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APHID-PARASITOID (HYMENOPTERA, BRACONIDAE, APHIDIINAE) ASSOCIATIONS ON WILLOWS AND POPLARS IN IRAN

E. RAKHSHANI,[1] A. A. TALEBI,[2] P. STARÝ,[3] Ž. TOMANOVIĆ [4] and S. MANZARI[5]

[1]*Department of Plant Protection, College of Agriculture, Zabol University, P. O. Box: 998615–538, I. R. Iran; E-mail: erakhshani@gmail.com*
[2]*Department of Entomology, College of Agriculture, Tarbiat Modares University P. O. Box 14115–336, I. R. Iran; E-mail: talebia@modares.ac.ir*
[3]*Institute of Entomology, Academy of Sciences of the Czech Republic, Branišovská 31, 37005 České Budějovicé, Czech Republic; E-mail: stary@entu.cas.cz*
[4]*Institute of Zoology, Faculty of Biology, University of Belgrade, Studentski trg 16, 11000 Belgrade, Serbia and Montenegro; E-mail: ztoman@bf.bio.bg.ac.yu*
[5]*Insect Taxonomy Research Department, Plant Pest and Disease Research Institute, P.O. Box 1454, Tehran 19395, Iran; E-mail: manzari@ppdri.ac.ir*

Aphids and their parasitoids on willows (*Salix* spp.) and poplars (*Populus* spp.) were investigated in Iran and the tritrophic associations were reviewed. Eight species of aphid parasitoids were reared from 17 associations in different localities. The most common parasitoid was *Adialytus salicaphis* (FITCH) parasitizing *Chaitophorus* spp. on both *Salix* and *Populus*. *Euaphidius cingulatus* (RUTHE) attacks species of *Pterocomma*. Aphids of the genus *Cavariella* on *Salix* spp. had a more diverse spectrum of parasitoids, but all of them were rare; among the collected species, *Ephedrus chaitophori* GÄRDENFORS and *Binodoxys heraclei* (HALIDAY) were detected in Iran for the first time. The role of aphid-parasitoid associations on willows and poplars in biocorridors is discussed together with some ecosystem relationships.

Key words: Aphids, parasitoids, Salicaceae, *Salix*, *Populus*, Iran

INTRODUCTION

Several species of willows (*Salix* spp.) and poplars (*Populus* spp.) occur in a wide range of habitats, and are common shade trees in urban ecosystems in Iran (NEUMANN & SKVORTSOV 1969). A diverse range of insects attack willows and poplars in both urban and natural habitats (ABAI, 1984). Some research has been done on different insect pests and their natural enemies on poplars and willows, with the aim of achieving their integrated control (MOJIB *et al*. 2002, RAJABI *et al*. 2003). Species of several aphid genera feed on *Salix* and *Populus*. Among them, species of *Cavariella* and *Chaitophorus* are the most common, respectively (REZWANI 2004).

Aphid parasitoids associated with willows and poplars have been poorly investigated in Iran, in spite of the presence of rich ecosystems. STARÝ *et al*. (2000)

reviewed the parasitoid-aphid plant associations in Iran and listed some parasitoids that attack aphids on willows and poplars. Recently, TOMANOVIĆ *et al*. (2006) provided detailed information on aphids and their parasitoids associated with willows and poplars in Southeast Europe, and this evidence contributed to the undertaking of similar research in Iran.

The obtained evidence is presumed to be extendable to analyses of associations in river biocorridors and on dry land, their environmental interactions in natural semi-deserts, and on irrigated and unirrigated land.

MATERIAL AND METHODS

Sampling was conducted during 2001–2005 in several representative provinces of Iran. Sistan-Baluchistan Province at southeast have a dry climatic condition, sorrounded by mountains, not a natural habitate for Salicaceae, but Gilan and Mazandaran are rather rainy and humid with several rivers and canals as habitate for Salicaceae. The western provinces consist of Zanjan, Hamadan and Kordistan with mountains and cold climatic condition favoured for Salicaceae in valleys and riversides. Khorasan province at east as well. The central provinces consist of Fars at South and Tehran, Quazvin, Markazi and Isfahan with a moderately hot weather affected by central deserts on one hand, and several rivers from Central Alborz mountains.

The list of localities, together with coordinates (location, latitude, longitude): Zahedan: 30°58'N, 61°41'E; Tehran–Punak: 35°46'N; 51°20'E; Tehran–Peykanshahr: 35°18'N; 51°37'E; Tehran–Rodehen: 35°44'N; 51°54'E; Tehran–Arangeh: 35°55'N; 51°4'E; Tehran–Evin: 35°47'N; 51°23'E; Tehran–Shahrestanak: 35°28'N; 51°10'E; Karaj–Fardis: 35°26'N; 51°35'E; Karaj: 35°49'N; 51°3'E; Kordistan–Marivan: 35°31'N; 46°10'E; Quazvin–Abiek: 38°11'N; 48°14'E; Gilan–Rasht: 37°16'N; 49°35'E; Mazandaran–Chalous: 36°40'N; 51°25'E; Gilan–Rezwanshahr: 37°32'N; 49°7'E; Fars–Shiraz: 29°36'N; 52°32'E; Zanjan: 36°39'N; 48°29'E; Isfahan: 32°39'N; 51°40'E; Markazi–Mahallat: 33°52'N; 50°30'E; Khorasan–Mashhad: 36°17'N; 59°36'E; Hamadan: 34°47'N; 48°30'E.

Aphid – infested leaves of willows and poplars were collected in the field and kept in plastic boxes covered with mesh for ventilation. Selected fresh specimens of aphids were immersed in 75% ethanol and preserved there for later identification. Samples were reared for 1–3 weeks until parasitoids emerged. Adult parasitoids were preserved in 96% ethanol. Some specimens were mounted on slides.

The morphological terminology used in the key to parasitoid species is based on SHARKEY and WHARTON (1997), KAVALLIERATOS and LYKOURESSIS (1999–2000) and KAVALLIERATOS *et al*. (2001).

RESULTS

Eight parasitoid species were reared in associations with aphids on willows and poplars at different localities in Iran. Among them, *Ephedrus chaitophori* GÄRDENFORS and *Binodoxys heraclei* (HALIDAY) are recorded for the first time in Iran. Eight new host associations are herein added to the previous records.

APHID-PARASITOID-PLANT ASSOCIATIONS

Adialytus salicaphis (FITCH)
(Figs 4, 12, 20, 26)

Chaitophorus euphraticus HODJAT on *Populus euphratica*, Zahedan, 24 March 2003; *Chaitophorus remaudierei* PINTERA, on *Salix nubica*, Tehran–Punak, 22 April 2002; on *Salix alba*, Marivan, 8 October 2004; *Chaitophorus salijaponicus* MORDVILKO on *Salix* sp., Quazvin–Abiek, 23 May 2002; Tehran–Peykanshahr, 17 November 2004; Gilan–Rasht, 25 May 2002; *Chaitophorus populialbae* (BOYER DE FONSCOLOMBE) on *Populus alba*, Tehran–Peykanshahr, 9 October 2002; Mazandaran–Chalous, 24 May 2004; Fars–Shiraz (Eram garden), 27 April 2005; *Chaitophorus populeti* (PANZER), on *Populus nigra*, Tehran–Evin, 9 November 2002; Karaj, 25 November 2002; Tehran–Peykanshahr, 27 September 2004; *Chaitophorus leucomelas* KOCH on *Populus nigra*, Tehran–Arangeh 27 June 2003; Zanjan, 7 October 2004; Isfahan, 30 October 2004; *Chaitophorus vitellinae* (SCHRANK) on *Salix alba*, Markazi–Mahallat, 22 April 2005; *Chaitophorus truncatus* (HAUSMANN) on *Salix purpurea*, Tehran–Peykanshahr, 5 October 2003.

Aphidius salicis HALIDAY
(Figs 6, 14, 22, 28)

Cavariella aegopodii (SCOPOLI) on *Salix australior*, Tehran–Rodehen, 27 June 2002

Binodoxys brevicornis (HALIDAY)
(Figs 7, 15, 23, 29)

Cavariella aegopodii (SCOPOLI) on *Salix alba*, Markazi–Mahallat, 22 April 2005

Binodoxys heraclei (HALIDAY)
(Figs 8, 16, 24, 30)

Cavariella aspidaphoides HILLE RIS LAMBERS on *Salix* sp., Khorasan–Mashhad, 11 October 2004.

Ephedrus chaitophori GARDENFÖRS
(Figs 2, 10, 18)

Chaitophorus populeti (PANZER), on *Populus nigra*, Tehran–Evin, 9 November 2002

Ephedrus helleni MACKAUER
(Figs 1, 9, 17)

Cavariella aquatica (GILLETTE & BRAGG) on *Salix alba*, Tehran–Shahrestanak, 12 June 2005

Euaphidius cingulatus (RUTHE)
(Figs 5, 13, 21, 27)

Pterocomma pilosum BUCKTON on *Salix alba*, Gilan–Rezwanshahr, 25 May 2004; *Pterocomma populeum* BUCKTON on *Populus alba*, Karaj–Fardis, 13 May 2003.

Lysiphlebus confusus TREMBLAY & EADY
(Figs 3, 11, 19, 25)

Aphis farinosa GMELIN on *Salix alba*, Hamadan (Medical Plant Garden), 9 October 2004.

KEY FOR THE IDENTIFICATION OF APHID PARASITOID SPECIES ASSOCIATED WITH WILLOWS AND POPLARS IN IRAN BASED ON FEMALES

1 Forewing venation complete, with seven closed cells. Vein 1/Rs reaching the margin of wing. Vein 3/Rs shorter than 2/Rs. 2R1 cell closed (Figs 1, 2). Propodeum with a wide central pentagonal areola (Figs 9, 10) 2

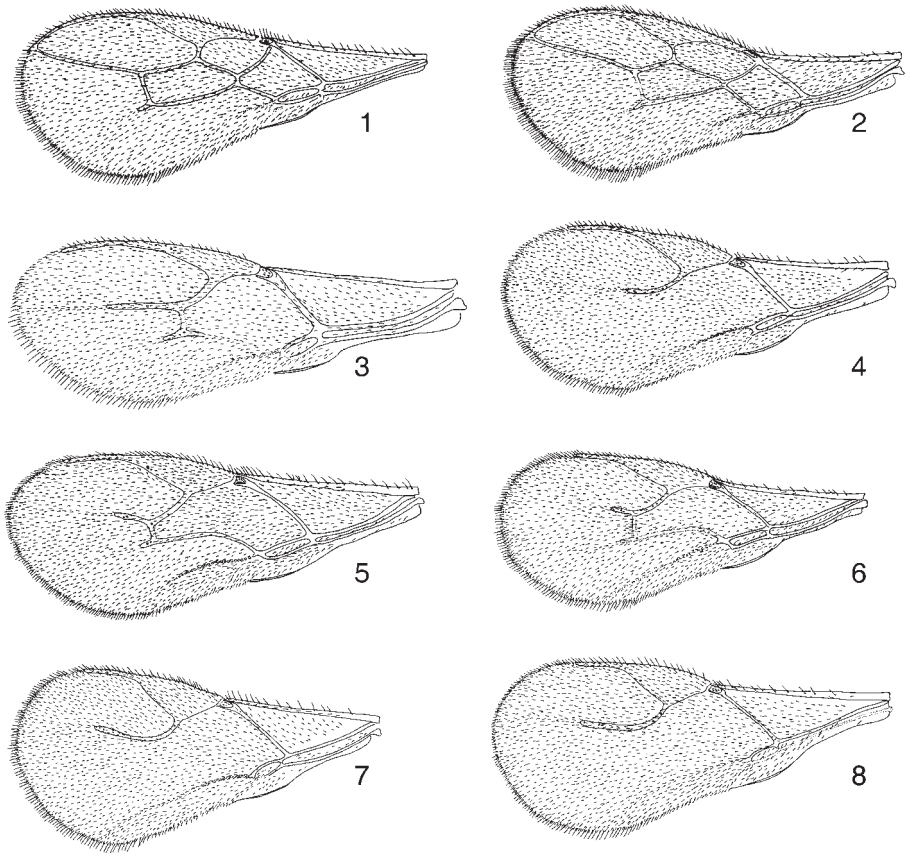
– Forewing venation not complete, with four closed cells or fewer. Vein 1/Rs not reaching the margin of wing. 2R1 cell open (Figs 3, 4, 5, 6, 7, 8). Propodeum smooth (Figs 11, 12) with incomplete (Figs 15, 16) or with a narrow central pentagonal areola (Figs 13, 14) 3

2 Antennae thickened at apex. Forewing 3/Rs length distinctly longer than 2/Rs (Fig. 1). Ovipositor sheath short, wide, gradually narrowing, ending to wide apex (Fig. 17) *Ephedrus helleni*

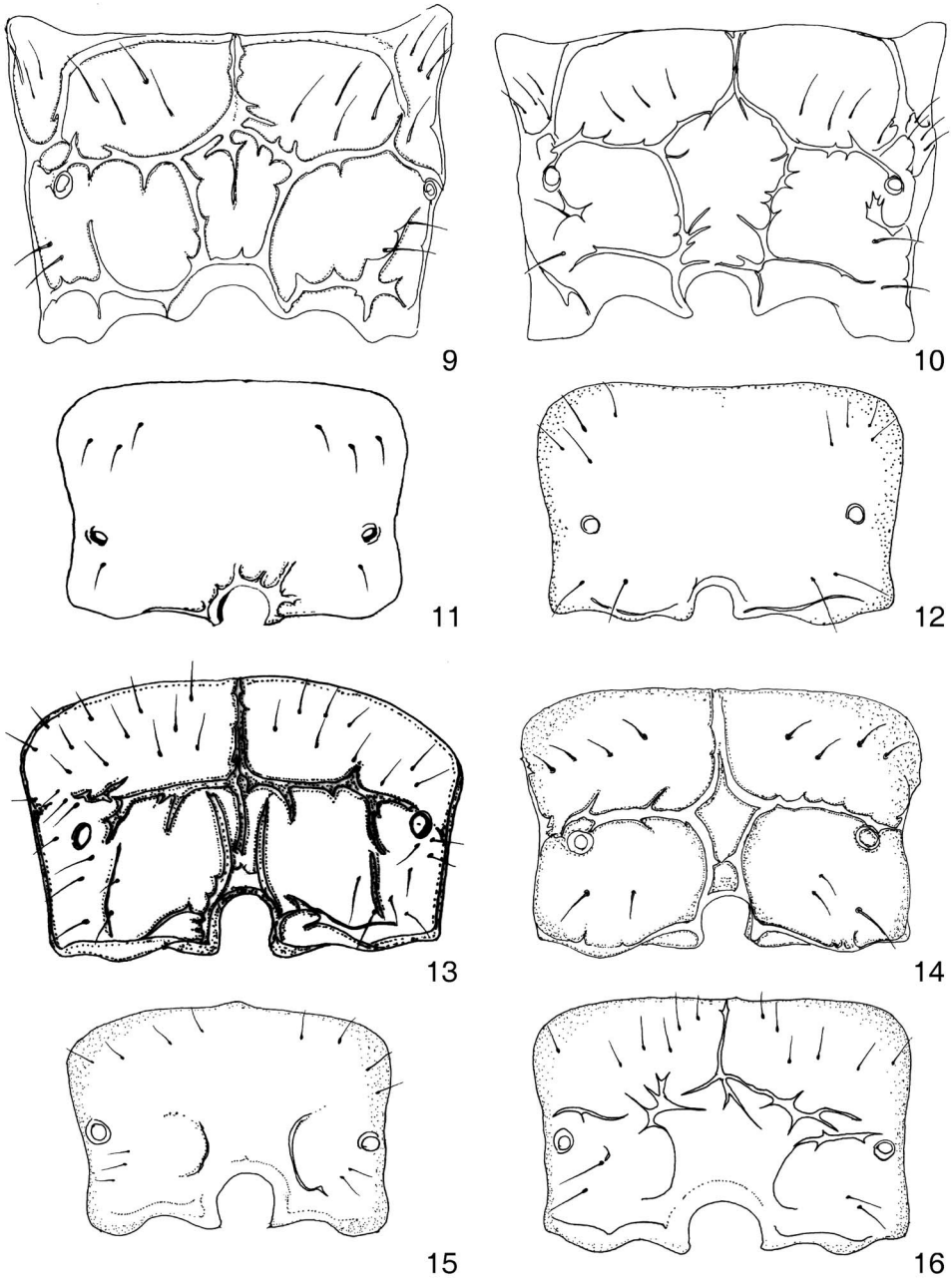
– Antennae filiform. Forewing 3/Rs length distinctly shorter than 2/Rs (Fig. 2). Ovipositor sheath long and slender, slightly widening at apex (Fig. 18) *Ephedrus chaitophori*

3 Terminal metasomal sternum with two curved prongs (Figs 23, 24). Petiole with two secondary lateral tubercules (Figs 29, 30) 4

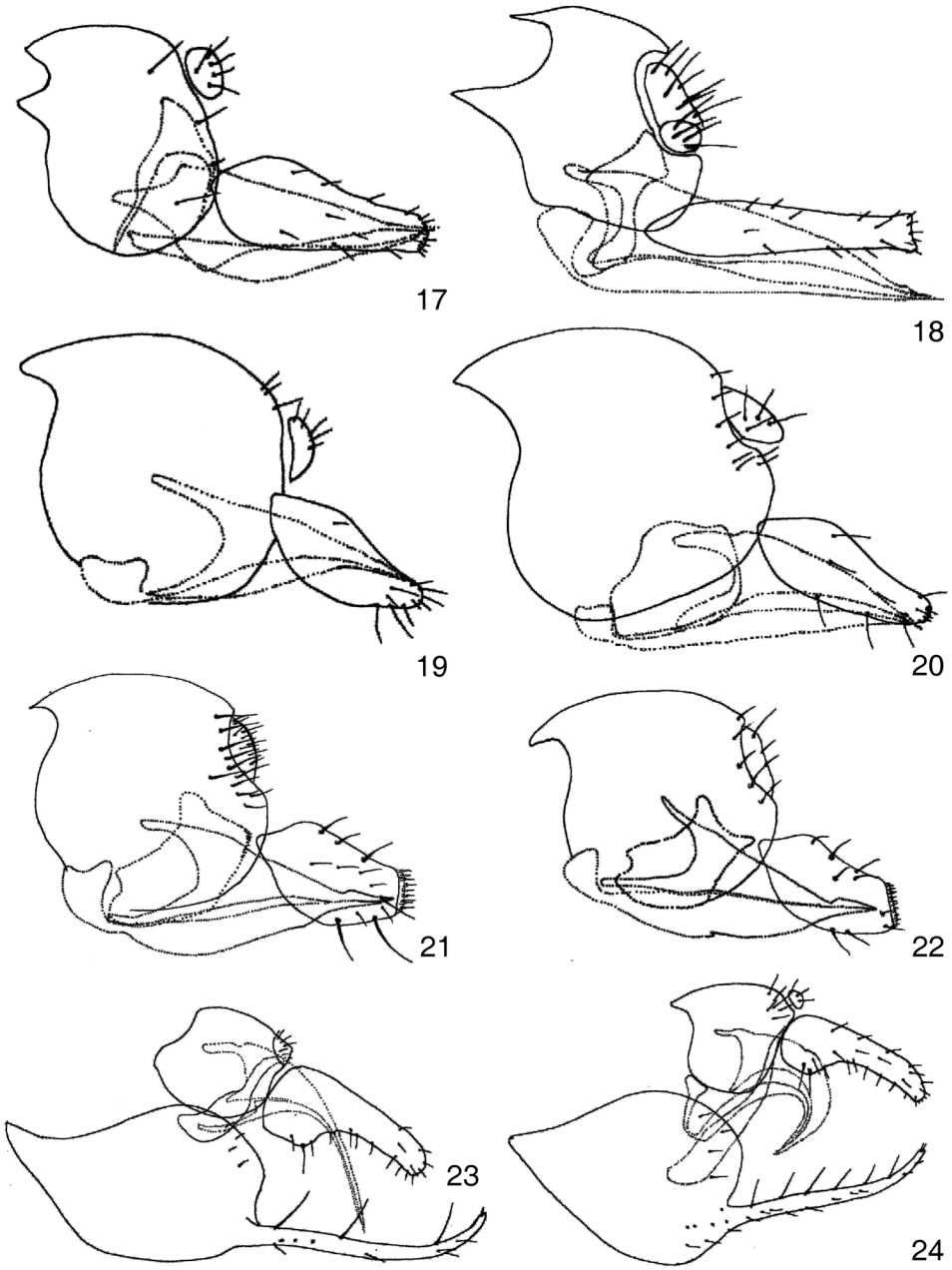
– Terminal metasomal sternum without prongs (Figs 19, 20, 21, 22). Petiole without secondary lateral tubercules (Figs 25, 26, 27, 28) 5



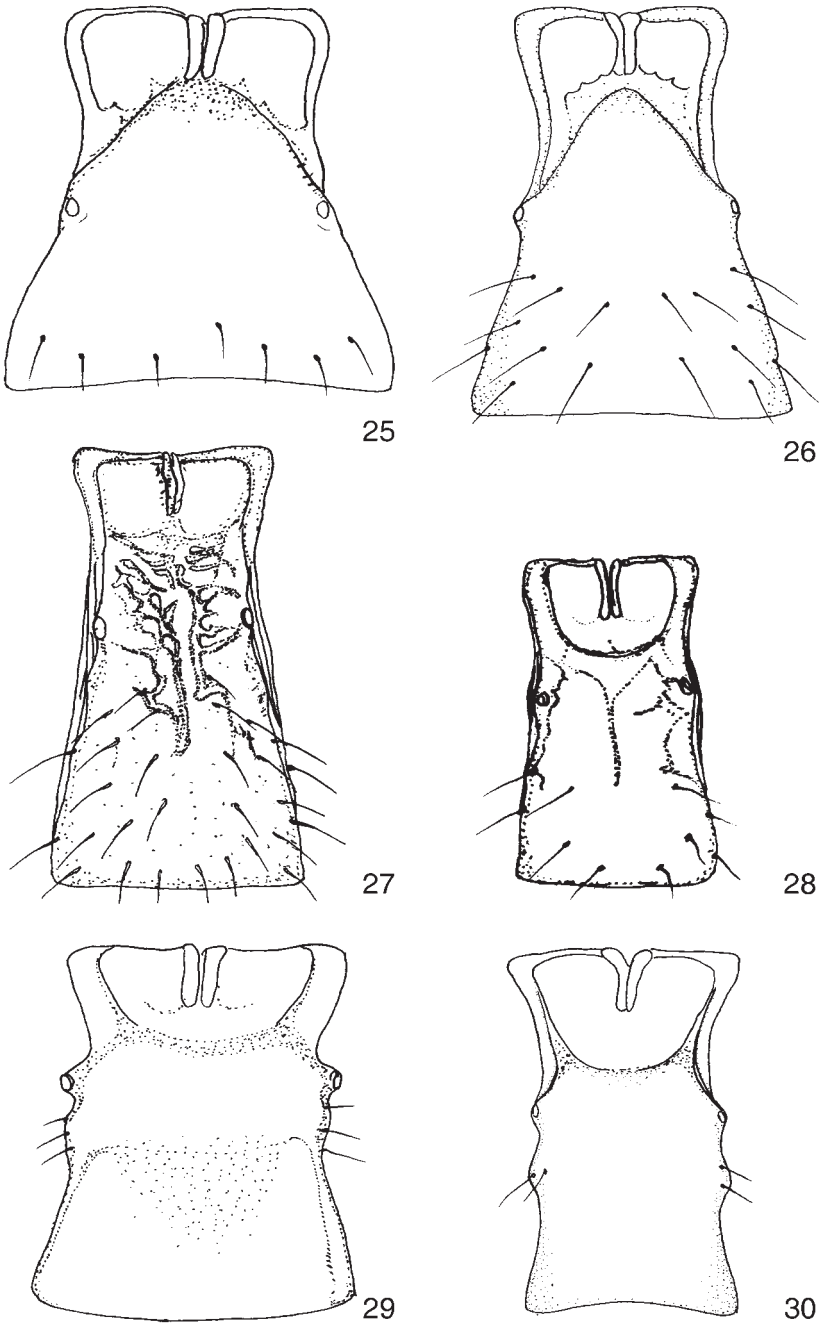
Figs 1–8. Forewing (+): 1 = *Ephedrus helleni*, 2 = *E. chaitophori*, 3 = *Lysiphlebus confusus*, 4 = *Adialytus salicaphis*, 5 = *Euaphidius cingulatus*, 6 = *Aphidius salicis*, 7 = *Binodoxys brevicornis*, 8 = *B. heraclei*



Figs 9–16. Dorsal aspect of propodeum (+): 9 = *Ephedrus helleni*, 10 = *E. chaitophori*, 11 = *Lysiphlebus confusus*, 12 = *Adialytus salicaphis*, 13 = *Euaphidius cingulatus*, 14 = *Aphidius salicis*, 15 = *Binodoxys brevicornis*, 16 = *B. heraclei*



Figs 17–24. Lateral aspect of genitalia (+): 17 = *Ephedrus helleni*, 18 = *E. chaitophori*, 19 = *Lysiphlebus confusus*, 20 = *Adialytus salicaphis*, 21 = *Euaphidius cingulatus*, 22 = *Aphidius salicis*, 23 = *Binodoxys brevicornis*, 24 = *B. heraclei*



Figs 25–30. Dorsal aspect of petiol (+): 25 = *Lysiphlebus confusus*, 26 = *Adialytus salicaphis*, 27 = *Euaphidius cingulatus*, 28 = *Aphidius salicis*, 29 = *Binodoxys brevicornis*, 30 = *B. heraclei*

4 Antennae 10 segmented. Distance between primary and secondary tubercules on petiole shorter than width at spiracles (Fig. 29). Prongs with 3 long setae on dorsal surface (Fig. 23). Propodeum without central areola (Fig. 15) *Binodoxys brevicornis*

– Antennae 11 segmented. Distance between primary and secondary tubercules on petiole shorter than width at spiracles (Fig. 30), prongs with 5–6 long setae on dorsal surface (Fig. 24). Propodeum with distinct central areola (Fig. 16) *Binodoxys heraclei*

5 Propodeum carinated, with narrow central pentagonal areola (Figs 13, 14). Vein M + m-cu developed completely (Figs 5, 6). Ovipositor sheath wide at apex (Figs 21, 22) 6

– Propodeum smooth (Figs 11, 12). Forewing M + m-cu vein partly (Fig. 3) or completely (Fig. 4) effaced. Ovipositor sheath sharply pointed at apex (Figs 19, 20) 7

6 Tentorial index 0.6–0.7. Antenna 19–20-segmented. Face densely pubescent. Petiole long, with dorsal central longitudinal carinae (Fig. 27) *Euaphidius cingulatus*

– Tentorial index 0.35–0.5. Antenna 12–13-segmented. Face sparsely pubescent. Petiole short, dorsally smooth or with uniform fine rugosities (Fig. 28) *Aphidius salicis*

7 Forewing M + m-cu completely effaced (Fig. 4). Length of petiole 2.2–2.4 times as its width at spiracles (Fig. 26) *Adialytus salicaphis*

– Forewing M + m-cu partly developed under r-m vein (Fig. 3). Length of petiole 1.7–1.8 times as its width at spiracles (Fig. 25) *Lysiphlebus confusus*

DISCUSSION

Binodoxys brevicornis was recorded as a parasitoid of *Hyadaphis* sp. on *Turginea* sp. in Iran (YAGHUBI 1997, YAGHUBI & SAHRAGARD 1998). It is an oligophagous species whose host spectrum includes among others, *Cavariella* spp. and *Brachycorynella asparagi* (MORDVILKO), pests of Umbelliferae and asparagus (STARÝ 1990).

Binodoxys heraclei was collected only on one occasion, in the east of Iran (Khorasan Province). This is the first record of this species from Iran. *Binodoxys heraclei* and *Aphidius salicis* were recorded as the most important parasitoids of

Cavariella aphids on cultivated Apiaceae in Southeast Europe (TOMANOVIĆ & BRAJKOVIĆ 2001, KAVALLIERATOS *et al*. 2004).

Ephedrus chaitophori is another parasitoid species newly recorded in Iran. It belongs to the *Ephedrus persicae* group and it attacks *Chaitophorus* spp. (GÄRDENFORS 1986). *Ephedrus helleni* has previously been recorded as a parasitoid of *Cavariella aquatica* on *Salix* sp. (STARÝ *et al*. 2000). *Euaphidius cingulatus* is the only parasitoid and a specific one of *Pterocomma* species on both *Salix* spp. and *Populus* spp.

Several gall-forming aphids belonging to the genus *Pemphigus* were identified in material collected in the studied areas. Among them, *Pemphigus spirothecae* PASSERINI was found to be hyperparasitized. Both *Pemphigus spirothecae* and *P. vesicarius* PASSERINI were heavily parasitized by *Protaphelinus nikolskayae* (YASNOSH) (Hymenoptera: Aphelinidae). The parasitism rate was between 50-98%. It appears that *P. nikolskayae* is a specific parasitoid of *Pemphigus* species in the closed micro-ecosystem of the gall. The black mummified nymphs remain inside the galls after migration of the alate aphids.

Two other aphids, *Phleomyzus passerinii* (SIGNORET) and *Tuberolachnus salignus* GMELIN, were free of parasitoids in all studied area. The large colonies of *T. salignus* cover the trunk and branches of willows in spring and especially in mid-autumn.

A. farinosa was found occasionally on *Salix* spp.. It was free of parasitoids in most cases, and *L. confusus* was reared in only one case. The latter is a common parasitoid of *A. farinosa* (KAVALLIERATOS *et al*. 2004, TOMANOVIĆ *et al*. 2006, TREMBLAY & EADY 1978). Furthermore, *L. confusus* represents a very important parasitoid of pest aphids on cotton, citrus and vegetable crops (KAVALLIERATOS & LYKOURESSIS 1999, 2004, KAVALLIERATOS *et al*. 2001, 2002, 2004, TOMANOVIĆ & BRAJKOVIĆ 2001). *L. fabarum* was also recorded as a parasitoid of *A. farinosa* in Serbia (KAVALLIERATOS *et al*. 2004, TOMANOVIĆ *et al*. 2006). *Binodoxys angelicae* (HALIDAY) is an abundant and common parasitoid attacking several species of aphids (RAKHSHANI *et al*. 2005, STARÝ *et al*. 2001, KAVALLIERATOS & LYKOURESSIS 1999, KAVALLIERATOS *et al*. 2001). It has previously been recorded as a parasitoid of *A. farinosa* on *Salix* sp. (YAGHUBI 1997), but we did not find it in association with aphids on Salicaceae.

Both poplars and willows are primarily associated with humid habitats such as brooks and rivers, irrigation canals in areas (WINTERBOURN 1995) and urban ecosystems (JOHNSON 1994). In this respect, they are highly trans-zonal and contribute to the species composition, diversity, and stability of river biocorridors in the landscape. Our research on aphids and their parasitoids demonstrated that most of their associations are limited to their host plants and respective habitats in the biocorridors. Less frequently, willow groves may represent refugia for some agri-

cultural pests (*Cavariella*) and their associated parasitoids as well (TOMANOVIĆ *et al*. 2006). *Chaitophorus* spp. are the most abundant and most common aphid pests on both willows and poplars. Sometimes they become serious pests, either due to direct feeding or as a result of honeydew secretion on leaves of trees grown as ornamentals in urban areas. Almost all species of *Salix* and *Populus* are attacked by these aphids. *Adialytus salicaphis* was the most abundant parasitoid and a specific one of *Chaitophorus* spp. As such, it seems to be the best candidate for biological control programs. Among the diverse complex of parasitoids attacking *Cavariella* spp. on willows, there are some species with a limited distribution but could be introduced to other regions. *Euaphidius cingulatus* is also a specific parasitoid of *Pterocomma* spp., which can attain pest-level incidence on both willows and poplars. The hyperparasitoids were abundant and may having a critical impact on efficacy of the primary parasitoid. The seasonal occurrence and phenology of primary parasitoids and hyperparasitoids are matters for future research.

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