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Aphid parasitoids (Hymenoptera: Braconidae, Aphidiinae) associated with pome and stone fruit trees in Iran

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Abstract: The aphidiine parasitoids (Hym., Braconidae) attacking the pest aphids on various pome and stone fruit trees in different parts of Iran were studied. A total of 13 species belonging to seven genera of aphid parasitoids were identified in association with 17 aphid species on 10 different species of fruit trees. Sixty nine tritrophic associations were detected from the studied area of which 25 associations are newly recorded from Iran. An illustrated key is prepared for identification of the species. The parasitoids were categorized based on their potential impacts in biocontrol of pest aphids into the less important species and the key-stones. The first group of parasitoids includes the broadly oligophagous species, and even an occasional opportunistic species, *Lysiphlebus fabarum* (Marshall), while the second group includes the specific associations like *Aphidius transcaspicus* Telenga on *Hyalopterus* spp. and *Pauesia antennata* (Mukerji) on *Pterochloroides persicae* (Cholodkovsky). A probable occurrence of the univoltine aphid parasitoid, *Pseudopauesia prunicola* Halme in association with *Ovatus insitus* (Walker) is discussed.

Keywords: Aphidiinae, tritrophic associations, biological control, Iran

Introduction

Wide variety of the fruit trees are grown in different parts of Iran. Among them, pome and stone fruits (pears, apples, apricots, sweet cherries, peaches and plums) are highly economic important products (Khoshkhooy *et al*., 2010; Jalili Marandi, 2008). Numerous insect pests attack these fruit trees in Iran (Radjabi, 1989), of which the aphids are one of the most important groups (Rezwani, 2004). Aphids feed on plants using their piercing-sucking mouth parts that are used to penetrate the sap streams (Miller and Foottit, 2009). Feeding by aphids can result in stunting, yellowing, leaf curling and other physical disorders (Blackman and Eastop, 1994). Certain aphid species cause damage to fruit trees through leaf curling and abscission, twisting of growing shoots, and systemic damage and they may induce direct damage by causing fruit to become stunted and deformed (Varn and Pfeiffer, 1989). Additionally, the aphids can induce damage indirectly, by secreting droplets of honeydew, which is a suitable substrate for growth of sooty mold that covers the leaf surface and interferes with photosynthesis (Jouraeva *et al.*, 2006). Large amounts of honeydew on the developing fruit can cause splitting and fruit cracking (Barnett and Rice, 1989) making the fruits unsuitable for the consumer market.

Many aphid species belonging to different genera are associated with pome and stone fruits in Iran (Rezwani, 2004), of which some species are considered as serious pests causing

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economic losses. These are the rosy apple aphid, *Dysaphis plantaginea* (Passerini), rosy leaf curling aphid, *Dysaphis devecta* (Walker), green apple aphid, *Aphis pomi* de Geer, green peach aphid, *Myzus persicae* (Sulzer), almond leaf-curl aphid, *Brachycaudus amygdalinus* (Schouteden), leaf-curling plum aphid, *Brachycaudus helichrysi* (Kaltenbach), and mealy plum aphid, *Hyalopterus pruni* (Geoffroy) (Radjabi, 1989).

Conventionally, a wide range of insecticides are used for control of the pests on fruit trees, including aphids (Rakhshani, 2011). On the other hand, the large scale usage of chemical pesticides has resulted in several associated adverse effects such as pesticide residues in fruits and environmental pollution (Konstantinoua *et al.*, 2006), development of resistance in pests, destruction of biocontrol agents and emergence of the secondary pests (Croft, 1982; Fenemore and Norton, 1985). The latter aspect is especially involved in the population outbreaks of some aphids on fruit trees. One of the most important components of pest management programs is the biological control. Many species of natural enemies contribute to reducing the populations of pest aphids of which the members of subfamily Aphidiinae (Hym., Braconidae) are the most important and specialized aphid parasitoids. They are solitary koinobiont endoparasitoids of aphids (Starý, 1970, 1975) which can effectively regulate the aphid populations and prevent serious outbreaks (Hughes, 1989; Hagvar and Hofsvang, 1991). Many studies have been done on the identification of natural enemies and biological control of the aphids on pome and other fruit trees throughout the world (Brown and Mathews, 2007; Wyss *et al.*, 1999).

In spite of several taxonomic and faunistic investigations on Aphidiinae of Iran (Barahoei *et al.*, 2010; Mossadegh *et al.*, 2011; Rakhshani *et al.*, 2005a, 2006, 2007, 2008; Starý *et al.*, 2000), few attempts have been performed with special emphasis on the aphidiine parasitoids associated with aphids on fruit trees including pome and stone fruits (Mokhtari *et al.*, 2000; Jafari *et al.*, 2011; Malkeshi *et al.*, 1998; Rakhshani *et al.*, 2005b). The availability of data on host associations of the aphid parasitoids is considered as the first step in their application as potential biocontrol agents. The purpose of this study was to determine the aphidiine parasitoids attacking aphids on pome and stone fruit trees in different parts of Iran, as well as to provide the background information about their host range patterns.

Materials and Methods

The studies were performed at different localities of 16 provinces, where the various commercial and non-commercial fruit orchards were cultivated. Samples of host plants bearing the aphid colonies were collected and carefully placed inside semi-transparent rearing plastic boxes that were covered by mesh for ventilation. The containers were then transferred to the laboratory, where they were kept under room conditions (22 – 28 °C) for 2 –3 weeks. A few live aphids from the same sample were collected and preserved in 55 % ethanol for later identification. The rearing boxes were checked daily for emerging parasitoids. Newly emerged adults were carefully picked up using an aspirator and dropped into the 75 % ethanol for further examination. Few specimens from each sample were dissected and slide mounted in Hoyer's medium. Measurements were taken in TPSdig ver 2.05 (Rohlf, 2006), using linear measurements option by the series of captured images from the slide mounted specimens. The morphological terminology of parasitoids in the key follows Sharkey and Wharton (1997). Abbreviations of the name of collectors and provinces where the collections were made are as follows:

Collectors: A. M. – Abutaleb Mousazadeh; A. S. – Abbas Sargazi; E. N. – Elham Nader; E. R. – Ehsan Rakhshani; H. B. – Hossein Barahoei; M. A. – Mahmoud Alikhani; R. D. – Reyhaneh Darsouei; S. K. – Sedigheh Kazemzadeh; S. T. – Saeid Taheri; Y. Z. – Yaser Nazari

Provinces: AL – ALBORZ; AR – ARDEBIL; FA – FARS; GL – GOLESTAN; GN – GUILAN;

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HA – HAMADAN; IM – ILAM; IS – ISFAHAN; KD – KORDISTAN; KE – KERMANSHAH; KN – KERMAN; KR – KHORASANE RAZAVI; KS – KHORASANE SHOMALI; QZ – QAZVIN; SB – SISTAN & BALUCHISTAN; TH – TEHRAN.

Results

In total, 13 species of the aphidiine aphid parasitoids belonging to seven genera in association with 17 aphid taxa on 10 species of fruit trees were determined. Sixty nine tritrophic associations were detected in the studied areas of which 25 associations are newly recorded. The newly recorded associations are marked by an asterisk (*).

Parasitoid-aphid-plant associations

***Aphidius colemani* Viereck 1912** (Figs. 1, 13, 22)
****Brachycaudus amygdalinus*** (Schouteden) on *Prunus persica*, IS - Hoye, 15. V. 2011, coll.: E. N., (1 ♀); ***Myzus persicae*** (Sulzer) on *Prunus padus*, TH - Shahriar, 17. X. 2003, coll.: E. R., (1 ♀ 3♂); 02. V. 2002, coll.: E. R., (14 ♀ 4 ♂); on *Prunus persica*, TH - Damavand, 14. IX. 2005, coll.: E. R., (9 ♀ 4 ♂); FA - Khafrak, 23. III. 2009, coll.: S. T., (1 ♀); ****Phorodon humuli*** (Schrank) on *Prunus persica*, TH - Damavand, 14. IX. 2005, coll.: E. R., (7 ♀ 6 ♂).

***Aphidius matricariae* Haliday 1834** (Figs. 2, 14, 23, 33)
Aphis pomi de Geer on *Malus domestica*, FA - Shiraz, 18. IV. 2004, coll.: E. R., (2 ♂ 6 ♀); ****Aphis spiraecola*** Patch on *Malus domestica*, GL - Taghiabad, 26. V. 2010, coll.: A. S., (1 ♀); on *Crataegus monogyna*, GL - Alangdareh, 04. V. 2010, coll.: A. S., (1 ♀ 1 ♂);****Brachycaudus amygdalinus*** (Schouteden) on *Prunus dulcis*, KE - Kermanshah, 18. V. 2011, coll.: Y. Z., (1 ♂ 7 ♀); ***Brachycaudus cardui*** (L.) on *Prunus padus*, TH - Tehran, 21. IV. 2002 (16 ♀ 12 ♂); ***Brachycaudus helichrysi*** (Kaltenbach) on *Prunus persica*, KR - Mashhad, 29. VII. 2009, coll.: E. R., (14 ♀ 11 ♂); ****Brachycaudus persicae*** (Passerini) on *Prunus persica*, TH - Damavand, 14. IX. 2005, coll.: E. R., (18 ♀ 14 ♂); ***Dysaphis plantaginea*** (Passerini) on *Malus domestica*, KR - Fariman, 05. V. 2010, coll., R. D., (841 ♀ 307 ♂); on *Pyrus communis*, KR - Fariman, 05. V. 2010, coll., R. D., (10 ♀); ***Myzus cerasi*** (Fabricius) on *Prunus cerasus*, TH - Arangeh, 27. VI. 2003, coll.: E. R., (1 ♀ 3 ♂); ***Myzus persicae*** (Sulzer) on *Prunus persica*, TH - Peykanshahr, 18. V. 2003, coll.: E. R., (7 ♀ 2 ♂); on *Prunus padus*, TH - Shahriar, 08. V. 2003, coll.: E. R., (15 ♀ 6 ♂); on *Prunus dulcis* L., KE - Kermanshah, 18. V. 2011, coll.: Y. Z., (9 ♂ 3 ♀); ***Ovatus insitus*** (Walker) on *Cydonia oblonga*, GL - Aghalla, 20. V. 2010, coll.: A. S., (1 ♀ 2 ♂); ***Rhopalosiphum padi*** (L.) on *Cydonia oblonga*, GL - Aghalla, 23. V. 2010, coll.: A. S., (6 ♀ 1 ♂).

***Aphidius transcaspicus* Telenga 1958** (Figs. 3, 15, 24, 34, 35)
Hyalopterus amygdali (Blanchard) on *Prunus dulcis*, IS - Meimeh, 17. V. 2005, coll.: E. R., (9 ♂ 8 ♀); FA - Shiraz, 27. IV. 2009, coll.: S. T., (8 ♂ 6 ♀); on *Prunus persica*, GL -Azadshahr, 07. V. 2010, coll.: A. S., (6 ♀ 8 ♂); HA - Hamadan, 08. XI. 2004, coll.: E. R., (9 ♀ 4 ♂); ***Hyalopterus pruni*** (Geoffroy) on *Prunus dulcis*, FA - Shiraz, 27. IV. 2009, coll.: S. T., (35 ♂ 15 ♀); on *Prunus domestica*, IS - Fereydoonshahr, 04. VI. 2011, coll.: E. N., (1 ♂ 4 ♀); on *Prunus persica*, IL - Chardavol, 02. VII. 2004, coll.: E. R., (6 ♀ 3 ♂); TH - Peykanshahr, 16. V. 2003, coll.: E. R., (22 ♀ 23 ♂); 14. VI. 2003 coll.: E. R., (35 ♀ 26 ♂); KS - Shirvan, 22. VI. 2007, coll.: S. K., (1 ♂ 4 ♀); on *Prunus armeniaca*, TH - Peykanshahr, 18. V. 2004, coll.: E. R., (17 ♀ 13 ♂); KS - Esfarayen, 09. X. 2007, coll.: S. K., (3 ♀).

***Binodoxys acalephae* (Marshall 1896)** (Figs. 4, 16, 25)
****Aphis pomi*** de Geer on *Malus domestica*, GL - Bandare Torkaman, 23. V. 2010, coll.: A. S., (1 ♀); HA - Hamadan, 08. XI. 2004, coll.: E. R., (6 ♀ 9 ♂); ****Aphis spiraecola*** Patch on *Cydonia oblonga*, GL - Aghalla, 15. V. 2010, coll.: A. S., (1 ♀).

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***Binodoxys angelicae* (Haliday 1833)** (Figs. 17, 26)
Aphis pomi de Geer on *Malus domestica*, AL - Shahrestanak, 28. V. 2003, coll.: E. R., (3 ♀ 1 ♂); ****Aphis spiraecola*** Patch on *Crataegus monogyna*, GL - Alangdareh, 04. V. 2010, coll.: A. S., (1 ♀ 1 ♂).

Diaeretiella rapae (M'Intosh 1855) (Figs. 5, 27)
Myzus persicae (Sulzer) on *Prunus armeniaca*, KR - Mashhad, 29. VII. 2009, coll.: E. R., (2 ♀);

***Ephedrus cerasicola* Starý 1962** (Figs. 6, 18, 28)
****Dysaphis plantaginea*** (Passerini) on *Malus domestica*, IS - Meimeh, 17. V. 2005, coll.: E. R., (6 ♀ 4 ♂); ****Myzus persicae*** (Sulzer) on *Prunus persica*, KR - Mashhad, 28. VII. 2009, coll.: E. R., (1 ♀ 2 ♂); KD - Marivam, 12. IX. 2004, coll.: E. R., (1 ♀ 2 ♂); ***Myzus cerasi*** (Fabricius) on *Prunus cerasus*, GN - Rasht, 07. VI. 2006, coll.: E. R., (2 ♀);

***Ephedrus persicae* Froggatt 1904** (Figs. 7, 19, 29)
Brachycaudus amygdalinus (Schouteden) on *Prunus dulcis*, KS - Bojnurd, 10. X. 2004, coll.: S. K., (2 ♀ 2 ♂); KE - Kermanshah, 16. V. 2009, coll.: Y. Z., (12 ♀ 5 ♂); ***Brachycaudus helichrysi*** (Kaltenbach) on *Prunus dulcis*, IS - Choghyort, 04. VI. 2011, coll.: E. N., (5 ♀ 1 ♂); IS - Ahmadreza, 20. V. 2011, coll.: E. N., (5 ♀ 2 ♂); on *Prunus persica*, TH - Tehran, 21. IV. 2002, coll.: E. R., (6 ♀ 3 ♂); KD - Marivam, 12. IX. 2004, coll.: E. R., (6 ♀ 9 ♂); KR - Mashhad, 29. VII. 2009, coll.: E. R., (1 ♀ 1 ♂); ***Dysaphis plantaginea*** (Passerini) on *Malus domestica*, IS - Meimeh, 17. V. 2005, coll.: E. R., (3 ♀ 4 ♂); KE - Kermanshah, 08. V. 2010, coll.: Y. Z., (1 ♀); KE - Bistun, 23. V. 2011, coll.: Y. Z., (2 ♀); ***Dysaphis pyri*** (Boyer de Fonscolombe) on *Pyrus communis*, AL - Shahrestanak, 17. V. 2005, coll.: E. R., (2 ♀ 2 ♂); ****Dysaphis reaumuri*** (Mordvilko) on *Pyrus communis*, IS - Mahdiabad, 20. V. 2011, coll.: E. N., (4 ♀ 5 ♂); ***Hyalopterus amygdali*** (Blanchard) on *Prunus dulcis*, IS - Mohamadiyeh, 19. V. 2011, coll.: E. N., (4 ♀ 5 ♂); IS - Jafarabad, 20. V. 2011, coll.: E. N., (4 ♀ 2 ♂); IS - Najafabad, 02. V. 2011, coll.: E. N., (24 ♀ 18 ♂); ****Myzus cerasi*** (Fabricius) on *Prunus incana*, AL - Shahrestanak, 21. VII. 2003, coll.: E. R., (4 ♀ 1 ♂); ****Myzus persicae*** (Sulzer) on *Prunus dulcis*, KE - Kermanshah, 04. V. 2011, coll.: Y. Z., (4 ♀ 1 ♂); on *Prunus persica*, QZ - Qazvin, 22. X. 2003, coll.: E. R., (1 ♀ 2 ♂); ****Phorodon humuli*** (Schrank) on *Prunus dulcis*, FA - Shiraz, 25. IV. 2004, coll.: E. R., (2 ♀).

***Ephedrus plagiator* (Nees 1811)** (Figs. 8, 20, 30)
****Dysaphis pyri*** (Boyer de Fonscolombe) on *Pyrus communis*, AL - Shahrestanak, 17. V. 2005, coll.: E. R., (2 ♂); ****Brachycaudus helichrysi*** (Kaltenbach) on *Prunus persica*, KR - Mashhad, 29. VII. 2009, coll.: E. R., (1 ♀ 2 ♂).

***Lysiphlebus fabarum* (Marshall 1896)** (Figs. 9, 21, 31)
Aphis pomi de Geer on *Malus domestica*, GL - Bandare torkaman, 23. V.2010, coll.: A. S., (1 ♀); KR - Mashhad, 28. VII. 2009, coll.: E. R. (12 ♀ 2 ♂); ***Aphis spiraecola*** Patch on *Cydonia oblonga*, GL - Aghalla, 20. V. 2010, coll.: A. S., (4 ♀ 7 ♂); on *Crataegus monogyna*, GL - Alangdareh, 04. V. 2010, coll.: A. S., (2 ♀ 2 ♂); ****Brachycaudus amygdalinus*** (Schouteden) on *Prunus dulcis*, KE - Kermanshah, 18. V. 2011, coll.: Y. Z., (2 ♀ 1 ♂); ***Brachycaudus helichrysi*** (Kaltenbach) on *Prunus domestica*, KR - Mashhad, 28. VII. 2009, coll.: E. R. (19 ♀ 11 ♂); ***Brachycaudus persicae*** (Passerini) on *Prunus persica*, TH - Damavand, 14. IX. 2005 (1 ♀ 2 ♂); ***Dysaphis plantaginea*** (Passerini) on *Malus domestica*, IS - Najafabad, 06. VI. 2011, coll.: E. N., (2 ♀); IS - Mohamadiyeh, 19. V. 2011, coll.: E. N., (1 ♀); ****Hyalopterus amygdali*** (Blanchard) on *Prunus persica*, GL - Azadshahr, 07. V. 2010, coll.: A. S., (1 ♂).

***Pauesia antennata* (Mukerji 1950)** (Figs. 10, 32, 37)
Pterochloroides persicae (Cholodkovsky) on *Prunus armeniaca*, SB - Khash, 22. IV. 2003, coll.: E. R., (11 ♀ 9 ♂); SB - Saravan, 10. III. 2003, coll.: E. R., (24 ♀ 17 ♂); on *Prunus*

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dulcis, SB - Taftan, 29. IV. 2004, coll.: E. R., (18 ♀ 26 ♂); KE - Bistun, 23. V. 2011, coll.: Y. Z., (40 ♀ 22 ♂); on *Prunus dulcis*, KS - Shirvan, 11. V. 2007, coll.: S. K., (15 ♀); KS - Paghaleh, 23. V. 2008, coll.: S. K., (17 ♀ 2 ♂); on *Prunus padus*, TH - Peykanshahr, coll.: E. R., (3 ♀ 8 ♂); on *Prunus persica*, KN - Kerman, 07. V. 2009, coll.: H. B., (1 ♀); KE - Harsin, 22. X. 2010, coll.: Y. Z., (17 ♀ 7 ♂); TH - Peykanshahr, 09. XI. 2002, coll.: E. R., (16 ♀ 16 ♂); AR - Varzaghan, 18. XI. 2004, coll.: A. M., (2 ♀ 1 ♂); HA - Asadabad, 08. XI. 2004, coll.: E. R., (3 ♀ 2 ♂); KS - Barzo Dam, 15. IX. 2007, coll.: S. K., (7 ♀ 2 ♂).

***Praon abjectum* (Haliday 1833)** (Fig. 11)
Brachycaudus cardui (L.) on *Prunus padus*, 21. IV. 2002, TH - Peykanshahr, coll.: E. R., (1 ♀ 1 ♂).

***Praon volucre* (Haliday, 1833)** (Figs. 12, 36)
****Aphis pomi*** de Geer on *Malus domestica*, FA - Shiraz, 18. IV. 2004, coll.: E. R., (4 ♀ 3 ♂); ****Brachycaudus amygdalinus*** (Schouteden) on *Prunus dulcis*, 23. IV. 2003, SB - Khash, coll.: E. R., (2 ♀); ****Brachycaudus cardui*** L. on *Prunus persica*, 23. V. 2003, TH - Peykanshahr, coll.: E. R., (3 ♀); ****Brachycaudus helichrysi*** (Kaltenbach) on *Prunus persica*, KR - Mashhad, 29. VII. 2009, coll.: E. R., (11 ♀ 8 ♂); ****Brachycaudus persicae*** (Passerini) on *Prunus persica,* HA - Asadabad, 8. XI. 2004, coll.: E. R., (3 ♀ 5 ♂); ****Dysaphis pyri*** (Boyer de Fonscolombe) on *Pyrus communis*, AL - Shahrestanak, 17. V. 2005, coll.: E. R., (1 ♀); ***Hyalopterus pruni*** (Geoffrey) on *Prunus padus*, AL - Karadj, 06. VII. 2002, coll.: E. R., (12 ♀ 7 ♂); on *Prunus armeniaca*, TH - Peykanshahr, 18. V. 2003, coll.: E. R., (4 ♀ 3 ♂); on *Prunus persica*, AL - Karadj, 20. VI. 2003, coll.: E. R., (5 ♀ 1 ♂); ****Hyalopterus amygdali*** (Blanchard) on *Prunus dulcis*, KE - Kermanshah, 08. V. 2011, coll.: Y. Z., (2 ♀ 2 ♂); FA - Shiraz, 18. IV. 2004, coll.: E. R., (2 ♀ 3 ♂); HA - Hamadan, 08. XI. 2004, coll.: E. R., (3 ♀ 2 ♂); TH - Shahriar, 08. V. 2003, coll.: E. R., (9 ♀ 11 ♂); KS - Barzo Dam, 15. IX. 2007, coll.: S. K., (7 ♀ 2 ♂); ***Myzus persicae*** (Sulzer) on *Prunus persica*, KR - Mashhad, 29. VII. 2009, coll.: E. R., (6 ♀ 2 ♂); KD - Marivam, 12. IX. 2004, coll.: E. R., (5 ♀ 4 ♂); on *Prunus padus*, TH - Shahriar, 17. X. 2003 (5 ♀ 2 ♂).

Key to the species of the aphid parasitoids on pome and stone fruit trees in Iran

1- Forewing venation with eight cells. 3RSb vein reaching the margin of the wing (Figs. 6 – 9)..... **2**
– Forewing venation with less than eight cells. 3RSb vein (Figs. 1 – 3, 9, 10) or r & RS vein (Figs. 4 – 5, 11 – 12) not reaching the wing margin **4**
2- Forewing 3RS vein distinctly shorter than 2RS vein (Fig. 7). Length of petiole less than 1.5 X as long as its width (Fig. 19). Ovipositor sheath stout (Fig. 29) .... ***Ephedrus persicae***
– Forewing 3RS vein distinctly longer than 2RS vein (Figs. 6, 8). Length of petiole more than 1.8 X as long as its width (Figs. 18, 20). Ovipositor sheath elongated (Figs. 28, 30)..... **3**
3- Flagellomere I yellow, 1.3 – 1.5 X as long as flagellomere II bearing 1 – 2 longitudineal placodes. Antennal segments gradually thickened toward tip. ..... ***Ephedrus cerasicola***
– Flagellomere I brown with narrow yellowish ring, 1.1 – 1.3 X as long as flagellomere II bearing 3 – 5 longitudinal placodes. Antennae filliform .... ***Ephedrus plagiator***
4- Rs + M vein present (Figs. 11, 12) **5**
– Rs + M vein absent (Figs. 1 – 5, 9, 10).. **6**
5- Antennae 15 – 16 segmented..... ..... ***Praon abjectum***
– Antenna 17 – 18 (19)-segmented..... ..... ***Praon volucre***
6- Terminal metasomal sternum without prongs (Figs. 22 – 24, 27, 31, 32)..... **7**
– Terminal metasomal sternum with two prongs (Figs. 25, 26).....**12**
7- Forewing M + m-cu vein complete (Figs. 1 – 3, 10)..... **8**
– Forewing M + m-cu vein incomplete

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(Fig. 9) or absent (Fig. 5) **11**

8- Antenna 21 – 22-segmented. Ovipositor sheath with long and strongly curved setae (Fig. 32). Propodeum with wide central areola..... ***Pauesia antennata***

– Antennae with fewer number of segments. Ovipositor sheath with short and straight or slightly curved setae (Figs. 22 – 24). Propodeum with narrow and small central areola **9**

9- Anterolateral area of petiole costulate (Fig. 14) ..... ***Aphidius matricariae***

– Anterolateral area of petiole costate (Figs. 13, 15) **10**

10- Antenna (14) 15 – 16-segmented. Forewing stigma length/width ratio of 3.10 – 3.40 (Fig. 1).... ***Aphidius colemani***

– Antenna 16 – 17-segmented. Forewing stigma length/width ratio of 3.60 – 3.90 (Fig. 3)..... ***Aphidius transcaspicus***

11- Forewing M + m-cu vein short (Fig. 9). Ovipositor sheath apically pointed (Fig. 31). Antenna 12 – 13-segmented .... ***Lysiphlebus fabarum***

– Forewing M + m-cu vein absent (Fig. 5). Ovipositor sheath apically truncated (Fig. 27). Antennae 14 – 15-segmented .. ..***Diaeretiella rapae***

12- Distance between primary and secondary tubercles less than width at spiracles (Fig. 16). Ovipositor sheath sub-quadrate at base (Fig. 28)..... ***Binodoxys acalephae***

– Distance between primary and secondary tubercles more than width at spiracles (Fig. 18). Ovipositor sheath rounded at base (Fig. 29) .....***Binodoxys angelicae***

Discussion

In general, the aphid parasitoids that were found to be associated with pome and fruit trees in Iran can be categorized into three groups: 1) common and generalist species, *Ephedrus persicae*, *Aphidius matricariae*, *Praon volucre*, *Lysiphlebus fabarum*; 2) common and specific species, *Aphidius transcaspicus*, *Pauesia antennata* and 3) rarely encountered species, *Diaeretiella rapae* and *Praon abjectum* (Table 1). The first group of parasitoids include the broadly oligophagus species, and even the occasional opportunistic species, *Lysiphlebus fabarum*, in association with different aphid genera, from which *Aphis pomi* and *Brachycaudus helichrysi* seem to be the most preferable hosts. *Diaeretiella rapae* has a wide range of host aphids on many plants but is rare on the aphids of fruit trees (Kavallieratos *et al.*, 2008), as well as on their secondary host plants (Kavallieratos *et al.*, 2004). It has also previously been recorded in association with *Brachycaudus* aphids on *Prunus* species in Iran (Starý *et al.*, 2000).

Praon abjectum was firstly recorded from the same association in Iran (Rakhshani *et al.*, 2007), but the recent evidences (unpublished data) confirm the existence of this species with host aphids on herbaceous plants. It has also been recorded as a specialized parasitoid of various species of the genus *Aphis* in Iraq (Starý and Kaddou, 1971). Some other aphid species were also recorded as the hosts for this parasitoid (Kavallieratos *et al.*, 2004).

Among the species of the genus *Aphidius*, only *Aphidius transcaspicus* showed a strict association with *Hyalopterus* aphids, while two other species, *Aphidius matricariae* and *Aphidius colemani* were found on different aphid genera, excluding *Hyalopterus*. It has previously been indicated that *Aphidius transcaspicus* has a narrow host range and was thought to be a specialist on *Hyalopterus* spp., both on primary and secondary host plants, but also has been reported to parasitize *Melanaphis* species (Latham and Mills, 2010; Starý, 1975). On the other hand, the morphological similarities between *Aphidius colemani* and *Aphidius transcaspicus* led to some misleading reports of host associations for the latter species (Starý, 1975; Rabasse *et al.*, 1985). The identity of *Aphidius transcaspicus* and its host range has been clarified by Kavallieratos *et al.* (1999). Furthermore, *Aphidius colemani* has been introduced as a complex species with different morphological and biological characters attacking different host aphids (Garantonakis *et al.*, 2009).

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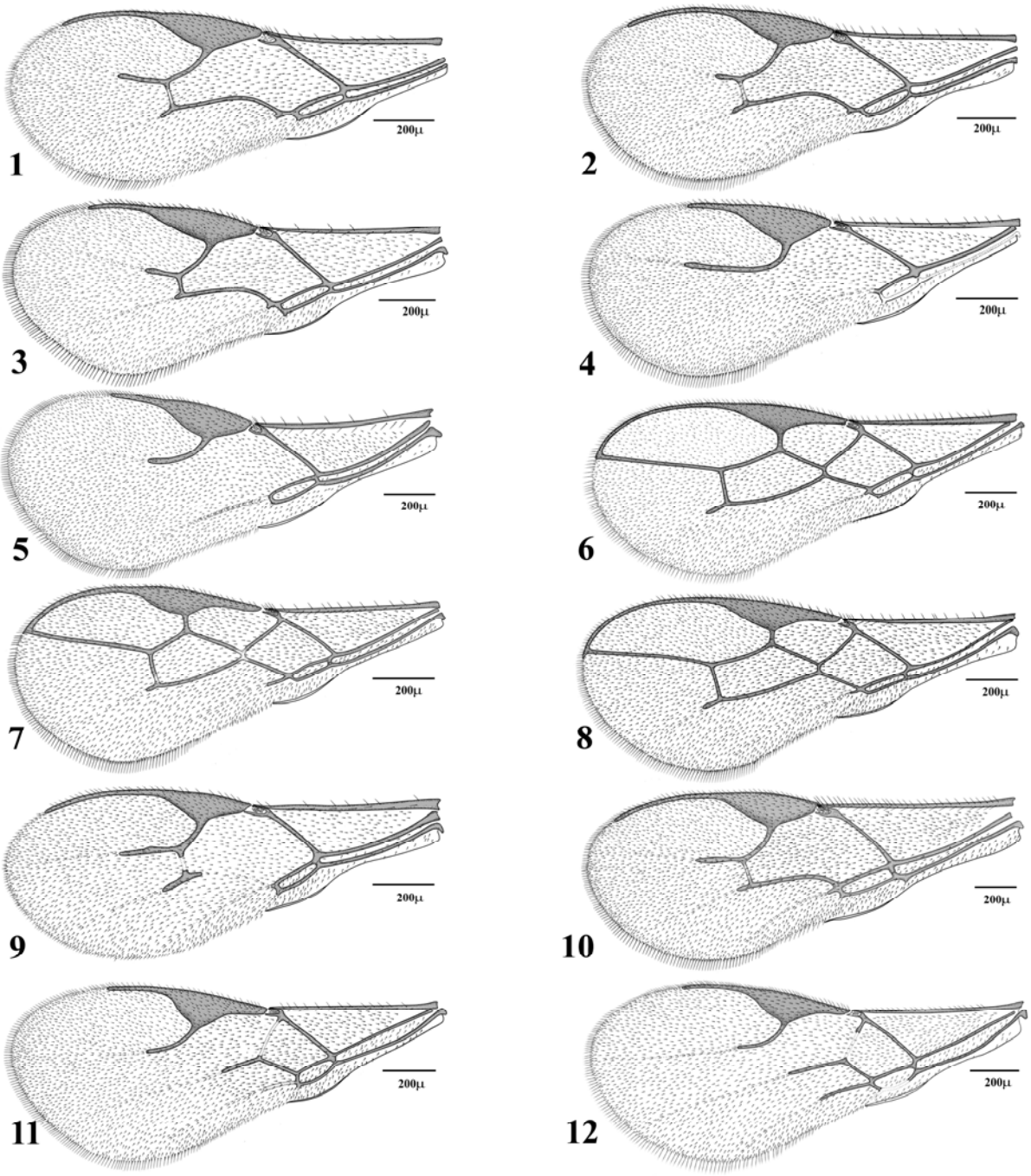

Figures 1–12 Forewings (females). 1. *Aphidius colemani* Viereck; 2. *Aphidius matricariae* Haliday; 3. *Aphidius transcaspicus* Telenga; 4. *Binodoxys acalephae* (Marshall); 5. *Diaeretiella rapae* (M´Intosh); 6. *Ephedrus cerasicola* Starý; 7. *Ephedrus persicae* Froggatt; 8. *Ephedrus plagiator* (Nees); 9. *Lysiphlebus fabarum* (Marshall); 10. *Pauesia antennata* (Mukerji); 11. *Praon abjectum* (Haliday); 12. *Praon volucre* (Haliday).

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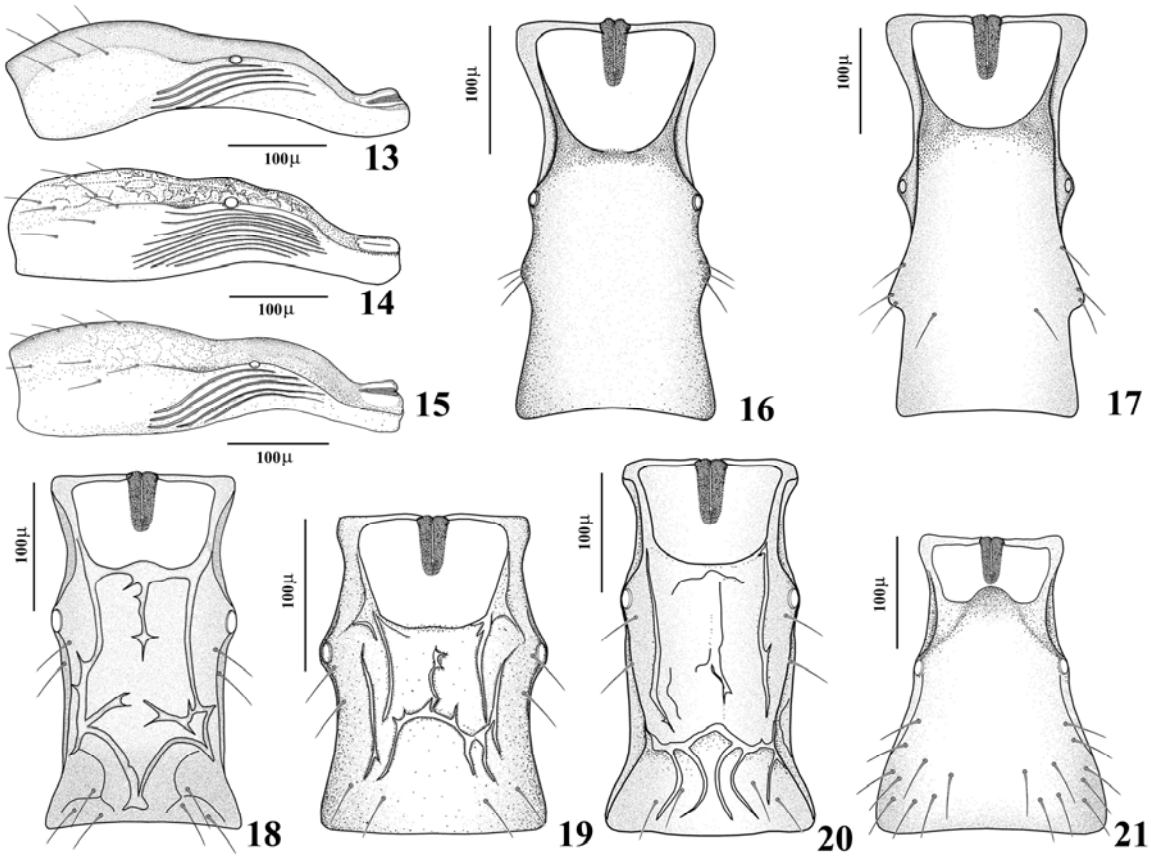

Figures 13–21 Lateral and dorsal aspects of petiole (females). 13. *Aphidius colemani* Viereck; 14. *Aphidius matricariae* Haliday; 15. *Aphidius transcaspicus* Telenga; 16. *Binodoxys acalephae* (Marshall); 17. *Binodoxys angelicae* (Haliday); 18. *Ephedrus cerasicola* Starý; 19. *Ephedrus persicae* Froggatt; 20. *Ephedrus plagiator* (Nees); 21. *Lysiphlebus fabarum* (Marshall).

Three species of the genus *Ephedrus* were found attacking the common aphids on both pome and stone fruit trees, but only *Ephedrus persicae* was a frequently encountered species, while the other species were less common. *Ephedrus cerasicola* was not a common species, but it seems to have some specific affinities with these fruit trees (Kavallieratos *et al.*, 2004, 2008). The previous records of this species from Iran were also in association with *Prunus* species (Mokhtari *et al.*, 2000). We found few specimens of *Ephedrus plagiator* on *Brachycaudus helichrysi* and *Dysaphis pyri*, which were mostly the male individuals. The absence of female specimens emerging from the latter aphid (*Dysaphis*) has limited further examination for possible existence of *Ephedrus dysaphidis* Tomanović, Kavallieratos & Starý, which is a recently described species from *Ephedrus plagiator* species group as a specialized parasitoid of *Dysaphis* aphids (Tomić *et al.*, 2005).

Two species of the genus *Binodoxys*, including *Binodoxys acalephae* and *Binodoxys angelicae* were found in association with *Aphis* spp. only on pome fruits. Both species are considered as parasitoids of *Aphis* species (Starý *et al*., 2000), but the associations with aphids of other genera have also been recorded (Jafari *et al.*, 2011; Kavallieratos *et al.*, 2008).

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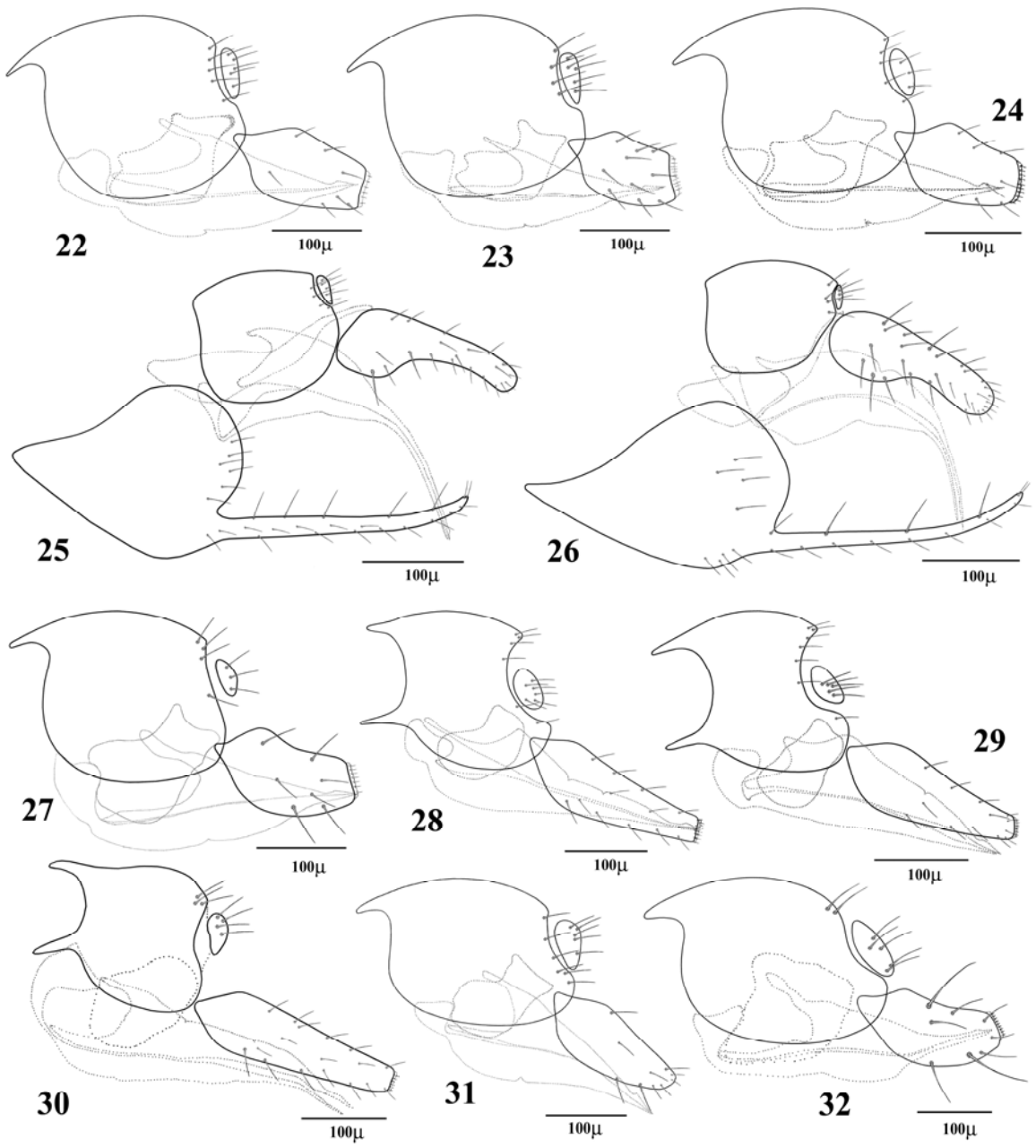

Figures 22–32 Lateral aspect of genitalia (females). 22. *Aphidius colemani* Viereck; 23. *Aphidius matricariae* Haliday; 24. *Aphidius transcaspicus* Telenga; 25. *Binodoxys acalephae* (Marshall); 26. *Binodoxys angelicae* (Haliday); 27. *Diaeretiella rapae* (M´Intosh); 28. *Ephedrus cerasicola* Starý; 29. *Ephedrus persicae* Froggatt; 30. *Ephedrus plagiator* (Nees); 31. *Lysiphlebus fabarum* (Marshall); 32. *Pauesia antennata* (Mukerji).

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Figures 33–38 Mummies of various parasitoids of aphids on pome and stone fruit trees. 33. *Aphidius matricariae* Haliday on *Dysaphis plantaginea* (Passerini) (Courtesy of R. Darsouei); 34. *Aphidius transcapicus* Telenga on *Hyalopterus amygdali* (Blanchard); 35. *Aphidius transcaspicus* Telenga on *Hyalopterus pruni* (Geoffrey); 36. *Praon volucre* (Haliday) on *Hyalopterus pruni* (Geoffroy); 37. *Pauesia antennata* (Mukerji) on *Pterocholorides persicae* (Cholodkovsky); 38. Unknown parasitoid (*Pseudopauesia prunicola* Halme?) on *Ovatus insitus* (Walker).

In addition to all collected species, a series of the mummified individuals of *Ovatus insitus* aphids were found on leaves of apple trees at Tehran province, of globular shape (Fig. 38). No adult parasitoids emerged from the mummified aphids after two years, indicating presence of a probably obligatory diapause, which can be broken after an overwintering in natural conditions. The parasitoids of univoltine host aphids, generally, have only one generation per year and consequently enter an obligatory and genetically determined diapause (Polgar and Hardie, 2000). Only a few aphid parasitoid species, like *Monoctonia pistaciaecola* Starý (Parasitoid of gall forming aphids on Pistachio) (Starý, 1968) and *Monoctonia vesicarii* Tremblay

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(Parasitoid of gall forming aphids on poplars) (Takada *et al.*, 2010) appear to be univoltine. The only known univoltine aphid parasitoid on fruit trees is *Pseudopauesia prunicola* Halme which is originally described from Finland (Halme, 1986) and also recorded in Germany (Sanchis *et al.*, 2000). However this species attacks a wide range of unrelated host aphids on shrubs or trees including *Rhopalosiphum padi* (L.) *Dysaphis sorbi* (Kaltenbach), *Dysaphis plantaginea* and *Myzus cerasi* (Halme, 1989), and the univoltinism is assumed to be an adaptation to habitat specialization in its area of distribution (Polgar and Hardie, 2000). Further attempts are necessary to breed the adult parasitoids from the same mummified aphids both on fruit trees and possibly on its secondary host plants.

Table 1 Host aphid-parasitoid associations on pome and stone fruit trees in Iran.

Aphid species	**Parasitoid species**
Aphis pomi de Geer	*Aphidius matricariae* Haliday, *Binodoxys acalephae* (Marshall), *Binodoxys angelicae* (Haliday), *Lysiphlebus fabarum* (Marshall), *Praon volucre* (Haliday)
Aphis spiraecola Patch	*Aphidius matricariae* Haliday, *Binodoxys acalephae* (Marshall), *Binodoxys angelicae* (Haliday), *Lysiphlebus fabarum* (Marshall)
Brachycaudus amygdalinus (Schouteden)	*Aphidius colemani* Viereck, *Aphidius matricariae* Haliday, *Ephedrus persicae* Froggatt, *Lysiphlebus fabarum* (Marshall), *Praon volucre* (Haliday)
Brachycaudus cardui (L.)	*Aphidius matricariae* Haliday, *Praon abjectum* Haliday, *Praon volucre* (Haliday)
Brachycaudus helichrysi (Kaltenbach)	*Aphidius matricariae* Haliday, *Ephedrus persicae* Froggatt, *Ephedrus plagiator* (Nees), *Lysiphlebus fabarum* (Marshall), *Praon volucre* (Haliday),
Brachycaudus persicae (Passerini)	*Aphidius matricariae* Haliday, *Lysiphlebus fabarum* (Marshall), *Praon volucre* (Haliday)
Dysaphis plantaginea (Passerini)	*Ephedrus cerasicola* Starý, *Ephedrus persicae* Froggatt, *Lysiphlebus fabarum* (Marshall)
Dysaphis pyri (Boyer de Fonscolombe)	*Ephedrus persicae* Froggatt, *Ephedrus plagiator* (Nees), *Praon volucre* (Haliday)
Dysaphis reaumuri (Mordvilko)	*Ephedrus persicae* Froggatt
Hyalopterus amygdali (Blanchard)	*Aphidius transcaspicus* Telenga, *Ephedrus persicae* Froggatt, *Praon volucre* (Haliday), *Lysiphlebus fabarum* (Marshall)
Hyalopterus pruni (Geoffrey)	*Aphidius transcaspicus* Telenga, *Praon volucre* (Haliday)
Myzus cerasi (Fabricius)	*Aphidius matricariae* Haliday, *Ephedrus cerasicola* Starý, *Ephedrus persicae* Froggatt
Myzus persicae (Sulzer)	*Aphidius colemani* Viereck, *Aphidius matricariae* Haliday, *Diaeretiella rapae* (M'Intosh), *Ephedrus cerasicola* Starý, *Ephedrus persicae* Froggatt, *Praon volucre* (Haliday)
Ovatus insitus (Walker)	*Aphidius matricariae* Haliday
Phorodon humuli (Schrank)	*Aphidius colemani* Viereck, *Ephedrus persicae* Froggatt
Pterochloroides persicae (Cholod.)	*Pauesia antennata* (Mukerji)
Rhopalosiphum padi (L.)	*Aphidius matricariae* Haliday

[DOR: 20.1001.1.22519041.2012.1.2.6.9]

Tanytrichophorus petiolaris Mackauer was reared from *Brachycaudus persicae* (Passerini) on *Prunus* sp., collected from Damavand (Tehran province) (Mackauer, 1961). This is the single record of this monotypic genus and no other specimens have been collected throughout the world. Although the original description was based on the male specimens, it was categorized as closely related taxon to the genus *Lysiphlebus* (Mackauer, 1961). Collections of the mummies of *Brachycaudus persicae* from the same region, have only yielded specimens of *Aphidius matricariae* and *Lysiphlebus fabarum*.

Occurrence of these complexes of aphid parasitoids both on pome and stone fruit trees and their secondary host plants (Starý *et al.*, 2000; Rakhshani *et al.*, 2008; Kavallieratos *et al.*, 2004, 2008) indicated some alternating refugia, which bear a rather important ecological consequence for the parasitoid to survive during the unfavorable conditions. At the same time, it is recommended to preserve the secondary host plants to support the naturally occurring biological control of aphids at the respective areas.

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زنبورهای پارازیتویید (Hymenoptera: Braconidae, Aphidiinae) شته‌های مرتبط با درختان

احسان رخشانی

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چکیده: در این تحقیق، زنبورهای پارازیتویید زیرخانواده Aphidiinae (Hym., Braconidae) که شته‌های آفت درختان میوه دانه‌دار را مورد حمله قرار می‌دهند، در مناطق مختلف ایران بررسی شد. در مجموع ۱۳ گونه زنبور پارازیتویید از هفت جنس مرتبط با ۱۷ گونه شته از روی ۱۰ درخت میوه شناسایی گردید. شصت و نه رابطه سه‌گانه تغذیه‌ای (پارازیتویید، شته، گیاه) در مناطق مورد مطالعه مشخص گردید که از بین آنها ۲۵ مورد برای ایران جدید بودند. یک کلید مصور برای شناسایی گونه‌های جمع‌آوری شده ارایه گردید. پارازیتوییدهای شناسایی شده براساس توانایی بالقوه در کنترل بیولوژیک شته‌های آفت به دو گروه کم‌اهمیت و پراهمیت تقسیم شدند. گروه اول شامل گونه‌های دارای دامنه میزبانی چندخواری وسیع مانند گونهٔ *Lysiphlebus fabarum* (Marshall) بوده، اما گروه دوم دربرگیرنده پارازیتوییدهای اختصاصی شته‌ها مانند زنبور *Aphidius transcaspicus* Telenga روی شته‌های جنس *Hyalopterus* و زنبور *Pauesia antennata* (Mukerji) روی شته *Pterochloroides persicae* (Cholodkovsky) است. احتمال وجود زنبور پارازیتویید تک‌نسلی *Pseudopauesia prunicola* Halme مرتبط با شته *Ovatus insitus* (Walker) در ایران نیز مورد بحث قرار گرفته است.

واژگان کلیدی: روابط تغذیه‌ای، کنترل بیولوژیک، ایران

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