampling was that try to collect aphid also ant species on as much as majority of the host plant which reflect study area floristic composition. As these relations were affected by host plant features, seasonal changes and climatic conditions, aphid and ant species were sampled from April to November during 2 years basically based on aphid sampling periods with 15 days intervally. Specimens were collected from both urban and rural areas, recorded on field notebook, kept separately and brought back to the laboratory for identification. Ant individuals were followed if they stay for a while or a long period in or around colony and then they were considered they have mutualistic relations with aphid species. Any ant individuals flood around the plant species, they have not considered as aphid mutualist partner. The collected specimens were kept in eppendorf tubes with 80% ethanol. The permanent slides of aphid specimens have been performed according to the principles of Martin (1983) in laboratory. The taxonomic characters of all aphids were examined and identified according to Blackman and Eastop, 2015. The ant specimens were identified by Dr. Yılmaz Çamlıtepe (Trakya University, Science Faculty). Taxonomic status and valid names of the identified aphid and ant species were checked with Blackman and Eastop, 2016. Also hostplants were identified by Dr. H. Güray Kutbay and Dr. Hasan Korkmaz (Ondokuz Mayıs University, Science and Art Faculty). Voucher specimens of aphids and ants have been located at the Biology Department of Ondokuz Mayıs University.

RESULTS

As a result of the study conducted between 2009 and 2011 in Samsun province, 141 aphid species determined and it was shown that that 13 ant species associated with 45 aphid species. The tending ant species and their attended aphid species number were as follows: *L. brunneus* 20 aphid species, *L. turcicus* 13 aphid species, *L. alienus* 11 aphid species, *F. rufibarbis* seven aphid species, *F. cunicularia* six aphid species, *Cremastogaster scutellaris* (Olivier, 1792) (Hymenoptera: Formicidae) and *Plagiolepis pygmaea* (Latreille, 1798) (Hymenoptera: Formicidae) five aphid species, *C. aethiops* and *Tetramorium caespitum* (Linnaeus, 1758) (Hymenoptera: Formicidae) four aphid species, *Formica fusca* Linnaeus, 1758 (Hymenoptera: Formicidae) two aphid species, *Camponotus lateralis* (Olivier, 1791) (Hymenoptera: Formicidae), *Formica sanguinea* Latreille, 1798 (Hymenoptera: Formicidae) and *Tetramorium forte* Forel,

1904 (Hymenoptera: Formicidae) one aphid species. The aphid species and their tending ants species list were given in Table 1.

Table 1. The list of aphid species and their mutualistic ant species

Aphids (Hemiptera: Aphididae)	Ants (Hymenoptera: Formicidae)
<i>Acyrtosiphon pisum</i> (Harris, 1776)	<i>Lasius turcicus</i> Santschi, 1921
<i>Aphis brotericola</i> Mier Durante, 1978	<i>Formica cunicularia</i> Latreille, 1798
<i>Aphis brunellae</i> Schouteden, 1903	<i>Lasius turcicus</i> Santschi, 1921
<i>Aphis craccivora</i> Koch, 1854	<i>Formica fusca</i> Linnaeus, 1758
	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Aphis fabae</i> Scopoli, 1763	<i>Camponotus aethiops</i> (Latreille, 1798)
	<i>Cremastogaster scutellaris</i> (Olivier, 1792)
	<i>Formica cunicularia</i> Latreille, 1798
	<i>Lasius alienus</i> (Foerster, 1850)
	<i>Lasius brunneus</i> (Latreille, 1798)
	<i>Lasius turcicus</i> Santschi, 1921
	<i>Plagiolepis pygmaea</i> (Latreille, 1798)
<i>Aphis gerardianae</i> Mordvilko, 1929	<i>Plagiolepis pygmaea</i> (Latreille, 1798)
<i>Aphis gossypii</i> Glover, 1877	<i>Lasius alienus</i> (Foerster, 1850)
	<i>Lasius turcicus</i> Santschi, 1921
	<i>Plagiolepis pygmaea</i> (Latreille, 1798)
<i>Aphis hillerislambersi</i> Nieto Nafria and Mier Durante, 1976	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Aphis middletonii</i> Thomas, 1879	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Aphis nasturtii</i> Kaltenbach, 1843	<i>Formica cunicularia</i> Latreille, 1798
	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Aphis pomi</i> De Geer, 1773	<i>Cremastogaster scutellaris</i> (Olivier, 1792)
	<i>Lasius alienus</i> (Foerster, 1850)
	<i>Lasius brunneus</i> (Latreille, 1798)
	<i>Lasius turcicus</i> Santschi, 1921
<i>Aphis pseudocardui</i> Theobald, 1915	<i>Lasius alienus</i> (Foerster, 1850)
<i>Aphis salviae</i> Walker, 1852	<i>Tetramorium caespitum</i> (Linnaeus, 1758)
<i>Aphis solanella</i> Theobald, 1814	<i>Formica cunicularia</i> Latreille, 1798
	<i>Lasius alienus</i> (Foerster, 1850)
<i>Aphis spiraecola</i> Patch, 1914	<i>Camponotus lateralis</i> (Olivier, 1791)
	<i>Cremastogaster scutellaris</i> (Olivier, 1792)
	<i>Formica cunicularia</i> Latreille, 1798
	<i>Formica rufibarbis</i> Fabricius, 1793
	<i>Lasius brunneus</i> (Latreille, 1798)

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Table 1. Continued.

Aphids (Hemiptera: Aphididae)	Ants (Hymenoptera: Formicidae)
<i>Aphis spiraeicola</i> Patch, 1914	<i>Lasius turcicus</i> Santschi, 1921
	<i>Plagiolepis pygmaea</i> (Latreille, 1798)
	<i>Tetramorium caespitum</i> (Linnaeus, 1758)
<i>Aphis urticata</i> J. F. Gmelin, 1790	<i>Lasius alienus</i> (Foerster, 1850)
<i>Aphis verbasci</i> Schrank, 1801	<i>Lasius alienus</i> (Foerster, 1850)
<i>Brachycaudus cardui</i> (Linnaeus, 1758)	<i>Camponotus aethiops</i> (Latreille, 1798)
	<i>Lasius alienus</i> (Foerster, 1850)
	<i>Lasius brunneus</i> (Latreille, 1798)
	<i>Lasius turcicus</i> Santschi, 1921
	<i>Plagiolepis pygmaea</i> (Latreille, 1798)
	<i>Tetramorium caespitum</i> (Linnaeus, 1758)
<i>Brachycaudus helichrysi</i> (Kaltenbach, 1843)	<i>Lasius turcicus</i> Santschi, 1921
<i>Chaitophorus melanosphon</i> Pintera, 1987	<i>Crematogaster scutellaris</i> (Olivier, 1792)
<i>Chaitophorus populeti</i> (Panzer, 1804)	<i>Formica sanguinea</i> Latreille, 1798
<i>Cinara cedri</i> Mimeur, 1936	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Cinara cupressi</i> (Buckton, 1881)	<i>Lasius brunneus</i> (Latreille, 1798)
	<i>Lasius turcicus</i> Santschi, 1921
<i>Cinara indica</i> Verma, 1970	<i>Formica rufibarbis</i> Fabricius, 1793
<i>Cinara tujafilina</i> (Del Guercio, 1909)	<i>Lasius brunneus</i> (Latreille, 1798)
	<i>Lasius turcicus</i> Santschi, 1921
<i>Dysaphis devector</i> (Walker, 1849)	<i>Formica rufibarbis</i> Fabricius, 1793
<i>Dysaphis foeniculus</i> (Theobald, 1923)	<i>Lasius alienus</i> (Foerster, 1850)
<i>Dysaphis plantaginea</i> (Passerini, 1860)	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Hyalopterus pruni</i> (Geoffroy, 1762)	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Lachnus roboris</i> (Linnaeus, 1758)	<i>Camponotus aethiops</i> (Latreille, 1798)
	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Macrosiphum rosae</i> (Linnaeus, 1758)	<i>Formica cunicularia</i> Latreille, 1798
<i>Myzus cerasi</i> (Fabricius, 1775)	<i>Lasius alienus</i> (Foerster, 1850)
	<i>Lasius turcicus</i> Santschi, 1921
<i>Myzus lythri</i> (Schrank, 1801)	<i>Tetramorium caespitum</i> (Linnaeus, 1758)
<i>Myzus ornatus</i> (Laing, 1932)	<i>Formica rufibarbis</i> Fabricius, 1793
<i>Myzus padellus</i> (Hille Ris Lambers and Rogerson, 1946)	<i>Formica rufibarbis</i> Fabricius, 1793
<i>Myzus varians</i> Davidson, 1912	<i>Lasius turcicus</i> Santschi, 1921

Table 1. Continued.

Aphids (Hemiptera: Aphididae)	Ants (Hymenoptera: Formicidae)
<i>Periphyllus aceris</i> (Linnaeus, 1761)	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Pterocomma populeum</i> (Kaltenbach, 1843)	<i>Lasius brunneus</i> (Latreille, 1798)
	<i>Lasius turcicus</i> Santschi, 1921
<i>Schizaphis pyri</i> Shaposhnikov, 1952	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Sipha maydis</i> Passerini, 1860	<i>Formica cunicularia</i> Latreille, 1798
	<i>Lasius alienus</i> (Foerster, 1850)
<i>Sitobion fragariae</i> (Walker, 1848)	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Thelaxes suberi</i> (Del Guercio, 1911)	<i>Camponotus aethiops</i> (Latreille, 1798)
	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Tuberolachnus salignus</i> (Gmelin, 1790)	<i>Formica rufibarbis</i> Fabricius, 1793
<i>Uroleucon kashmiricum</i> (Verma, 1966a)	<i>Lasius brunneus</i> (Latreille, 1798)
<i>Uroleucon sonchi</i> (Linnaeus, 1767)	<i>Tetramorium forte</i> Forel, 1904

Brief information about determined ant species and their mutuals were summarised as follows.

***Camponotus aethiops* (Latreille, 1798) (Hymenoptera: Formicidae)**

Material examined: Vezirköprü, from *B. cardui* on *Carduus pycnocephalus* and *Onopordum tauricum*, from *A. fabae* on *Echium* sp., from *Lachnus roboris* (Linnaeus, 1758) (Hemiptera: Aphididae) on *Quercus cerris*, Kavak, from *L. roboris* on *Quercus cerris*, 02.07.2009; Asarcık, from *Thelaxes suberi* (Del Guercio, 1911) (Hemiptera: Aphididae) on *Quercus petraea*, 04.07.2009.

***Camponotus lateralis* (Olivier, 1791) (Hymenoptera: Formicidae)**

Material examined: Bafra, from *A. spiraeicola* on *Scaligeria* sp., 06.07.2009.

***Cremastogaster scutellaris* (Olivier, 1792) (Hymenoptera: Formicidae)**

Material examined: Alaçam, from *Chaitophorus melanosiphon* Pintera, 1987 (Hemiptera: Aphididae) on *Populus* sp., 05.07.2009; Bafra, from *A. fabae* on *Clematis* sp., 06.07.2009; Atakent, from *Aphis pomi* De Geer, 1773 (Hemiptera: Aphididae) on *Cydonia* sp. and from *A. spiraeicola* on *Crateagus* sp., 12.07.2009; Atakum, from *Pterocomma rufipes* (Hartig, 1841) (Hemiptera: Aphididae) on *Salix* sp., 22.05.2010.

***Formica cunicularia* Latreille, 1798 (Hymenoptera: Formicidae)**

Material examined: Bafra, from *Macrosiphum rosae* (Linnaeus, 1758) (Hemiptera: Aphididae) on *Rosa* sp., 12.05.2009; Atakum, from *A. spiraeicola* on *Scaligeria* sp., 24.05.2009; Ladik, from *A. fabae* on *Pimpinella saxifraga*, 03.07.2009; Asarcık, from *Aphis brotericola* Mier Durante, 1978 (Hemiptera: Aphididae) on *Euphorbia* sp. and from *Aphis solanella* Theobald, 1814 (Hemiptera: Aphididae) on *Centaurea* sp., 04.07.2009; Terme, from *Aphis nasturtii* Kaltenbach, 1843 (Hemiptera: Aphididae) on *Zea mays*, 10.07.2009; Atakum, from *Sipha maydis* Passerini, 1860 (Hemiptera: Aphididae) on *Bromus* sp., 19.05.2010.

***Formica fusca* Linnaeus, 1758 (Hymenoptera: Formicidae)**

Material examined: Ladik, from *Aphis craccivora* Koch, 1854 (Hemiptera: Aphididae) on *Onobrychis* sp., 03.07.2009; Terme, from *Aphis esulae* (Börner, 1940) (Hemiptera: Aphididae) on *Euphorbia* sp., 23.05.2010.

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***Formica rufibarbis* Fabricius, 1793 (Hymenoptera: Formicidae)**

Material examined: Ayvacık, from *Cinara indica* Verma, 1970 (Hemiptera: Aphididae) on *Cedrus* sp., from *Myzus ornatus* (Laing, 1932) (Hemiptera: Aphididae) on *Punica* sp., from *Dysaphis devecta* (Walker, 1849) (Hemiptera: Aphididae) on *Malus* sp., from *Cinara occidentalis* (Davidson, 1909) (Hemiptera: Aphididae) on *Abies* sp., from *A. spiraeola* on *Prunus* sp. and *Cydonia* sp., from *Tuberolachnus salignus* (Gmelin, 1790) (Hemiptera: Aphididae) on *Salix* sp., from *Myzus padellus* (Hille Ris Lambers and Rogerson, 1946) (Hemiptera: Aphididae) on *Prunus cerasus*, 24.05.2010.

***Formica sanguinea* Latreille, 1798 (Hymenoptera: Formicidae)**

Material examined: Ladik, from *Chaitophorus populeti* (Panzer, 1804) (Hemiptera: Aphididae) on *Populus* sp., 03.07.2009.

***Lasius alienus* (Foerster, 1850) (Hymenoptera: Formicidae)**

Material examined: Vezirköprü, from *A. fabae* on *Helianthus* sp., 02.07.2009; Ladik, from *A. fabae* on *Eryngium creticum*, from *A. solanella* on *Centaurea iberica*, from *B. cardui* on *Cirsium* sp., from *Aphis pseudocardui* Theobald, 1915 (Hemiptera: Aphididae) on *Sonchus* sp., from *A.pomi* on *Malus* sp. and from *Aphis gossypii* Glover, 1877 (Hemiptera: Aphididae) on *Verbascum* sp., 03.07.2009; Asarcık, from *A. fabae* on *Pimpinella saxifraga* and from *B. cardui* on *Cirsium* sp., 04.07.2009; Alaçam, from *Myzus cerasi* (Fabricius, 1775) (Hemiptera: Aphididae) on *Prunus cerasus* and from *Dysaphis foeniculus* (Theobald, 1923) (Hemiptera: Aphididae) on *Eryngium creticum*, 05.07.2009; Terme, from *S. maydis* on *Digitaria* sp., 10.07.2009; Atakum, from *Aphis urticae* J. F. Gmelin, 1790 (Hemiptera: Aphididae) on *Urtica* sp., 22.05.2010; Terme, from *Aphis verbasci* Schrank, 1801 (Hemiptera: Aphididae) on *Verbascum* sp., 23.05.2010.

***Lasius brunneus* (Latreille, 1798) (Hymenoptera: Formicidae)**

Material examined: Atakum, from *A. spiraeola* on *Eriobotrya* sp. and from *A. fabae* on *Sium* sp., 25.05.2009; Kavak, from *L. roboris* on *Quercus cerris*, 02.07.2009; Ladik, from *A. spiraeola* on *Rumex crispus* and from *A. fabae* on *Pimpinella saxifraga*, 03.07.2009; Asarcık, from *A. spiraeola* on *Crateagus* sp. and *Quercus cerris*, from *A. fabae* on *Pimpinella saxifraga*, from *B. cardui* on *Echium vulgare* and from *A. spiraeola* on *Oenanthe* sp., Samsun center, from *Uroleucon kashmiricum* (Verma, 1966a) (Hemiptera: Aphididae) on *Campanula* sp., 04.07.2009; Alaçam, from *Schizaphis pyri* Shaposhnikov, 1952 (Hemiptera: Aphididae) on *Pyrus* sp., from *A. nasturtii* on *Punica* sp., from *A. spiraeola* on *Malus* sp., from *Hyalopteris pruni* (Geoffroy, 1762) (Hemiptera: Aphididae) on *Prunus* sp. and from *Aphis middletonii* Thomas, 1879 (Hemiptera: Aphididae) on *Centaurea iberica*, 05.07.2009; Bafra, from *A. spiraeola* on *Zea mays* and from *A. craccivora* on *Cichorium* sp., 06.07.2009; Salıpazarı, from *Periphyllus aceris* (Linnaeus, 1761) (Hemiptera: Aphididae) on *Acer* sp., from *A. spiraeola* on *Cydonia* sp. and from *A. fabae* on *Pimpinella* sp., Çarşamba, from *Cinara tujaefilina* (Del Guercio, 1909) (Hemiptera: Aphididae) on *Cupressus* sp., Ayvacık, from *L. roboris* on *Quercus cerris*, 09.07.2009; Terme, from *A. spiraeola* on *Mespilus germanica* and from *A.pomi* on *Malus* sp., 10.07.2009; Tekkeköy, from *Sitobion fragariae* (Walker, 1848) (Hemiptera: Aphididae) on *Bromus* sp., 15.05.2010; Atakum, from *Cinara cedri* Mimeur, 1936 (Hemiptera: Aphididae) on *Cedrus* sp., from *A. fabae* on *Trifolium repens* and from *Cinara cupressi* (Buckton, 1881) (Hemiptera: Aphididae) on *Thuja* sp., 19.05.2010; Atakum, from *Pterocomma populeum* (Kaltenbach, 1843) (Hemiptera: Aphididae) on *Populus* sp. and from *Aphis hillerislaemersi* Nieto Nafria and Mier Durante 1976 (Hemiptera: Aphididae) on *Euphorbia* sp., 22.05.2010.

***Lasius turcicus* Santschi, 1921 (Hymenoptera: Formicidae)**

Material examined: Bafra, from *Acyrtosiphon pisum* (Harris, 1776) (Hemiptera: Aphididae) on *Vicia* sp., from *B. cardui* on *Carduus* sp., from *M.cerasi* on *Prunus cerasus* and from *A. spiraeola* on *Malus* sp., 12.05.2009; Atakum, from *C. tujaefilina* on *Cupressus* sp., from *Brachycaudus helichrysi* (Kaltenbach, 1843) (Hemiptera: Aphididae) on *Matricaria chamomila* and Canik, from *C. tujaefilina* on *Cupressus* sp., 24.05.2009; Vezirköprü, from *A. gossypii* on *Chenopodium* sp., 02.07.2009; Atakum, from *Myzus varians* Davidson, 1912 (Hemiptera: Aphididae) on *Prunus persica*, 04.07.2009; Çarşamba, from *A.*

gossypii on *Pyrus* sp., Salıpazarı, from *A. pomi* on *Malus* sp. and from *A. fabae* on *Pimpinella* sp., 09.07.2009; Terme, from *A. pomi* on *Pyrus* sp. and from *Aphis brunellae* Schouteden, 1903 (Hemiptera: Aphididae) on *Prunella* sp., 10.07.2009; Çarşamba, from *P. populeum* on *Populus* sp., 15.05.2010; Atakum, from *A. spiraeicola* on ornamental plant, from *C. cupressi* on *Thuja* sp. and from *C. tujaefilina* on *Thuja* sp., 19.05.2010.

***Plagirolepis pygmaea* (Latreille, 1798) (Hymenoptera: Formicidae)**

Material examined: Vezirköprü, from *B. cardui* on *Onopordum tauricum*, 02.07.2009; Ladik, from *A. fabae* on *Centaurea* sp., 03.07.2009; Bafra, from *Aphis gerardianae* Mordvilko, 1929 (Hemiptera: Aphididae) on *Euphorbia* sp. and from *A. gossypii* on *Origanum vulgare*, 06.07.2009; Salıpazarı, from *A. spiraeicola* on *Crateagus* sp., 09.07.2009; Çarşamba, from *B. cardui* on *Myosotis* sp., 15.05.2010.

***Tetramorium caespitum* (Linnaeus, 1758) (Hymenoptera: Formicidae)**

Material examined: Havza, from *B. cardui* on *Carduus acicularis*, 02.07.2009; Ladik, from *B. cardui* on *Carduus pycnocephalus*, 03.07.2009; Bafra, from *B. cardui* on *Carduus* sp., from *A. spiraeicola* on *Chenopodium* sp. and from *Myzus lythri* (Schränk, 1801) (Hemiptera: Aphididae) on *Lythrum salicaria*, 06.07.2009; Atakum, from *Aphis salviae* Walker, 1852 (Hemiptera: Aphididae) on *Salvia* sp., 22.05.2010.

***Tetramorium forte* Forel, 1904 (Hymenoptera: Formicidae)**

Material examined: Bafra, from *Uroleucon sonchi* (Linnaeus, 1767) on *Crepis foetial foetidia*, 06.05.2009.

CONCLUSIONS AND DISCUSSION

Turkey is located in important geographical region in terms of faunal and floristic richness, climatic variability and transition between European and Asian and also some African biological constituents. As a result of the these general characteristics, there are considerable number of both aphid and ant species (Görür *et al.*, 2012; Kiran and Karaman, 2012; Akyıldırım *et al.*, 2014; Şenol *et al.*, 2015). Despite these features, ecological and agricultural importance of aphid-ant mutualistic relations, there are very few studies conducted (Özdemir *et al.*, 2008; Akyıldırım *et al.*, 2014). There are about 12.000 ant and 5.000 aphid species determined all around the world and it was shown that mutualistic association ratio between ant and aphid species is about 40 % (Kunkel and Kloft, 1985). 141 aphid species and 13 ant species recorded from study area and dramatically only 2 ant species have been listed at the literature from Samsun Province so far (Kiran and Karaman, 2012). 45 of the identified aphid species has association with 13 ant species and in turn determined aphid and ant species association ratio is about 32% which is lower than general aphid-ant association. Shown aphid-ant association ratio is close to ratio pointed out by Akyıldırım *et al.* (2014) which was about 28%. There are various factors influences this relations such as honeydew density and composition, host plant quality, host plant genotype, seasonal differences in the honeydew demand of ants, aphid colony size, distance of aphid colony to the ant nest. (Völkl *et al.*, 1999; Yao and Akimoto, 2001). Mortazavi *et al.* (2015) and Latibari *et al.* (2016) conducted studies on aphid-ant interaction in different parts of the Iran and they done important contribution to this association indicating importance of these types of studies in this particular association.

There are about 530 aphid and 286 ant species determined from Turkey. Despite the high diversity of the ant and aphid fauna, few studies have been conducted on these

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group of insects in Turkey. Findings of this preliminary studies figured out that much more detailed study should be conducted to observe aphid-ant mutualistic associations in Turkey.

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REFERENCES

- Akyıldırım, H., Şenol, Ö., Görür, G., Aktaş, N., Demirtaş, E., 2014, Determined aphid and ant associations from Trabzon, Rize and Artvin provinces of the Turkey. *Journal of the Entomological Research Society*, 16(2): 29-37.
- Beggs, J. R., Karl, B. J., Wardle, D. A., Bonner, K. I., 2005, Soluble carbon production by honeydew scale insects in a New Zealand beech forest. *New Zealand Journal of Ecology*, 29(1): 105-115.
- Billick, I., Hammer, S., Reithel, J. S., Abbot, P., 2007, Ant-Aphid interactions: Are ants friends, enemies, or both? *Annals of the Entomological Society of America*, 100(6): 887-892.
- Binazzi, A., Scheurer, S., 2009, *Atlas of The Honeydew Producing Conifer Aphids of Europe*. 1st edn. Aracne editrice, Rome, 127.
- Blackman, R. L., Eastop, V. F., 2015, Aphids on the world's plants: an online identification and information guide (Adobe Digital Editions version). <http://www.aphidsonworldsplants.info> (2012-2015).
- Bristow, C. M., 1991, *Why are so few aphids ant- tended?* In: Huxley, C. R. and Cutler, D. F., (Eds.). Ant-plant interactions. Oxford University Press, Oxford, UK., 104-119 .
- DelClaro, K., Oliveria, P. S., 1993, Ant-Homoptera interaction: do alternative sugar sources distract tending ants? *Oikos*, 68: 202-206.
- Depa, Ł., Mróz, E., Szawaryn, K., 2012, Molecular identity of *Stomaphis quercus* (Hemiptera: Aphidoidea: Lachnidae) and description of a new species. *European Journal of Entomology*, 109: 435-444.
- Dixon, A. F. G., 1998, *Aphid Ecology*. 2nd edn. Chapman and Hall, Glasgow, London, 300.
- Dixon, A. F. G., 2004, *Insect Herbivore-Host Dynamics: Tree Dwelling Aphids*. Cambridge University Press, Cambridge, 194.
- Fischer, M. K., Shingleton, A. W., 2001, Host plant and ants influence the honeydew sugar composition of aphids. *Functional Ecology*, 15: 544-550.
- Fischer, M. K., Völkl, W., Hoffmann, K. H., 2005, Honeydew production and honeydew sugar composition of polyphagous black bean aphid, *Aphis fabae* (Hemiptera: Aphididae) on various host plants and implications for ant attendance. *European Journal of Entomology*, 102: 155-160.
- Flatt, T., Weisser, W. W., 2000, The effects of mutualistic ants on aphid life history traits. *Ecology*, 81(12): 3522-3529.
- Görür, G., Akyıldırım, H., Olcabey, G., Akyürek, B., 2012, The aphid fauna of Turkey: An updated checklist. *Archives of Biological Sciences Belgrade*, 64(2): 675-692.
- Kaplan, I., Eubanks, M. D., 2002, Disruption of cotton aphid (Homoptera: Aphididae) -natural enemy dynamics by red imported fire ants (Hymenoptera: Formicidae). *Environmental Entomology*, 31(6): 1175-1183.
- Katayama, N., Suzuki, N., 2003, Bodyguard effects for aphids of *Aphis craccivora* Koch (Homoptera: Aphididae) as related the activity of two ant species, *Teramorium caespitum* Linnaeus (Hymenoptera: Formicidae) and *Lasius niger* L. (Hymenoptera: formicidae). *Applied Enomology and Zoology*, 38(3): 427-433.
- Keller, L., Gordon E., 2010, *The Lives of Ants*. Oxford University Press Inc., New York, 261.

- Kıran, K., Karaman, C., 2012, First annotated checklist of the ant fauna of Turkey (Hymenoptera: Formicidae). *Zootaxa*, 3548: 1-38.
- Kunkel, H. Kloft, W. J., 1985, *Die Honigtauerzeuger des Waldes*. In: Kloft, W. J., Kunkel, H. (Eds.), *Waldtracht und Waldhonig in der Imkerei*, Ehrenwirth, Munich, Germany, 48-265.
- Latibari, M. N, Moravvej, G., Namaghi, H. S., 2016, Investigation on the mutualistic interactions of ant species and the aphids, *Cinara* spp. (Hemiptera: Aphididae) on *Pinus mugo* trees in urban green space of Mashhad, Razavi Khorasan, Iran. *Entomofauna*, 24: 401-412.
- Martin, J. H., 1983, The identification of common aphid pests of tropical agriculture. *Tropical Pest Management*, 29(4): 395-411.
- Mortazavi, Z. S., Sadeghi, H., Aktaş, N., Depa, L., Fekrat, L., 2015, Ants (Hymenoptera: Formicidae) and their aphid partners (Homoptera: Aphididae) in Mashhad region, Razavi Khorasan Province, with new records of aphids and ant species for Fauna of Iran. *Halteres*, 6: 4-12.
- Özdemir, I., Aktaş, N., Toros, S., Kılınçer, N., Gürkan, M. O., 2008, Investigations of the associated between aphids and ants on wild plants in Ankara province (Turkey). *Munis Entomology and Zoology*, 3(2): 606-613.
- Shingleton, A. W., Stern, D. L. S., Foster, W. A., 2005, The origin of a mutualism: a morphological trait promoting the evolution of ant-aphid mutualisms. *Evolution*, 59: 921-26.
- Stadler, B., 1997, *The relative importance of host plants, natural enemies and ants in the evolution of life-history characters in aphids*. In: Dattner, K., Bauer, G., Volkl, W. (Eds.). *Vertical food web interactions*. Springer, New York. 241-256.
- Stadler, B., Dixon, A. F. G., 1998, Costs of ant attendance for aphids. *Journal of Animal Ecology*, 67: 454- 59.
- Stadler, B., Dixon, A. F. G., 2005, Ecology and evolution of aphid-ant interactions. *Annual Review of Ecology, Evolution and Systematics*, 36: 345-372.
- Stadler, B., Kindlmann, P., Smilauer, P., Fiedler K., 2003, A comparative analysis of morphological and ecological characters of European aphids and lycaenids in relation to ant attendance. *Oecologia*, 135: 422-430.
- Stewart-Jones, A., Pope, T. W., Fitzgerald, J. D., Poppy, G. M., 2008, The effect of ant attendance on the success of rosy apple aphid populations, natural enemy abundance and apple damage in orchards. *Agricultural and Forest Entomology*, 10: 37- 43.
- Şenol Ö., Akyıldırım Beğen, H., Görür, G., Demirtaş, E., 2015, New additions and invasive aphid to Turkey aphidofauna (Hemiptera: Aphidoidea), *Turkish Journal of Zoology*, 39: 39-45.
- Ülgentürk, S., 2001, Ants (Hymenoptera: Formicidae) associated with soft scale insects in Turkey: A Preliminary List. *Acta Phytopathologica et Entomologica Hungarica*, 36(3-4): 405-409.
- Vantaux, A., Ende, W., Billen, J., Wenseleers, T., 2011, Large interclone differences in melezitose secretion in the facultatively ant-tended black bean aphid *Aphis fabae*. *Journal of Insect Physiology*, 57(12): 1614-1621.
- Völkl, W., Woodring, J., Fischer, M., Lorenz, M. V., Hoffmann, K. H., 1999, Ant-aphid mutualisms: The impact of honeydew production and honeydew sugar composition on ant preferences. *Oecologia*, 118: 483-491.
- Yao, I., Akimoto, S., 2001, Ant attendance changes the sugar composition of the honeydew of the Drepanosiphid aphid *Tuberculatulus quercicola*. *Oecologia*, 128: 36-43.

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