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Survey on ants (Hymenoptera: Formicidae) and their aphid partners (Homoptera: Aphididae) in Northeast and Center of Iran

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Abstract

A survey of ant-aphid interaction was conducted by collecting and identifying samples of ants and aphids associated with some aphid host plants in the urban landscape of Mashhad and Yazd, Iran. As a result, a total of 11 ant species representing 3 subfamilies and 5 aphid species were identified. All ant species are newly recorded for the fauna of Yazd Province, Iran.

Key words: Aphididae, Formicidae, Homoptera, Hymenoptera, Mutualistic association.

Introduction

Aphids extract sap from plant stems, specifically the phloem tissue. They excrete "honeydew" which still contains plant sugars. Ants collect this honeydew, often by "milking" the aphids, and use it as food. In return, they protect the aphids against predators. Ants prey on predators of aphids such as ladybird beetles (coccinellids), thus defending the aphids. Ants also shelter aphids by taking them or their eggs into their nests during inclement seasons. In a sense, ants herd aphids like cows. Furthermore, without removal of honeydew, aphid colonies become fouled (MÜLLER 2013).

Mutualism is an interaction in which two species provide benefits for each other. Antaphid associations play an important role on the biological control of aphid pests, as ants' defence against natural enemies of aphids may reduce efficiency of predators, parasitoid and even microbial agent (HEIDARI et al. 2016).

it is a reciprocally beneficial relationship among organisms (HERRE et al. 1999). Because the most studied relationships between ecosystems are those between predator and prey, mutualisms are often ignored. The mutualism phenomenon is demonstrated between numerous species on earth, and is often the ecologically dominant foundation of entire ecosystems such as coral reefs (CHAMBERLAIN & HOLLAND 2009). Ant-aphid association is considered as a well-documented example of protective mutualism, which is observed across a variety of ecosystems and locations. Generally, the larger ants offer protection from predators and disease, and clean the smaller aphids. In turn, aphids produce honeydew, a sugar-rich substance as the waste product of aphid's sap diet. Ants derive all or a large part of their nutrients from this honeydew as a source of food (DIXON 1977).

Studies have suggested that mutualism with ants benefits aphids with increased colony sanitation, longevity, survivorship, reproduction rates, and overall colony growth. Many of these benefits can be density dependent. This mutualistic interaction can be defined by a phenomenon called the "goldilocks principal", where there is an ideal level of tending (not too much or too little) (TEGELLAR et al. 2011). Both high levels and low levels of tending intensity will result in similar decrease in aphid colony performance. As the number of ants per aphid increases, higher levels of stress are implemented on honeydew production, causing a negative effect on aphid longevity. At low levels of tending, the aphid aggregations have a decreased performance due to poor sanitation and lack of protection (YOO et al. 2011).

Materials and Methods

During 2014-2015, various cultivated and wild plants were examined for aphids and their associated ants in Mashhad, Razavi Khorasan and Mehriz, Yazd, Iran. Because host identity is important in identifying aphids, sampling was done by visual inspection of plants, and the aphids and their attendant ants were removed using soft brush and forceps. In order to further inspection, some infested branches were also cut and transferred to the laboratory. Collected materials were preserved in ethanol (70%). Aphid species were identified by Colin Favret and Mohsen Mehrparvar. Ant species were sent to Dr Nihat Aktac for confirmation.

Results and Discussion

The family of ants (Formicidae), belonging to the order Hymenoptera is an important part of terrestrial biodiversity. Due to their high variability, high population, important role in the ecosystem and easy sampling, ants are responsible as model organisms for a wide range of scientific research including studies in behavior, ecology and evolutionary biology (ANDERSEN et al. 2003). The family Formicidae has 16 valid existing and four extinct subfamilies and currently 13,061 described species (BOLTON 2014). Despite the high diversity of the ant fauna, few studies have been published on this group of insects in Iran (FOREL 1904; RADCHENKO 1996; RADCHENKO 1997; PAKNIA & KAMI 2007; PAKNIA et al. 2010; FIROUZI et al. 2011; MOHAMMADI et al. 2012; KIRAN et al. 2013).

Aphids attack nearly all species of plants. When leaves are attacked by aphids, damage often appears first as spotty yellow discolorations, usually on the undersides of leaves; the leaves may later dry out and wilt. Some aphid species form galls or cause distorted, curled, or deformed leaves. The galls are swellings of plant tissues that are usually globular or spindle - shaped, with mouth-like openings (DETRAIN et al. 2010). Many galls turn brown and are considered unsightly. Each gall or deformed leaf may contain numerous aphids in all stages of development. Aphids attached to other plant parts such as stems or twigs may cause stunted growth, early leaf fall, or twig mortality, but aphid damage very rarely kills the plant. Aphids are small, soft-bodied, pear-shaped insects that are frequently found in large numbers. Their bodies may be translucent, but are usually various shades of green, brown, yellow, or white, sometimes blending in with the plant on which they are feeding. Many aphid species have two tube-like structures, called cornicles, which extend from the back and secrete a defensive fluid. Adult forms may be winged or wingless, depending upon their stage of development during the season. Winged forms have four membranous wings that rest upright above the body. The life cycle of many aphids is somewhat unusual and complex. Most species overwinter in the egg stage on the host plant; the eggs hatch into young female nymphs (stem mothers) in the spring, and subsequently reproduce without mating (parthenogenetic reproduction), giving birth to living young. Several generations of aphids may breed in this manner during the summer, but only females are produced (GLEN 1973).

In the present study, a total of 11 species in 3 subfamilies of ants (Formicidae) were reported to associate with five species of aphids. It is the first report of mutualistic interaction between Cinara tujafilina, Macrosiphum rosae, Brachycaudus cardui and Metopolophium dirhodum, and ants in Iran. All mutualistic ant species associated with C. tujafilina on Thuja orientalis trees were similar to those associated with Cinara spp. on Pinus mugo trees (HEIDARI et al. 2016).

The first observation on mutualistic relationship of Cardiocondyla shalbergi with aphids in the world and first observation on associations of Cataglyphis aenescens and Cataglyphis emearyi with aphids from Iran and symbiotic relationships of Crematogaster subdentata, Tapinoma erraticum, Lasius alienus, Formica cunicularia, Cataglyphis aenescens and Cataglyphis emearyi with Cinara aphids from Iran have been already documented (HEIDARI et al. 2016).

The association of Pheidole pallidula was reported with Aphis davletshinae , Aphis umbrella , Aphis gossypii and Myzus persicae from Khuzestan province (SHIRAN et al. 2013). Lepisiota nigra was reported from citrus orchard of Fars province in symbiosis with Nipaecoccus viridis (MOHAMMADI et al. 2012). Lasius paralienus was observed in symbiosis with some aphids such as Aphis craccivora, Aphis fabae, Aphis davletshinae, Aphis frangulae, Aphis gossypii, Aphis umbrella, Cinara palaestinensis, Myzus persicae, Chaitophorus euphraticus, Chaitophorus populeti, Chaitophorus populialbae, Chaitophorus remaudierei, Chaitophorus truncates, and Pterochloroides persicae in Khuzestan and Esfahan provinces (SHIRAN et al. 2013). Cataglyphis noda was collected on Aphis gossypii in Khuzestan province (SHIRAN et al. 2013). The characteristics of collected symbiotic ant species were provided as below.

Ants associated with *Cinara tujafilina* (Hem: Lachnidae)

Host plant: *Thuja orientalis*

Subfamily Dolichoderinae

Tapinoma erraticum

Material examined: Iran, Khorasan Razavi, Mashhad, 985 m a.s.l., 36°15'N, 59°38'E, 09. X. leg. Minoo Heidari 2014, 6♀♀ and ♂♂.

Distribution: Albania, Andorra, Armenia, Austria, Balearic Islands, Belarus, Belgium, Bulgaria, Canary Islands, Channel Islands, Croatia, Czech Republic, France (type locality), Georgia, Germany, Gibraltar, Greece, Hungary, Iberian Peninsula, Iran, Israel, Italy, Kazakhstan, Kyrgyzstan, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Netherlands, Poland, Portugal, Republic of Macedonia, Republic of Moldova, Romania, Russian, Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkmenistan, Ukraine, UnitedKingdom of Great Britain and Northern Ireland, Åland Islands (SEIFERT 1984).

Subfamily: Myrmicinae

***Pheidole pallidula* (NYLANDER, 1849)**

Material examined: Iran, Khorasan Razavi, Mashhad, 985 m a.s.l., 36°15'N, 59°38'E, 09.X. leg. Minoo Heidari 2014, 23♀♀ and ♂♂.

Distribution: Albania, Bulgaria, former Yugoslavia, Greece, Turkey France, Spain, Portugal (AGOSTI & COLLINGWOOD 1987) and Iran (PAKNIA et al. 2008).

***Crematogaster subdentata* (MAYR, 1877)**

Material examined: Iran, Khorasan Razavi, Mashhad, 985 m a.s.l., 36°15'N, 59°38'E, 09. X. leg. Minoo Heidari 2014, 3♂♂.

Distribution: Turkey, Iran, Afghanistan, Central Asia, South Khazakhstan, Central Caucasus (ARAKELIAN 1994).

***Cardiocondyla shalbergi* (FOREL, 1913)**

Material examined: Iran, Khorasan Razavi, Mashhad, 985 m a.s.l., 36°15'N, 59°38'E, 09.X. leg. Minoo Heidari 2014, 9♂♂.

Distribution: Bulgaria, Serbia, Croatia, Ukraine, Montenegro, Slovenia, Austria, Hungary, Germany, Slovakia, Romania, Czech Republic, Poland, Czechowski, Macedonia, Iran (CSOSZ et al. 2011).

Subfamily: Formicinae

***Lepisiota nigra* (DALLA TORRE, 1893)**

Material examined: Iran, Khorasan Razavi, Mashhad, 985 m a.s.l., 36°15'N, 59°38'E, 09.X. Minoo Heidari 2014, 14♀♀ and ♂♂.

Distribution: South East Europe, Oman, U.A.E, Italy and Egypt (COLLINGWOOD & AGOSTI 1996).

***Lasius alienus* (FOERSTER, 1850)**

Material examined: Iran, Khorasan Razavi, Mashhad, 985 m a.s.l., 36°15'N,

59°38'E, 09. X. leg. Minoo Heidari 2014, 21♂♂.

Distribution: Albania; Algeria; Armenia; Austria; Belarus; Belgium; Bosnia and Hercegovina; Britain; Bulgaria; Croatia; Czech Rep.; Denmark; Estonia; Finland; France: mainland; Georgia; Germany; Hungary; Iran; Ireland; ?Israel; Italy: mainland; Latvia; Lithuania;

Luxembourg; Macedonia; Moldova; Montenegro; Netherlands; Norway; Poland; Portugal; Romania; Russia; Serbia; Slovakia; Slovenia; Spain: mainland; Sweden; Switzerland; Turkey; Ukraine (LECH & SEBASTIAN 2012).

***Lasius paralienus* (SEIFERT, 1992)**

Material examined: Iran, Khorasan Razavi, Mashhad, 985 m a.s.l., 36°15'N, 59°38'E, 09. X. leg. Minoo Heidari 2014, 19♂♂.

Distribution: Europe, Turkey, Caucasus, Iran, Siberia (BRACKO et al. 2014).

***Formica cunicularia* (LATREILLE, 1798)**

Material examined: Iran, Khorasan Razavi, Mashhad, 985 m a.s.l., 36°15'N, 59°38'E, 09.X. leg. Minoo Heidari 2014, 15♂♂.

Distribution: Europe, Turkey, Caucasus, Kazakhstan, Iran (BRACKO et al. 2014; PAKNIA et al. 2008).

***Cataglyphis aenescens* (NYLANDER, 1849)**

Material examined: Iran, Khorasan Razavi, Mashhad, 985 m a.s.l., 36°15'N, 59°38'E, 09.X. leg. Minoo Heidari 2014, 26♂♂.

Distribution: Albania; Armenia; Bosnia and Hercegovina; Bulgaria; Croatia; Cyprus; Georgia; Hungary; Iran; Italy: mainland; Macedonia; Moldova; Romania; Russia; Serbia;Slovakia; Turkey; Ukraine (LECH & SEBASTIAN 2012).

***Ctaglyphis emearyi* (KARAVAIEV, 1911)**

Material examined: Iran, Khorasan Razavi, Mashhad, 985 m a.s.l., 36°15'N, 59°38'E, 09. X. leg. Minoo Heidari 2014, 5♂♂.

Distribution: Angola, Cameroon, Egypt, Israel, Madagascar, Morocco, Nepal, Nigeria,Polynesia, Rwanda, South Africa, Spain, Sri Lanka, Sudan, Uganda, Tanzania, Yemen and Zimbabwe (LECH & SEBASTIAN 2012).

***Cataglyphis noda* (BRULLÉ, 1833)**

Material examined: Iran, Khorasan Razavi, Mashhad, 985m a.s.l., 36°15'N, 59°38'E, 09. X. leg. Minoo Heidari 2014, 9♂♂.

Distribution: Albania; Armenia; Bosnia and Hercegovina; Bulgaria; Croatia; Cyprus; Egypt; Georgia; Hungary; Iran; Iraq; Macedonia; Montenegro; Romania; Slovakia; Serbia; Syria; Turkey; United Arab Emirates (PAKNIA et al. 2010).

Ants associated with *Myzus persicae* (Hem: Aphididae)

Host plant: *Persica vulgaris*

Subfamily: Formicinae

***Lepisiota nigra*（DALLA TORRE, 1893）**

Material examined: Iran, Yazd, Mehriz, 31°31'70"N 54°25'97"E. in Khormiz. leg. Mehdi Zare Khormizi 2015, 14♀♀ and ♂♂.

Distribution: South East Europe, Oman, U.A.E, Italy and Egypt (COLLINGWOOD & AGOSTI 1996).

Lasius paralienus **(SEIFERT, 1992)**

Material examined: Iran, Yazd, Mehriz, 31°31'70"N 54°25'97"E. in Khormiz. leg. Mehdi Zare Khormizi 2015, 19♀♀ and ♂♂.

Distribution: Europe, Turkey, Caucasus, Iran, Siberia (BRACKO et al. 2014).

Ants associated with *Metopolophium dirhodum* (Hem: Aphididae)

Host plant: *Triticum aestivum*

Subfamily: Formicinae

Lasius alienus **(FOERSTER, 1850)**

Material examined: Iran, Yazd, Mehriz, 31°31'70"N 54°25'97"E. in Khormiz. leg. Mehdi Zare Khormizi 2015, 21♀♀ and ♂♂.

Distribution: Albania; Algeria; Armenia; Austria; Belarus; Belgium; Bosnia and Hercegovina; Britain; Bulgaria; Croatia; Czech Rep.; Denmark; Estonia; Finland; France: mainland; Georgia; Germany; Hungary; Iran; Ireland; ?Israel; Italy: mainland; Latvia; Lithuania; Luxembourg; Macedonia; Moldova; Montenegro; Netherlands; Norway; Poland; Portugal; Romania; Russia; Serbia; Slovakia; Slovenia; Spain: mainland; Sweden; Switzerland; Turkey; Ukraine (LECH & SEBASTIAN 2012).

Ants associated with *Brachycaudus cardui* (Hem: Aphididae)

Host plant: *Platanus orientalis*

Subfamily: Formicinae

Formica cunicularia **(LATREILLE, 1798)**

Material examined: Iran, Yazd, Mehriz, 31°31'70"N 54°25'97"E. in Khormiz. leg. Mehdi Zare Khormizi 2015, 15♀♀ and ♂♂.

Distribution: Europe, Turkey, Caucasus, Kazakhstan, Iran (BRACKO et al. 2014; PAKNIA et al. 2008).

Ants associated with *Macrosiphum rosae* (Hem: Aphididae)

Host plant: *Rosa hybrida*

Subfamily: Myrmicinae

Pheidole pallidula **(NYLANDER, 1849)**

Material examined: Iran, Yazd, Mehriz, 31°31'70"N 54°25'97"E. in Khormiz. leg. Mehdi Zare Khormizi 2015, 23♀♀ and ♂♂.

Distribution: Albania, Bulgaria, former Yugoslavia, Greece, Turkey France, Spain, Portugal (AGOSTI & COLLINGWOOD 1987) and Iran (PAKNIA et al. 2008).

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