J. Agric. Sci. Technol. (2008) Vol. 10: 123-133

Natural Enemies of Cypress Tree Mealybug, *Planococcus vovae* (Nasonov) (Hem., Pseudococcidae), and their Parasitoids in Tehran, Iran

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ABSTRACT

The cypress tree mealybug, *Planococcus vovae* (Nasonov) (Hem., Pseudococcidae) is one of the most important pests of cypress trees, especially *Cupressus sempervirens fastigiata* L. in Iran. A survey was carried out to determine the natural enemies of cypress tree mealybug in Tehran Province, during 2004-2005. As a result of this study, 17 species of predators, parasitoids and hyperparasitoids belonging to 10 families and 15 genera were collected and identified. Among the natural enemies associated with *P. vovae* three species, *Coccidoxenoides perminutus* Girault (Hym., Encyrtidae), *Aprostocetus ceroplastae* (Girault) (Hym., Eulophidae) and *Pachyneuron bonum* Xu and Li (Hym., Pteromalidae) were recorded here for the first time from Iran. The diagnostic morphological characteristics of the newly recorded species are given here and illustrated. The host range and economic importance of its natural enemies are reviewed and discussed.

Keywords: Biological control, Cypress tree mealybug, Iran, Natural enemies, *Planococcus vovae*.

INTROCUTION

Planococcus vovae (Nasonov) was first recorded in 1999 in Iran (Williams and Moghaddan, 1999) and is now a major pest of cypress trees, especially *Cupressus sempervirens* var. *fastigiata* L. (Lotfalizadeh and Ahmadi, 2000). This pest infests the leaves and branches of cypress trees. It is a strictly oligophagous species feeding entirely on cypress, in contrast with its congener, *P. citri* (Risso), which is polyphagous and occurs on a wide range of flowering plants (Bartlett, 1978; Williams, 1985). Its females pass through three nymphal instars before reaching adulthood and the nymphs differ from the adult females by having a much thinner wax covering and fewer antennal segments (Cox, 1989). The cypress tree mealybug is a Trans-palearctic species, occurring from sub-alpine forests in Central Europe to sea level in most Mediterranean countries. In the Middle East the pest was first noted in the early 1980s (Cox, 1989; Francardi and Covassi, 1992), and has also been reported in the last few years from the adjacent country, Turkey (Japoshvili and Karaca, 2002).

The pest can cause both direct and indirect damage. The direct feeding activity of *P. vovae* leads to the desiccation of twigs. Damage is also caused by the development of a sooty mould on its honeydew which weakens heavily infested trees. The mealybugs produce wax and this covers the bodies of most instars. The curled wax filaments are also found on the surfaces of ovisacs,

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[DOR: 20.1001.1.16807073.2008.10.2.7.1]

droplets of honeydew and ostiole exudates. Because of this waxy layer, chemical application on the cypress tree mealybug has no significant effects. In any case, the use of insecticides in urban ecosystems faces legal restrictions and causes environmental pollution. Therefore, biological control may be a useful alternative candidate (Francardi and Covassi, 1992).

Information on the biology and natural enemies of *P. vovae* is scanty and only a few attempts have been made in to study it Iran. Lotfalizadeh and Ahmadi (2000) investigated the natural enemies of *P. vovae* in Shiraz. Two parasitoid wasps, *Anagyrus pseudococci* Girault and *Dusmetia fuscipennis* Noyes and Hayat, as well as several coccinelids and chrysopids were identified as natural enemies of *P. vovae*. A different assemblage of natural enemy species was recorded in Italy, these included the parasitoids *Leptomastidea matritensis* Mercet, *L. bifasciata* Mayer, *Allotropa mecrida* (Walker) (Hym., Platygasteridae) and *Charotcerus subaeneus* Förster, along with the predatory coccinellids *Nephus bisignatus* Bohemann and *Scymnus interruptus* Goeze (Francardi and Covassi, 1992).

Several attempts have been made to integrate the impact of natural enemies with pesticide chemicals for control of pseudococcids (Mineo and Viggiani, 1977; Luppino, 1979; Raciti *et al*., 1997). Natural enemies have also been introduced into some countries in which pseudococcids attack crops (Mani, 1994; Barbagallo *et al*., 1993; Nagarkatti *et al*., 1992). Indigenous natural enemies may have a significant effect on populations of cypress tree mealybug, because it only became a significant pest following the extensive use of pesticides. Successful programs of biological control depend on the correct identification of the natural enemies of the target pest species. The present work provides a first survey and identification of *P. vovae* natural enemies in Tehran.

MATERIALS AND METHODS

During a field survey conducted in Tehran Province (Iran) from 2004 to 2006, the natural enemies of cypress tree mealybugs, eggs, larvae and pupae of lacewings, coccinellids, syrphids, chammamaeids as well as parasitized pseudococcids were collected from infested cypress in urban areas and parks. These were subsequently reared in the laboratory and the adults identified. The insects were kept within transparent plastic boxes with mesh for ventilation, and were held in a growth cabinet with constant conditions of 25±5°C, RH: 70±5% and a 16L: 8D photoperiod. Mealybug nymphs were fed on by predators, as was observed directly for 3-4 weeks. Some insects, which did not feed on the mealybugs in the laboratory, were rejected.

Six parasitoids were dissected subsequently for microscopic studies. The external morphology of parasitoids was illustrated using a phase contrast microscope with a drawing tube. Notes are given on the morphology and taxonomy of the newly recorded natural enemies of the cypress tree mealybug. Synonyms and terminology used are mainly based on Noyes (2006) and Gibson *et al*. (1998), respectively. All species of parasitoids and predators of *P. vovae* were sent to taxonomic experts for the definitive identification. Material examined is deposited in the Insect Collection of Tarbiat Modares University (Tehran). Descriptions of the newly recorded species are provided to help Iranian workers in identifying those species.

RESULTS

Six species of chalcidoid wasps (Hym., Chalcidoidea) were associated with the *P. vovae* and their predators along with 9 species of predatory insects. These include three new records for the fauna of I. R. Iran. These are marked with an asterisk follows:

[DOR: 20.1001.1.16807073.2008.10.2.7.1]

Parasitoids and hyperparasitoids

Anagyrus pseudococci (Girault) (Hym., Encyrtidae)
Coccidoxenoides perminutus Girault (Hym., Encyrtidae)*
Aprostocetus ceroplastae (Girault) (Hym., Eulophidae)*
Pachyneuron bonum Xu and Li (Hym., Pteromalidae) *
Marietta picta (Andre) (Hym., Aphelinidae)
Homalotylus sinensis Xu and He (Hym., Encyrtidae) on Coccinellid beetle larvae

Predators:

Oenopia conglobata (L.) (Col., Coccinelidae)
Exochomus nigromaculatus (Goeze) (Col., Coccinelidae)
E. quadripustulatus (L.) (Col., Coccinelidae)
Chilocorus bipustulatus (L.) (Col., Coccinelidae)
Nephus bipunctatus (Kugelann) (Col., Coccinelidae)
Hyperaspis femorata (Motschulsky) (Col., Coccinelidae)
Hyperaspis sp. (Col., Coccinelidae)
Geocoris quercicola Linnavaouri (Hem., Lygaeidae)
Leucopomyia sogdiana Tanasijtshuk (Dip., Chamaemyiidae)
Sympherobius pygmaeus (Rambur) (Neu., Hemerobiidae)
Chrysoperla carnea (Stephens) (Neu., Chrysopidae)

Notes on the Newly Recorded Species

***Coccidoxenoides perminutus* Girault, 1915 (Hym., Encyrtidae)**

Material examined: Tehran, Peykanshahr, 25.VI.2005- 4 males, 5 females; 5.VII.2005- 2 males, 4 females; 20.V.2006- 3 males, 2 females; 4.VI.2006- 3 males, 8 females; 12.VI.2006- 4 males, 3 females on *Planococcus vovae*, Leg. A. Ameri.

Diagnosis: Head blackish brown, with a metallic shine, compound eyes red, scape and pedicle dark brown, other segments lighter, mesoscutum metallic green, other parts brown. Head wide and trapezoid in shape, face punctuated, lateral aspects of the compound eyes and vertex with semi-erected setae (Figure 1A), maxillary palp long, antennae inserted in the middle space between the lower surface of the compound eyes and clypeus, 11-segmented, ring with four segments, first flagellar segment shorter than the second segment (Figure 1E). Submarginal vein long, slightly curved at the second half, with more than 5 long setae at margin of wing, stigmal vein short, but longer than post marginal vein, speculum wide, closed, with a line of setae in lower portion, extended into the posterior margin of wing (Figure 1D). Notaulices present at ascendant portion of mesoscutum, axillae reaching each other, mesoscutum with fine sculpture dorsally, covered with short setae (Figure 1B). Tarsi 5-segmented (Figure 1F, G, H). Cercal plate bearing 4 unequal setae, last tergum densly pubescent (Figure 1C).

***Aprostocetus ceroplastae* (Girault, 1916) (Hym., Eulophidae)**

Material examined: Tehran, Peykanshahr, 25.VI.2005- 6 males, 5 females; 5.VII.2005- 9 males, 15 females; 20.VII.2005- 12 males, 32 females; 8.VIII.2005- 5 males, 8 females; 3.IX.2005- 3 males, 11 females; 20.V.2006- 3 males, 16 females; 4.VI.2006- 15 male, 10 females; 9.VII.2006- 6 males, 9 females on *Planococcus vovae*, Leg. A. Ameri.

Diagnosis: Head wide, spherical, compound eyes slightly prominent laterally, lateral portions of the face (gena) with sparse hairs; antennae inserted at middle of face, between the compound eyes (Figure 2A), antennae 8-segmented, ring 2-segmented, funicle and club 3-segmented (Figure 2B); maxillary palp 2-segemeted; forewing with short submarginal and relatively long marginal vein with several short erected setae in margin, postmarginal vein rudimentary, stigmal vein short with small triangular stigma (Figure 2D); mesoscutum wide with few long setae

[DOR: 20.1001.1.16807073.2008.10.2.7.1]

in behind margin, axilla separated completely, scutellum sub-quadrate with 2 longitudinal line divided the segment to 3 parts, lateral parts with two long setae (Figure 2C), tarsi 4-segmented (Figure 2F, G, H), ovipositor protrudes beyoned end of the gaster (Figure 2E).

***Pachyneuron bonum* Xu and Li, 1991 (Hym., Pteromalidae)**

Material examined: Tehran, Peykanshahr, 25.VI.2005- 8 males, 7 females; 5.VII.2005- 5 males, 11 females; 20.VII.2005- 5 males, 8 females; 8.VIII.2005- 2 males, 4 females;

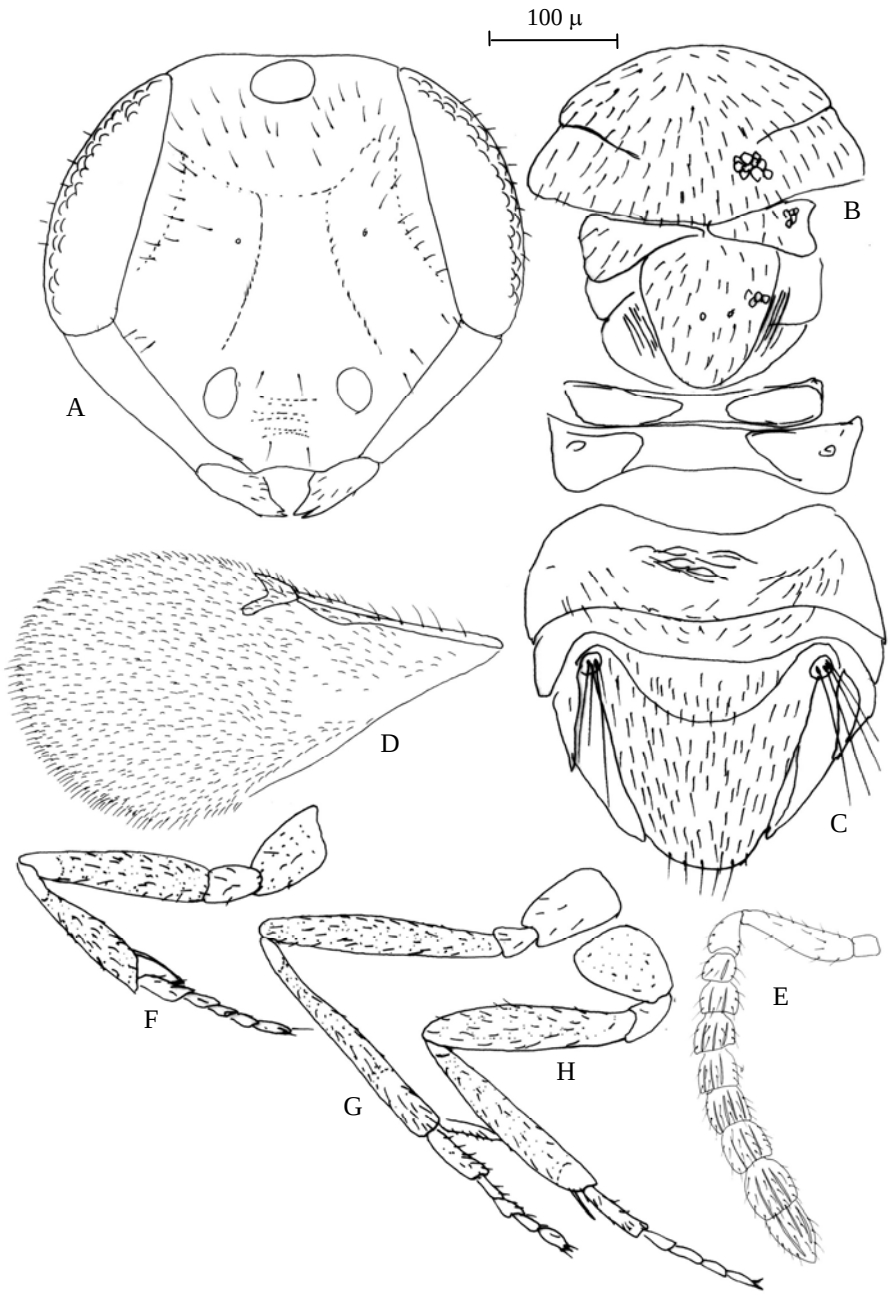

Figure 1. Morphological characteristics of female *Coccidoxenoides perminutus* Girault, A. Head; B. Dorsal aspect of thorax; C. Dorsal aspect of gaster; D. Forewing; E. Antenna; F, G, and H. Fore, mid and hind legs, respectively.

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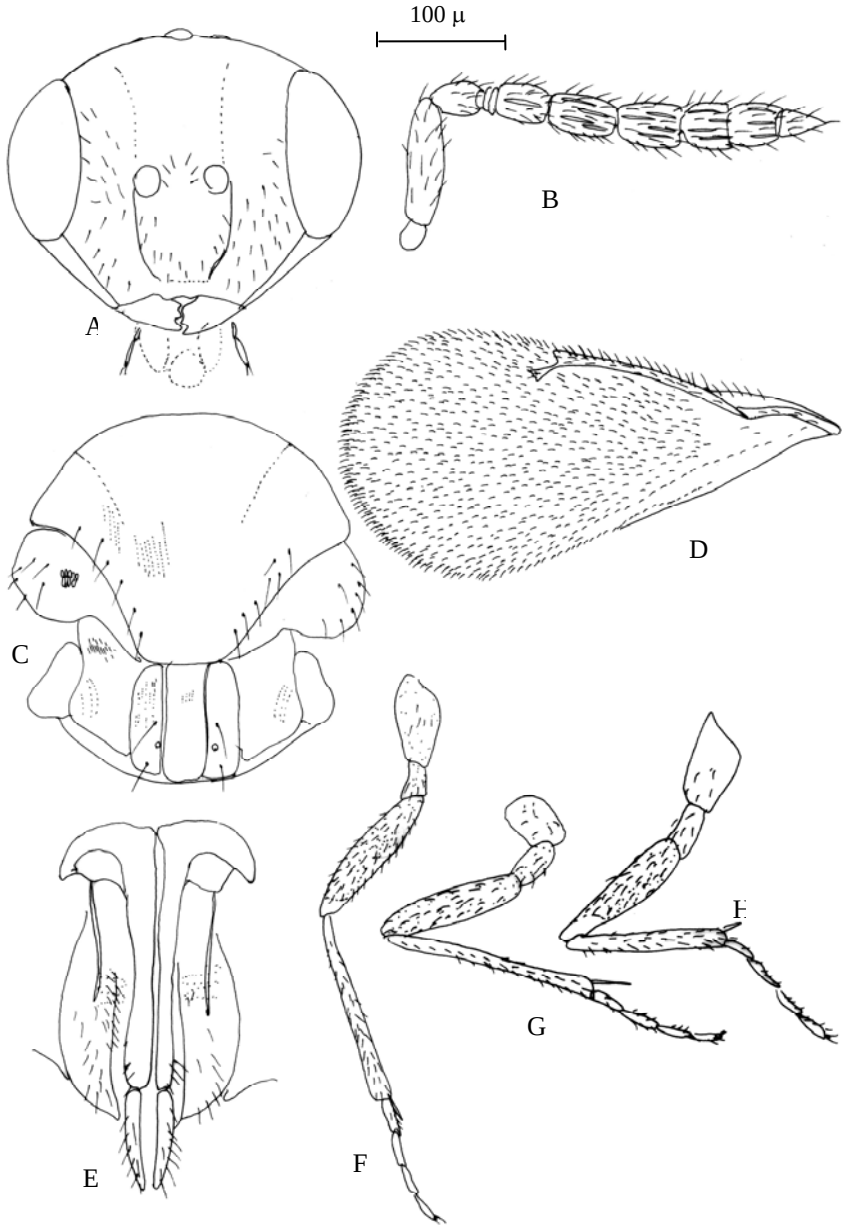

Figure 2. Morphological characteristics of female *Aprostocetus ceroplastae* (Girault), A. Head; B. Antenna; C. Thorax; D. Forewing; E. Ovipositor; F, G and H. fore, mid and hind legs, respectively.

2.IX.2005- 3 males, 14 females; 20.V.2006- 5 males, 19 females; 4.VI.2006- 3 male, 12 females; 9.VII.2006- 4 males, 4 females; 6.VIII.2006- 3 males; 2 females; on *Planococcus vovae*, Leg. A. Ameri.

Diagnosis: Head with relatively fine sculpture, antennae inserted at upper half of the face, maxillary and labial palps 3-segmented, labial palp with very small middle segment (Figure 3A); antenae11-segmented in males and 10-segmented in females, ring 2-segmented in males and 3-segmented in females (Figure 3D); forewing with long submarginal vein, relatively long and thickened marginal vein, postmarginal vein as long as marginal vein of a little

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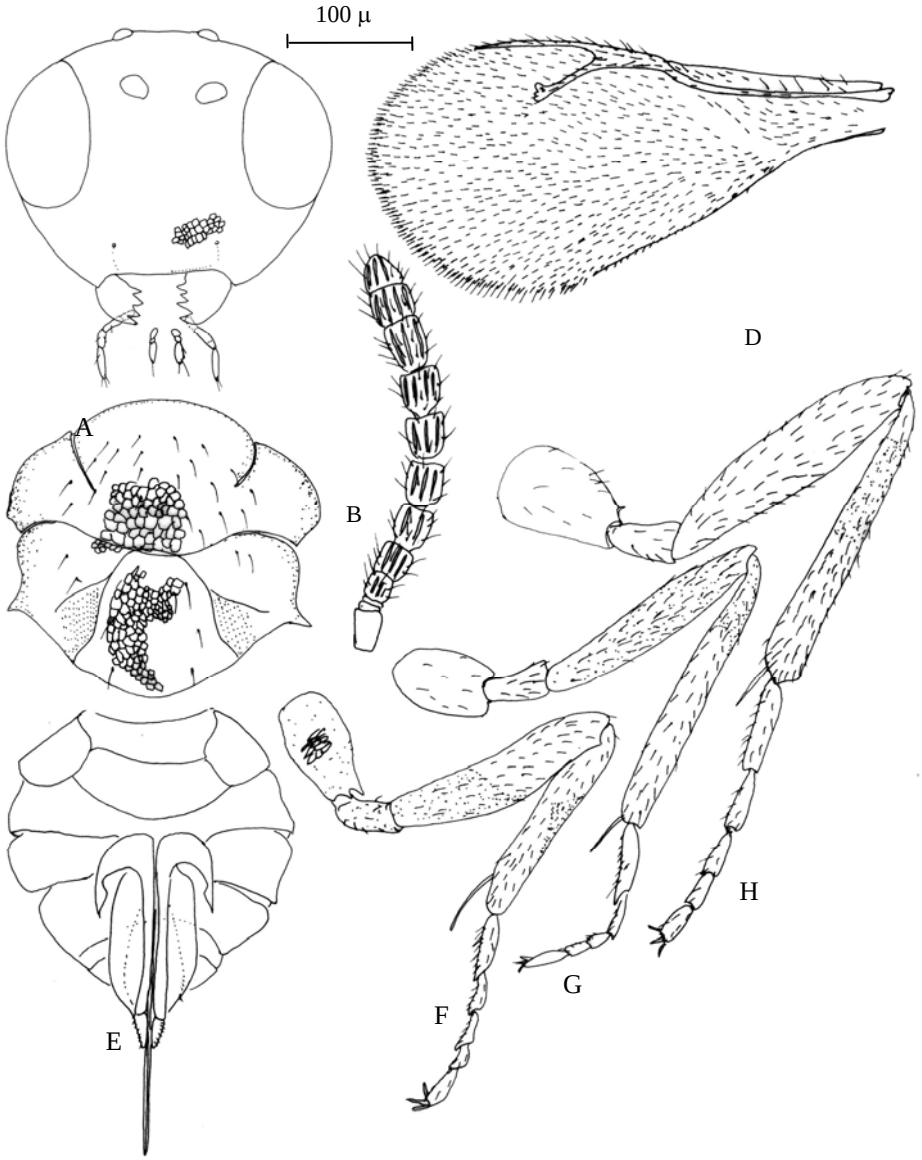

Figure 3. Morphological characteristics of female *Pachyneuron bonum* Xu and Li, A. Head; B. Antenna; C. Thorax; D. Forewing; E. Abdomen and Ovipositor; F, G and H. fore, mid and hind legs, respectively.

longer, stigmal vein equal to marginal vein, speculum open at base with unique line of the short setae at proximal side (Figure 3D); mesoscutum with developed notaulices, not reaching the middle of mesocutum, punctuated with sparse short setae in front part, scutellum with 3 short setae at each sides (Figure 3B); tarsi 5-segmented, foreleg with curved tibial spur (Figure 3F, G, H); ovipositor sheath short, and ovipositor extended as half long as gaster (Figure 3E).

DISCUSSION

The occurrence of such a diversity of natural enemies indicates a good potential for biological control of *P. vovae* in Tehran.

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The species of the genus *Anagyrus* Howard (Hym., Encyrtidae) are primary parasitoids of mealybugs. *A. pseudococci* is a well-known parasitoid of the citrus mealybug, *P. citri*, in many parts of the world (Noyes and Hayat, 1994). It has been previously recorded as a parasitoid of *P. citri* and *Nipaecoccus filamentosus* (Cockerell) in Iran (Chojai, 1968). This parasitoid also attacks closely related species such as *Pseudococcus comstocki* (Kuwana). Currently, it is being used to suppress a new invasive pest, the vine mealybug, *P. ficus* in California, USA (Daane *et al*., 2004).

C. perminutus is an asexual parasitoid of *P. citri* (Ceballo and Walter, 2004), which is of Australian origin (Noyes and Hayat, 1994). This parasitoid has been introduced to some countries for the biological control of citrus mealybug. There is no other record of parasitization of *P. vovae* by this parasitoid in Iran. We found the parasitoid in a few locations, but only in low numbers. High temperature has been proposed as a factor that limits the ability of this parasitoid (Davies *et al*., 2004). The parasitoid is also distributed in Africa (Noyes and Prinsloo, 1998), Cuba (Noyes, 2000), India (Hayat, 1986) and Israel (Trijapitzin, 1989)

A. ceroplastae had been recorded as an active parasitoid of third instar nymphs and adults of *Ceroplastes destructor* Newstead (Hom., Coccidae) in Africa (Wakagari, 2001). This parasitoid was also reared from *Gascardia brevicauda* (Hall) (Hom., Coccidae) (Prinsloo, 1984) and *Pulvinaria elongata* Newstead (Panis, 1975). Its distribution extends from Africa to Australia, China, Lebanon, Egypt and Turkey (Noyes, 2006).

The genus *Pachyneuron* Walker includes primary and secondary parasitoids of syrphids, aphids, coccids, psyllids and Diptera. The species associated with coccids are hyperparasitoids of other chalcidoids or Diptera (Ben-Dov and Hodgson, 1997). This genus is represented in Iran by three species. These are *P. aphidis* (Bouché) (Talebi *et al*., 2001a), *P. muscarum* (Linnaeus) (Lotfalizadeh and Ahmadi, 2000) and *P. formosum* Walker (Anonymous, 1971). This parasitoid has been reared on *Ericerus pela* Chavannes (Hom., Coccidae) from China (Xu *et al*., 1991) and it is the second record in the world.

The genus *Marietta* Motschulsky is represented in Iran by one species, *Marietta picta*. All species of *Marietta* are hyperparasitoids of other parasitic Hymenoptera, including species of Chalcidoidea. Secondary hosts include homopterous insects and have been reared from diaspidids, pseudococcids, cercopids and psyllids (Ben-Dov and Hodgson, 1997). *M. picta* is known throughout the Palaearctic region, though it has also been reported from some parts of Oriental, Neotropical and Nearctic regions (Hayat, 1986). This species was previously known as a hyperparasitoid of *A. pseudococci* from Fars Province (Lotfalizadeh and Ahmadi, 2000).

The genus *Homalotylus* Mayr comprises one of the most important parasitoids of Coccinellidae with about 50 species worldwide (Noyes, 2006). We reared *H. sinensis* from fourth instar larvae and pupae of *Exochomus nigromaculatus* and *Exochomus quadripustulatus* as new host records. *H. sinensis* was first described from China by Xu and He (1997) and has most recently been reported from Shiraz Province (Fallahzadeh *et al*., 2006). This species will possibly extend its distribution area towards other Near Eastern countries. Seven species of parasitoids of ladybirds are previously reported from Iran. These include *Homalotylus quaylei* Timberlake on *Scymnus subvillosus* (Goeze) (Maafi *et al*., 1998), *H. nigricornis* Mercet on *Scymnus* sp. (Lotfalizadeh and Ebrahimi, 2001), *H. ephippium* (Ruschka) on *E. quadripustulatus* (Xu and Lotfalizadeh, 2000), *H. turkmenicus* Myartseva on *Hyperaspis transversoguttata* Faldermann (Trjapitzin, 1989), *H. flaminius* (Dalman) on *Nephus bipunctatus* (Kugelann) (Fallahzadeh *et al*., 2006), *Metastenus concinnus* Walker (Hym., Pteromalidae) on *Cryptolaemus monterouzieri* Mulsant (Gharizadeh and Hesami, 2003) and *Perilitus coccinellae* (Schrank) (Hym., Braconidae) on *Coccinella septempunctata* L.

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(Bagheri, 1998). *Homalotylus flaminius* Dalman is reported as a larval parasitoid of *E. nigromaculatus* in Russia (Trjapitzin, 1989). Also, Japoshvili (2000) reported *H. flaminius* as a parasitoid of *E. quadripustulatus* in Georgia. Up to 95% parasitism of *Chilocorus bipustulatus* L. was recorded from North Africa by *H. flaminus* (Hym., Encyrtidae) and more than 90% parasitism in *Chilocorus* species around the Black Sea by a complex of *H. flaminius* and *Oomyzus scaposus* (Thomson) (Hym., Eulophidae) (Majerus, 1994). Therefore, further studies are necessary to understand better the influence of *Homalotylus* spp. on ladybird beetle population dynamics.

Ladybird beetles (Col., Coccinellidae) are the most common and best studied of the natural enemies of aphids, soft scales, armored scales, whiteflies and mites (Majerus, 1994). The coccinellids were commonly found associated with *P. vovae* in large numbers from January to August, and played a significant role in reducing the pest population.

Different species of *Hyperaspis* are predators of Homoptera, mainly scale insects (Ben-Dov and Hodgson, 1997). *P. vovae* is a new prey recorded for *H. femorata*. Whose larvae and adults were the active predators of *P. vovae* in Tehran Province.

The species of *Geocoris* sp. are generally regarded as beneficial because they prey upon numerous kinds of insect and mite pests of turf, ornamental and agricultural crops (Schuh and Slater, 1995). *G. quercicola* Linnavouri was recorded for the first time from Iran (Fars province) by Lotfalizadeh and Ahmadi (2000). It is a polyphagous predator that feeds on mealybugs and phytophagous true bugs.

Two neuropteran species, *S. pygmaeus* and *C. carnea* were collected on cypress tree mealybugs in Tehran. The brown lace wing was previously recorded as a predator of *Chromaphis juglandicola* (Kaltenbach) (Hom., Aphididae) (Talebi *et al*., 2001b) but its preying on *P. vovae* is a new record for Iran. *C. carnea* is a very common predator in nature. Only the larval stages can feed on hosts, while the adult usually feeds on nectar, honeydew and other sugar sources.

Among the natural enemies, two ladybird beetle species, *Exochomus nigromaculatus* and *E. quadripustulatus* were the major predators. Comparative biology of these two species was recently studied by Ameri (2006). Both adults and larvae were found preying on the eggs, larvae and adults of *P. vovae*. *A. pseudococci* was the most common parasitoid attacking the cypress tree mealybug. It is a solitary internal parasitoid that specializes on the citrus mealybug, the grape mealybug (Noyes and Hayat, 1994) and on the cypress tree mealybug. The adult emerges through an irregular exit hole gnawed at the posterior end of the mummy.

Ultimately, it is hoped that this study will provide a general basis for study of the natural enemies of *P. vovae* in future works.

ACKNOWLEDGEMENTS

We are most grateful to H. Boroumand and S. Serri (Plant Pests and Diseases Research Institute, Tehran) for the identification of ladybird beetle species. Dr. Z. Xu in Zhejiang University, China and H. Lotfalizadeh (Montpellier, France) kindly identified some of the encyrtid wasps. We are also thankful to five anonymous reviewers for critically reading the manuscript and providing valuable suggestions.

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دشمنان طبیعی شپشک آرد آلود سرو، *Planococcus vovae* (Nasonov) (Hom., Pseudococcidae) و پارازیتوییدهای آنها در تهران، ایران

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چکیده

شپشک آردآلود سرو، *Planococcus vovae* (Nasonov) (Hom., Pseudococcidae) یکی از مهمترین آفات سرو به ویژه زیرگونه *Cupressus sempervirens fastigiata* L. در ایران است. طی سال‌های ۱۳۸۳-۱۳۸۴ بررسی هایی در خصوص شناسایی دشمنان طبیعی شپشک آردآلود سرو در استان تهران انجام شد. در نتیجه این تحقیق ۱۷ گونه شکارگر، پارازیتویید و هیپرپارازیتویید از ۱۰ خانواده و ۱۵ جنس جمع آوری و شناسایی گردید. در میان دشمنان طبیعی مرتبط با شپشک *P. vovae* سه گونه زنبور شامل *Coccidoxenoides perminutus* Girault (Hym.:Encyrtidae)، *Aprostocetus Ceroplastae* (Girault) (Hym.: Eulophidae) و *Pachyneuron bonum* Xu and Li (Hym.: Pteromalidae) برای اولین بار از ایران گزارش می شوند. ویژگی های مرفولوژیک افتراقی گونه های جدید برای فون ایران به طور مختصر ارائه و ترسیم شده است. پراکنش جغرافیایی و اهمیت اقتصادی هر یک از دشمنان طبیعی مورد بحث قرار گرفته است.

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