INTRODUCTION

Ants (Hymenoptera: Formicidae) are the economically important and metropolitan insects on earth. Formicidae is divided into 20 subfamilies (Bolton, 1994; Bolton et al., 2006; Ward, 2007). Ants are good in seed dispersal (Hanzawa et al., 1988). They improve soil aeration (Holldobler and Wilson, 1990). They are known as ecosystem engineers as they are active in underground activities (Folgarait, 1998). They also perform different roles in ecosystem like scavengers, decomposers, predators, pollinators and herbivores. Harvester ants grow fungus in their nest by accumulating leaves and also feed on them (Holldobler and Wilson, 1990). Ants consume honey dew secretions of aphids in symbiotic association (Styrsky and Eubanks, 2007; Jahn and Beardsley, 1996). There is a mutualistic association between ants and aphids (Depa and Węgierek, 2011). In this relationship, aphids provide food to the ants, while in return ants provide them protection from natural enemies (Sudd, 1987; Cushman and Beattie,
Among mutualisms, ant-aphid interactions are among the most variable in terms of their outcomes whether or not the ant aphid interaction is beneficial to the aphids often depends upon both the spatial and ecological context. Aphids, the serious insect pests of various crops, fruits, vegetables etc. are myrmecophilous (tended by ants) and non-myrmecophilous (unattended). The great majority of ants taking part in such associations belong to phylogenetically advanced sub-families Dolichoderinae, Formicinae and Myrmicinae (Delabie, 2001). The mutualistic relationship between ants and aphids has been the subject of many studies on various aspects of this phenomenon in various regions of the world. In different regions like Iran, 21 ant species associated with 26 aphid species from 37 host plant species (Mortazavi et al., 2015), 18 ants species associated with 34 species of aphids from Florida (Nielsson et al., 1971), 10 species of ants associated with 24 aphid species from Russia (Addicott, 1979), 23 species of ants associated with 11 aphid species from Oceania (Idechil et al., 2007), 16 species of ants in association with 19 species of aphids from Ankara Province of Turkey (Özdemir et al., 2008), 17 species of ants associated with aphids in Indonesia (Herwina et al., 2013), 20 species of ants associated with 3 species of aphids in India (Kataria and Kumar, 2013) etc. But as far as Pakistan is concerned, recently a lot of work on both ants and aphid partners on various host plants in different areas of Pothwar and Jehlum were conducted for the collection of ants and aphids (Kataria and Kumar, 2013). Material examined during these studies in Pakistan

Material examined

40°, Rawalpindi: N33° 38.929’ E073° 04.943’ 1671 ft. elev., 02-12-2015 Triticum aestivum (Wheat), 2♂, N33° 38.929’ E073° 04.943’ 1645 ft. elev., 01-01-2016 Parthenium hysterophorus (Parthenium weed), Duranta erecta (Golden dewdrop), Bougainvillea spectabilis (Paperflower), Moringa oleifera (Moringa), Cannabis sp. (Hemp); 38°, Islamabad: N33° 40.527’ E073° 08.376’

RESULTS AND DISCUSSION

Seven different species of ants belonging to seven different genera were associated with different aphid partners on various host plants in different areas of Pothwar region. All associations are new. New distribution records for ants have also been added.
Trophic Associations of Ants with Aphids from Pothwar Eregion

1762 ft. elev., 03-09-2015 Zea mays (Maize), Triticum aestivum (Wheat), Solanum nigrum (Black nightshade), Spinacia oleracea (Spinach), Parthenium hysterophorus (Parthenium weed), Capsicum annuum (Green Chilly), Abelmoschus esculentus (Okara), Asclepias sp. (Milk weed), Punica granatum (Pomegranate), 3♂, N33 42.558° E073 01.330°, 1686 ft. elev., 20-11-2015 Bougainvillea spectabilis (Paperflower), Jasminum officinale (Jasmine); 15♂, Murree: N33 59.652° E073 28.593° 4980 ft. elev., 28-11-2015 Spinacia oleracea (Spinach), Jasminum officinale (Jasmine), Parthenium hysterophorus (Parthenium weed), Debreggia silicifolia (Siharu), 5♂, N33’ 55.341’ E073 24.216’ 6302 ft. elev., 09-01-2017 Fragaria ananassa (Strawberry); 2♂, N33 55.016° E073 23.699° 6415 ft. elev., 28-11-2015 Carthamus oxyanthus (Wild Safflower), Quercus ilex (Holly oak); 6♂, N33 59.342° E073 28.573° 5020 ft. elev., 09-01-2016 Fragaria ananassa (Strawberry), Viola odorata (Sweet violet), Artemisia absinthium (Wormwood), Helianthus annuus (Sunflower), Bischofia javanica (Bishop wood); 14♂, Chakwal: N32 46.160° E072 42.299°, 2209 ft. elev., 29-09-2015 Eriobotrya japonica (Loquat), Parthenium hysterophorus (Parthenium weed); 10♂, Jhelum: N32 58.118’ E073 41.601°, 859 ft. elev., 15-04-2016 Parthenium hysterophorus (Parthenium weed), Rosa indica (Rose).

Comments on ant-aphid associations

This ant has been reported in association with 5 aphid species namely Aphis craccivora (Kataria and Kumar, 2013; Rakhashan and Ahmad, 2015), Aphis fabae (Kataria and Kumar, 2013), Aphis gossypii (Verghese and Tandon, 1987; Kataria and Kumar, 2013; Lokeshwari et al., 2015), Aphis nerii (Kataria and Kumar, 2013) and Myzus persicae (Kataria and Kumar, 2013) from various parts of the world on different host plants. Here we have added new associations of this species with 12 different aphid partners from Pakistan. Camponotus compressus was found in abundance in association with 12 aphid species on Triticum aestivum (Wheat), Parthenium hysterophorus (Parthenium weed), Duranta erecta (Golden dewdrop), Bougainvillea spectabilis (Paper flower), Moringa oleifera (Moringa) and Cannabis sp. (Hemp) from various localities of district Rawalpindi. On Zea mays (Maize), Triticum aestivum (Wheat), Solanum nigrum (Black nightshade), Spinacia oleracea (Spinach), Parthenium hysterophorus (Parthenium weed), Capsicum annuum (Green Chilly), Abelmoschus esculentus (Okara), Asclepias sp. (Milk weed), Punica granatum (Pomegranate), Bougainvillea spectabilis (Paper flower) and Jasminum officinale (Jasmine) from different locations of Islamabad. On Spinacia oleracea (Spinach), Jasminum officinale (Jasmine), Parthenium hysterophorus (Parthenium weed), Debreggia silicifolia (Siharu), Fragaria ananassa (Strawberry), Carthamus oxyanthus (Wild Safflower), Quercus ilex (Holly oak), Viola odorata (Sweet violet), Artemisia absinthium (Wormwood), Helianthus annuus (Sunflower) and Bischofia javanica (Bishop wood) from Murree, Eriobotrya japonica (Loquat) and Parthenium hysterophorus (Parthenium weed) from district Chakwal and Parthenium hysterophorus (Parthenium weed) and Rosa indica (Rose) from areas of district Jhelum. It was found on the tree trunks and barks tending aphids for honey dew secretion. All the collected specimens were identified and found similar to published description of Bingham (1903). Camponotus compressus is reported for the first time in association with any aphid species from Pakistan, so it is reported as new country record.

Comments on distribution of camponotus compressus in Pakistan

Umair et al. (2012) mentioned the distribution of this species only from Islamabad and Rawalpindi. We have added new distribution records in various localities of Pothwar.

2. *Formica fusca* Linnaeus, 1758

Aphid partners in association reported during these studies in Pakistan

Pine aphid (*Cinara orientalis* Takahashi, 1925)

Material examined


Comments on ant-aphid associations

This species has been recorded to be associated with 57 aphid species from various parts of the world as reviewed by Siddiqui et al. (2019). During our studies, 1 new trophic association of this species with aphid, *Cinara orientalis* was observed. This association is new country record from Pakistan. This ant species was observed and found in abundance on the pine tree *Pinus wallichiana* (Himalayan pine) in association with *Cinara orientalis*. Both the ants and aphids were present in the lenticels of the tree. Aphids were sucking sap from tree trunk and ants were getting honey dew from aphids. All the collected specimens were identified and found similar to the published description of species by Bingham (1903).
Comments on distribution of Formica fusca in Pakistan
Menozzi (1939) reported this species from Karakorum (Province Gilgit-Baltistan). During our surveys, new distribution pattern in Murree (Province Punjab) has been added.

3. Formica clara Forel, 1886
Aphid partners in association reported during these studies in Pakistan
Pine aphids (Cinara confluens (Koch, 1856), (Cinara orientalis (Takahashi, 1925)

Material examined

Comments on ant-aphid associations
Siddiqui et al. (2019) mentioned this ant species to be in association with 8 aphid species from the world. During these studies, new associations with 2 aphid species have been added.

Formica clara was found in association with two aphid species namely, Cinara confluens and Cinara orientalis on Abies pindrow (Pindrow fir) and Pinus wallichiana (Himalayan pine) trees. Both aphids and ants were present in the lenticels on the tree trunks. All the collected specimens were identified and found similar to the published species description of Bingham (1903). Formica clara is reported for the first time in association with any aphid species from Pakistan.

Comments on distribution of Formica clara
Seifert and Schultz (2009) mentioned only its distribution in Pakistan but not the exact localities were reported. Here we have added exact localities of its distribution in Pothwar region of Pakistan.

4. Lepisiota frauenfeldi (Mayr, 1855)
Aphid partners in association reported during these studies in Pakistan
Loquat aphid (Aphis eugeniae van der Goot), Giant bark willow aphid (Tuberolachnus salignus (Gmelin, 1776), Wild fig aphid (Greenidea (Greenidea) ficicola (Takahashi, 1921), Greenidea aphid (Greenidea (Trichosiphum) formosana (Maki, 1917), Greenidea aphid (Greenidea (Decusperm) Takahashi), Apple aphid (Aphis pomi de Geer), Crepe myrtle aphid (Tinocallis kahawaluokalani (Kirkaldy), Chrysanthemum aphid (Macrosiphoniella sanborni (Gillette), Mint aphid (Ovatus crateagusarii), Cotton Aphid (Aphis gossypii Glover, 1877), Black bean aphid (Aphis fabae Scopoli, 1763).

Material examined
10♂, Rawalpindi: N33 38.612' E073 04.476' 1733 ft. elev., 09-02-2016 Eriobotrya japonica (Loquat); 5♂, Islamabad: N33 39.656' E073 23.047', 3327 ft. elev., 19-03-2016 Eriobotrya japonica (Loquat); 4♀, N33 39.516' E073 29.307', 2153 ft. elev., 01-03-2016 Eriobotrya japonica (Loquat); 7♂, Chakwal: N33 46.160' E072 42.299', 2209 ft. elev., 29-03-2016 Eriobotrya japonica (Loquat); 4♀, N33 40.527' E073 08.376' 1762 ft. elev., 03-03-2016 Eriobotrya japonica (Loquat); 5♀, Rawalpindi: N33 38.929' E073 04.943' 1645 ft. elev., 11-03-2016 Salix sp. (Willow); 4♀, Islamabad: N33 40.527' E073 08.376' 1763 ft. elev., 13-04-2016; 10♀, Rawalpindi: N33 38.612' E073 04.476' 1733 ft. elev., 09-03-2016 Salix sp. (Willow); 15♂, Attock: N32 56.655' E072 31.312', 1663 ft. elev., 09-03-2016 Salix sp. (Willow); 6♀, Rawalpindi: N33 39.516' E073 23.047', 2153 ft. elev., 24-04-2016, Ficus sp. (Fig): 2♀, Rawalpindi: N33 38.612' E073 04.476' 1733 ft. elev., 09-04-2016 Ficus sp. (Fig); 7♀, Islamabad: N33 43.929' E073 179.3836ft, elev., 17-04-2016 Ficus sp. (Fig); 5♀, Rawalpindi: N33 38.929' E073 04.943' 1671 ft. elev., 14-04-2016 Eugenia jambolana (Jaman); 2♀, N33 39.516' E073 29.307', 2153 ft. elev., 24-04-2016 Eugenia jambolana (Jaman); 8♀, Murree: N33 55.341' E073 24.216' 6302 ft. elev., 09-04-2016 Eugenia jambolana (Jaman); 4♀, Kalar-Kahar: N32 46.138' E072 42.537', 2153 ft. elev., 12-04-2016 Eugenia jambolana (Jaman); 6♀, Jhelum: N32 58.119' E073 41.602', 859 ft. elev., 15-04-2016 Eugenia jambolana (Jaman); 3♀, Islamabad: N33 40.527' E073 08.376' 1762 ft. elev., 23-02-2016 Eugenia jambolana (Jaman); 2♀, Rawalpindi: Ns33 38.929' E073 04.943' 1645 ft. elev., 12-03-2016 Psidium guajava (Guava); 12♀, Islamabad: N33 40.527' E073 08.376' 1762 ft. elev., 03-04-2016 Psidium guajava (Guava); 5♀, Rawalpindi: N33 38.612' E073 04.476' 1733 ft. elev., 09-02-2016 Eriobotrya japonica (Loquat); 3♀, Islamabad: N33 39.656' E073 23.047', 3327 ft. elev., 19-03-2016 Eriobotrya japonica (Loquat); 2♀, N33 39.516' E073 29.307', 2153 ft. elev., 01-03-2016 Eriobotrya japonica (Loquat); 6♀, Chakwal: N32 46.160' E072 42.299', 2209 ft. elev., 29-03-2016 Eriobotrya japonica
Comments on ant-aphid associations

According to Shiran et al. (2013), this species has trophic association with 11 different aphid partners. Siddiqui et al. (2019) mentioned this ant species to be in association with 2 aphids.

In our studies, 9 new ant aphids' trophic associations have been added. This ant was most abundantly found in association with aphids on a large number of host plant species. It was found associated with 11 aphid species on different plant species including Mentha longifolia (Mint), Chrysanthemum indicum (Chrysanthemum flower), Lagerstromia indica (Crepe myrtle), Malus pumila (Apple), Eriobotrya japonica (Loquat), Psidium guajava (Guava), Eugenia jambolana (Jaman), Ficus sp. (Fig) and Salix sp. (Willow) from different areas of district Rawalpindi, Jhelum, Chakwal, Attock, Murree and Islamabad. It was the most active species found in association with aphids.

All the collected specimens were identified and found similar to the published description of species by Bingham (1903). Lepisiota frauenfeldi is reported for the first time in association with any aphid species from Pakistan, so it is added as new country record.

Comments on distribution of Lepisiota frauenfeldi in Pakistan

Umair et al. (2012) recorded this species only from Rawalpindi and Islamabad. New locality records have been added during these studies.

5. Myrmica aimonisabaudiae Menozzi, 1939

Aphid partners in association reported during these studies in Pakistan

Black bean aphid (Aphis fabae Scopoli, 1763), wild rose aphid (Chaetosiphon (Pentatrichopus) glabrum David, Rajasingh and Narayanan, 1971), Pine aphids (Cinara confinis (Koch, 1856), (Cinara orientalis (Takahashi, 1925)).

Material examined

(Jangli Palak) from different areas of Chara Pani, Kuldana, Aliote, Hill Dhuloo and Osia from district Rawalpindi. All the collected specimens were identified and found similar to the published description of Bingham (1903). Myrmica aironissabaudiae is reported for the first time in association with any aphid species from Pakistan as well as from the whole world, so it is new country as well as new to science association.

Comments on distribution of Myrmica aironissabaudiae in Pakistan

Menozzi (1939) reported this species only from 2 localities, Karakorum (Gilgit Baltistan Province), Gund (Sindh Province) of Pakistan. Here we reported it for the first time from Pothwar region of Pakistan.

6. Tapinoma melanocephalum (Fabricius, 1793)

Aphid partners in association reported during these studies in Pakistan

Loquat aphid (Aphis eugeniae van der Goot), Giant bark willow aphid (Tuberolachnus salignus (Gmelin, 1776), Wild fig aphid (Greenidea (Greenidea) ficicola Takahashi, 1921, Greenidea aphid (Greenidea (Trichosiphum) formosana (Maki, 1917), Greenidea aphid (Greenidea (Greenidea) decasperm) Takahashi), Apple aphid (Aphis pomi de Geer), Crepe myrtle aphid (Tinocallis kahawaluokalani (Kirkaldy), Chrysanthemum aphid (Macrosiphoniella sanborni (Gillette), Black Bean Aphid (Aphis fabae solanella Theobald, 1914), Cotton Aphid (Aphis gossypii Glover, 1877), Mint aphid (Ovatus myrtle), 8 sp.

Material examined

8♀, Rawalpindi: N33 38.612’ E073 04.476’ 1733 ft. elev., 09-02-2016 Eriobotrya japonica (Loquat); 8♂, Islamabad: N33 39.656’ E073 23.047’, 3327 ft. elev., 19-03-2016 Eriobotrya japonica (Loquat); 8♂, N33 39.516’ E07323.007’, 2153 ft. elev., 01-03-2016 Eriobotrya japonica (Loquat); 7♀, Chakwal: N32 46.160’ E072 42.299’, 2209 ft. elev., 29-03-2016 Eriobotrya japonica (Loquat); 8♂, N33 40.527’ E073 08.376’ 1762 ft. elev., 03-03-2016 Eriobotrya japonica (Loquat); 5♀, Rawalpindi: N33 38.929’ E073 04.943’ 1645 ft. elev., 11-03-2016 Salix sp. (Willow); 3♀, Islamabad: N35 40.527’ E072 08.376’ 1763 ft. elev., 13-04-2016; 6♂, Rawalpindi: N33 38.612’ E073 04.476’ 1733 ft. elev., 09-03-2016 Salix sp. (Willow); 2♀, Attock: N32 56.655’ E072 51.312’, 1663 ft. elev., 09-03-2016 Salix sp. (Willow); 5♀, Rawalpindi: N33 39.516’ E07323.007’, 2153 ft. elev., 24-04-2016; Ficus sp. (Fig); 2♀, Rawalpindi: N33 38.612’ E073 04.476’ 1733 ft. elev., 09-04-2016 Ficus sp. (Fig); 4♀, Rawalpindi: N33 38.929’ E073 04.943’ 1671 ft. elev., 14-04-2016 Eugenia jambolana (Jaman); 4♂, N33 39.516’ E07323.007’, 2153 ft. elev., 24-04-2016; Eugenia jambolana (Jaman); 7♀, Murree: N335.341’E073 24.216’ 6302 ft. elev., 09-04-2016 Eugenia jambolana (Jaman); 5♂, Kalar-Kahar: N32 46.138’ E072 42.537’, 2153 ft. elev., 12-04-2016 Eugenia jambolana (Jaman); 3♀, Jhelum: N32 58.119’ E073 41.602’, 859 ft. elev., 15-04-2016 Eugenia jambolana (Jaman); 7♀, Islamabad: N33 40.527’ E073 08.376’ 1762 ft. elev., 23-02-2016 Eugenia jambolana (Jaman); 3♂, Rawalpindi: N33 38.929’ E073 04.943’ 1645 ft. elev., 12-03-2016 Psidium guajava (Guava); 6♂, Islamabad: N33 40.527’ E073 08.376’ 1762 ft. elev., 03-04-2016 Psidium guajava (Guava); 2♀, Rawalpindi: N33 38.612’ E073 04.476’ 1733 ft. elev., 09-02-2016 Eriobotrya japonica (Loquat); 8♂, Islamabad: N33 39.656’ E073 23.047’, 3327 ft. elev., 19-03-2016 Eriobotrya japonica (Loquat); 2♀, N33 39.516’ E07323.007’, 2153 ft. elev., 01-03-2016 Eriobotrya japonica (Loquat); 4♀, Chakwal: N32 46.160’ E072 42.299’, 2209 ft. elev., 29-03-2016 Eriobotrya japonica (Loquat); 8♂, N33 40.527’ E073 08.376’ 1762 ft. elev., 03-03-2016 Eriobotrya japonica (Loquat); 5♀, Rawalpindi: N33 39.655’ E07323.047’, 3323 ft. elev., 09-03-2016 Malus pumila (Apple); 2♀, Islamabad: (Pir Suhawa) N33 43.929’ E07302.179’ 3836ft. elev., 17-3-2016 Malus pumila (Apple); 6♂, Rawalpindi: N33 38.929’ E073 04.943’ 1645 ft. elev., 17-08-2016 Lagerstroemia indica (Crepe myrtle); 3♀, Islamabad: N33 43.929’ E07302.179’ 3836ft. elev., 27-07-2016 Lagerstroemia indica (Crepe myrtle); 6♂, Chakwal: N32 46.160’ E072 42.299’, 2209 ft. elev., 29-09-2016 Lagerstroemia indica (Crepe myrtle); 4♀, Jhelum: N32 58.118’ E073 41.601’, 850 ft. elev., 15-07-2016 Lagerstroemia indica (Crepe myrtle); 8♀, Rawalpindi: N32 38.928’ E074 04.943’ 1640 ft. elev., 21-03-2016 Chrysanthemum indicum (Chrysanthemum flower); 7♀, Islamabad: N33 40.527’ E072 08.375’ 1760 ft. elev., 3-04-2016 Chrysanthemum indicum (Chrysanthemum flower); 7♀, Rawalpindi: N34 38.612’ E073 04.470’ 1730 ft. elev., 09-03-2016 Chrysanthemum indicum (Chrysanthemum flower); 10♂, Attock: N32 56.655’ E072 51.312’, 1663 ft. elev., 09-03-2016 Chrysanthemum indicum (Chrysanthemum flower); 5♀, Murree: N33 59.652’ E073 28.593’ 4980 ft. elev., 28-04-2016; 7♀, Chakwal: N32 46.160’ E072 42.299’ 2209 ft. elev., 29-09-2016 Chrysanthemum indicum (Chrysanthemum flower); 3♀, Islamabad: N33 40.527’ E073 08.376’ 1762 ft. elev., 03-09-2016 Solanum nigrum (Black nightshade); 6♂, Rawalpindi: N32 38.928’ E074 04.943’ 1640 ft. elev., 21-05-2016 Cassia fistula (Amalatas); 8♀, Islamabad: N33 40.527’ E073 08.376’ 1762 ft. elev., 03-09-2016 Parthenium hysterophorus (Parthenium weed),
**Trophic Associations of Ants with Aphids from Pothwar Region**

7. **Tapinoma melanocephalum** (Willow), *Capsicum annuum* (Green Chilly), *Abelmoschus esculentus* (Okara); 3♂, Rawalpindi: N33 38.929’ E073 04.943’ 1671 ft. elev., 02-11-2015 *Eriobotrya japonica* (Loquat); N33 38.929’ E073 04.943’ 1645 ft. elev., 01-01-2017 *Parthenium hysterophorus* (Parthenium weed), *Duranta erecta* (Golden dewdrop); 6♂, Chakwal: N32 46.160’ E072 42.299’, 2209 ft. elev., 29-09-2016 *Eriobotrya japonica* (Loquat); 10♂, Murree: N33 55.016’ E073 23.699’ 6415 ft. elev., 28-02-2016 *Mentha longifolia* (Mint).

**Comments on ant-aphid associations**

This ant species has been recorded in association with 4 aphid species namely, *Aphis gossypii*, *Hysteroneura setariae*, *Myzus persicae* and *Pentalonia nigronervosa* as reviewed by Siddiqui et al. (2019). Here we added 11 new trophic associations of this ant with different aphids on different host plants. *Tapinoma melanocephalum* was most abundantly found in association with aphids on a large number of host plants. It was found associated with 12 aphids species on *Mentha longifolia* (Mint), *Parthenium hysterophorus* (Parthenium weed), *Duranta erecta* (Golden dewdrop), *Capsicum annuum* (Green Chilly), *Abelmoschus esculentus* (Okara), *Cassia fistula* (Amaltas), *Solanum nigrum* (Black nightshade), *Chrysanthemum indicum* (Chrysanthemum flower), *Lagerstroemia indica* (Crepe myrtle), *Malus pumila* (Apple), *Eriobotrya japonica* (Loquat), *Psidium guajava* (Guava), *Eugenia jambolana* (Jaman), *Ficus sp.* (Fig) and *Salix sp.* (Willow), from different locations of District Rawalpindi, Islamabad, Attock, Jhelum and Chakwal. All the collected specimens were identified and found similar to the species description of Bingham (1903). *Tapinoma melanocephalum* is reported for the first time in association with any aphid species from Pakistan, so it is added as new country record.

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Statement to conflict of interest
The authors declare there is no conflict of interest.

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