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Short paper

Natural enemies of *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) and their population fluctuations in Ahvaz, southwest of Iran

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Abstract: The pink hibiscus mealybug *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) is a serious economic pest in tropical and subtropical regions and causes damage to many agricultural, forestry and greenhouse crops. In order to identify the natural enemies of this pest, bi-weekly samplings were done in infested areas of Ahvaz, located at southwest Iran during 2011-2012. Samples were also taken from Chinese hibiscus shrubs, *Hibiscus rosa-sinensis* L. at two urban areas in Ahvaz to determine the pest population fluctuations. Other infested plants were also sampled for exploring natural enemies associated with *M. hirsutus*. The identified natural enemies in this study are as follows: *Nephus arcuatus* Kapur, *Hyperaspis polita* Weise, *Hyperaspis vinciquerrae* Capra, *Exochomus nigripennis* Erichson, *Scymnus* (*Pullus*) *syriacus* Marseul (Col., Coccinellidae) – *Chrysoperla carnea* (Stephens) (Neu., Chrysopidae) – *Anagyrus* sp. (Hym., Encyrtidae). Also one parasitoid of coccinellid larvae and three species of hyperparasitoids were identified as follows: *Homalotylus quaylei* Timberlake (parasitoid of coccinellid larvae), *Prochiloneurus aegyptiacus* (Mercet), *Prochiloneurus bolivari* Mercet (Hym., Encyrtidae) and *Chartocerus kurdjumovi* (Nikol'skaya) (Hym., Signiphoridae). The coccinellid *H. vinciquerrae* is new to the fauna of Iran. The natural enemies, i.e. *N. arcuatus* and *Anagyrus* sp. had the highest populations on the host plants throughout the year.

Keywords: Mealybugs, *Maconellicoccus hirsutus*, Natural enemies, *Hyperaspis vinciquerrae*, Iran

Introduction

Mealybugs (Hemiptera: Pseudococcideae) are widely distributed in tropical and subtropical regions of the world and in temperate regions are found in greenhouses (Ebling, 1959). These pests feed on all parts of the plant (roots, stems, trunks, leaves and fruits) and cause direct and indirect damages, such as leaf and fruit drop, malformation of leaves and young shoots and transmission of some viral diseases. Development of sooty mould on infested leaves and stems is the result of heavy honeydew secretions of the mealybug (Moore, 1988). They also produce white fluffy wax which covers all developmental stages, as well as the ovisacs. The wax is protective in function and is impermeable to water and most pesticides. The presence of large quantities of wax reduces the aesthetic and commercial value of ornamentals (Kairo *et al*., 2001).

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As a typical host, *Hibiscus rosa-sinensis* is frequently attacked by pink hibiscus mealybug (PHM) *Maconellicoccus hirsutus* (Green) (Anonymous, 2005). During February 2009, this mealy bug was collected on the ornamental plant *H. rosa-sinensis* for the first time in Ahvaz, SW Iran, and was identified by Dr. C. J. Hodgson (National Museum of Wales, UK). The host plant is an ornamental shrub with large and ruddy flowers that is commonly planted in urban landscapes of Ahvaz.

The damage due to this mealybug is so severe that the shrubs in some regions of Ahvaz die and fall off. This pest has spread in several areas of Ahvaz, in less than one year. It seems that some factors such as wind, insects that feed on honeydew secretions of the mealybug, presence of ever-green hosts and their abundance may affect the distribution of the pest. PHM is considered as a serious threat to urban landscapes of Ahvaz. Chemical control is not effective on mealybugs, since they show resistance to various pesticides (Grasswitz and Burts, 1995). In addition, achieving acceptable levels of chemical control is hindered by the mealybugs' tendency to feed in protected sites (leaf axils, crevices at the base of shoots, etc.), where they are hard to reach with insecticides (Grasswitz and Burts, 1995). Chemical control also destroys the useful insects (natural enemies and honey bees).

Biological control of mealybugs, in contrast, can be completely successful if carried out properly. Features such as soft body, slow movement and most importantly, feeding in groups, make these pests easy preys (Ebling, 1959). The aim of this study was to identify the natural enemies of PHM and their activity periods in urban landscapes of Ahvaz, Southwest Iran.

Material and Methods

In order to determine the natural enemies of PHM, samples were taken from the infested plants in Ahvaz during 2011-2012. At first step, by shaking the infested branches on a white tray, observed natural enemies were collected, using an aspirator. Then some of the infested branches were cut and kept in ventilated containers for 3 weeks to collect emerging natural enemies (especially parasitoids). The emerged natural enemies were transferred to test tube containing 75% ethanol. Specimens were identified as level as possible according to available keys and resources (e. g. Raimundo and Van Harten, 2000; Noyes and Hayat, 1994).

To determine the population fluctuation of natural enemies of *M. hirsutus* at Ahvaz, bi-weekly samplings were carried out on Chinese hibiscus shrubs at two distinct areas, about 3 kilometers apart: sampling area 1- Residential area of Water and Power Authority, and sampling area 2- College of Agriculture at Shahid Chamran University campus. In each sampling date, five shrubs were selected randomly, from each of which eight twigs, each five cm long, were cut from the upper and lower halves of each quadrant (north, west, south and east). Samples were transferred to the laboratory in separate labeled plastic bags. The content of each bag was kept in a separate ventilated container with the sampling data, for three weeks and the containers were checked daily for the appearance of natural enemies. Emerged natural enemies were identified and counted according to their species. Some unwanted changes (e.g. spraying the soil around the shrubs and cultivation of sunflowers under the shrubs) took place in the sampling area 1 which will be elaborated on, in the discussion section. At least half of the materials examined for each species were deposited at Insect and Mite Collection of Ahvaz (IMCA), Department of Plant Protection, Shahid Chamran University of Ahvaz and the rest were sent to Dr. Hayat, Dr. Noyes and Dr. Fursch for final identification / confirmation.

Results

In this study, a total of seven species belonging to three orders and three families of natural enemies; one parasitoid of coccinellid larvae and three species of hyperparasitoids were collected and identified as follows:

1. *Nephus arcuatus* Kapour (Col.: Coccinellidae)
Material examined: 95 ♀, 88 ♂, May 1 – September 4, 2011, May 13 – July 8, 2012, Sampling area 1; 8 ♀, 10 ♂, May 19 – August 11, 2011, New side area; 106 ♀, 103 ♂, May 1 – September 18, October 30 and November 13, 2011, May 13 – July 8, 2012, Sampling area 2.
Distribution: Yemen, Saudi Arabia (Raimundo and van Harten, 2000) and Iran (Löbl and Smetana, 2007; Mossadegh *et al*., 2012).
Remarks. This parasitoid has been reported as the predator of *Phenacoccus solenopsis* Tinsely (Mossadegh *et al.*, 2012).

2. *Hyperaspis polita* Weise (Col.: Coccinellidae)
Material examined: 2♀, 1♂, July 10, 2011; 1♀, August 21, 2011; 1♂, May 27, 2012, Sampling area 1; 1♀, June 12, 2011; 2♀, July 10, 2011; 1♀, October 2, 2011; 1♀, 1♂ June 10, 2012; 2♂ July 8, 2012, Sampling area 2.
Distribution: Lebanon and the coastal areas of the Eastern Mediterranean region, Turkey to Pakistan and dry regions in South Western Asia (Fursch, 2012, personal communication) and Iran (Montazeri and Mossadegh, 1995).
Remarks. It has been recorded as a predator of the mealybug *Nipaecoccus viridis* (New.) (Asadeh and Mossadegh, 1991, Mossadegh and Kocheili, 1993, Novin, 2000 and Hesami and Fallahzadeh, 2004), *M. hirsutus* (Fallahzadeh and Hesami, 2004), *Planococcus ficus* (Signoret) (Fallahzadeh *et al*., 2008) and *Ph. solenopsis* (Mossadegh *et al.*, 2012).

3. *Hyperaspis vinciquerrae* Capra (Col.: Coccinellidae) (Fig. 1)
Diagnostic characters: Length: 2.8-3.2 mm. Body oval, somewhat convex; head dark in female, testaceous in male; pronotum black**,** with whitish yellow lateral margins in female and uniformly black in males; elytra dark brown to black, with bright spots untied to meridional bands that join at elytra base; some specimens show, at elytra centre, three separate spots in a meridional row; others may represent a transitional form. Male genitalia with parameres slightly longer than basal lobe; siphonal tip without special characteristics (Raimundo and van Harten, 2000)**.**
Material examined: 3♀, June 26, 2011; 1♂, June 10, 2012; 1♀, 1♂, July 8, 2012, Sampling area 2.
Distribution: Libya, northern and eastern Africa, Yemen and Saudi Arabia (Raimundo and Van Harten, 2000)**.**
Remarks. First record from Iran (this study).

Figure 1 The coccinellid beetle *Hyperaspis vinciquerrae* (Col. Coccinellidae), new record for Iranian fauna.

4. *Exochomus nigripennis* (Erichson) (Col.: Coccinellidae)
Material examined: 2 ♀, 1 ♂, April 17, 2011, Sampling area 1.
Distribution: Armenia, Azerbaijan, Canary Islands, Egypt, Georgia, Iraq, Iran, Jordan,

Lebanon, Malta, Sicily, Turkey, and North Africa (De Jong, 2011).

Remarks. It has been recorded as predator of *M. hirsurus* (Fallahzadeh and Hesami, 2004), *N. viridis* (Hesami and Fallahzadeh, 2004), and *Ph. solenopsis* (Mossadegh *et al.*, 2012).

5. *Scymnus* (*Pullus*) *syriacus* Marseul (Col.: Coccinellidae)

Material examined: 2♀, May 29, 2011, Sampling area 1; 2♀, May 19, 2011, 3 ♂, June 2, 2011, New side area; 2♀, May 13, 2012, 2♀,1♂, May 27, 2012, 1♀,2♂, June 10, 2012, 1♂, June 24, 2012, 2♀, July 8, 2012, Sampling area 2.

Distribution: Eastern Mediterranean region especially Jordan, Lebanon, Turkey, Libya. Arabia, Yemen and Egypt (Fursch, 2012, personal communication) and Iran (Montazeri and Mossadegh, 1995).

6. *Chrysoperla carnea* Stephens (Neuroptera: Chrysopidae)

Material examined: 42 larvae, May 1 – June 26, 2011 and 2012, Sampling area 1; 2 Larvae, April 17, 2011, New side area; 30 Larvae, May 1 – June 26 and October 30, 2011 and May 1 – June 10, 2012, Sampling area 2.

Distribution: It is found in many parts of North America, Europe and Asia (Iqbal *et al*., 2011).

Remarks. It has been recorded as predator of *N. viridis* (Novin *et al.*, 2000) and *Ph. solenopsis* (Mossadegh *et el*., 2012). Larval stages of this species were observed feeding on young nymphs of *M. hirsutus* in spring.

7. *Anagyrus* sp. (Hym.: Encyrtidae)

Material examined: 42♀, 38♂, May 13 – July 8, 2012, Sampling area 1; 7♀,4♂, September 18, 2011, New side area; 69♀, 76♂, October 3 – November 28, 2011 and April 30 – June 24, 2012, Sampling area 2.

Remarks. This species is probably new to science (Noyes, 2012 Personal Communication).

8. *Homalotylus quaylei* Timberlake (Hym.: Encyrtidae)

Material examined: 1♀, May 13, 2012, Sampling area 1; 1♀, June 16, 2011, 2♀, June 30, 2011, 2♀, July 14, 2011, New side area; 2♀, June 26, 2011, 3♀, July 10, 2011, 1♀ August 7, 2011. 2♀ September 18, 2011, 1♀, May 13, 2012, 1♀, June 10, 2012, 4♀, June 24, 2012, 1♀, July 8, 2012, Sampling area 2.

Distribution: Armenia, Azerbaijan, Brazil, Bulgaria, Canary Islands, Egypt, Georgia, India, Italy, Jordan, Sicily, Spain, Turkey, Turkmenistan, Uzbekistan, Venezuela (Noyes, 2003) and Iran (Asadeh and Mossadegh, 1991).

Remarks. It has been recorded on *Nephus includens* Kirsch (Col.: Coccinellidae) associated with *N. viridis* (Asadeh and Mossadegh, 1991 and Novin *et al.*, 2000), on *N. arcuatus* Kapour Col.: Coccinellidae) (Zarghami *et al*., 2012) and on *Scymnus subvillosus* (Goeze) (Col.: Coccinellidae) associated with *Planococcus citri* (Risso) (Hem.: Pseudococcidae) (Mafi *et al*., 1998).

9. *Prochiloneurus aegyptiacus* (Mercet) (Hym.: Encyrtidae)

Material examined: 13♀, May 13 – June 24, 2012, Sampling area 1; 4♀, June 16, 2011, New side area; 13♀, May 27 – July 8, 2012, Sampling area 2.

Distribution: Afghanistan, Ethiopia, Egypt, India, Iraq, Italy, Nigeria, Turkmenistan, Tanzania, Yugoslavia, North and South Africa (Noyes, 2003) and Iran (Hesami and Fallahzadeh, 2004).

Remarks. It has been recorded as a Parasitoid of *Anagyrus* spp. (Hym.: Encyrtidae) (Hesami and Fallahzadeh, 2004) and hyperparasitoid of *M. hirsutus* (Fallahzadeh *et al.*, 2008).

10. *Prochiloneurus bolivari* Mercet (Hym.: Encyrtidae)

Material examined: 1♀, June 24, 2012 Sampling area 1; 1♀, July 14, 2011, New side area; 9♀, June 11, 2012, Sampling area 2.

Distribution: Afghanistan, Algeria, Armenia, Azerbaijan, Bulgaria, Congo, Former Czechoslovakia, Egypt, Finland, France, Georgia, Hungary, Italy, Japan, Moldova, Mongolia, Nigeria, Poland, Rumania, Russia,

Slovakia, South Africa, Spain, Sweden, Turkmenistan, United Kingdom, Uzbekistan, Former Yugoslavia (Noyes, 2003) and Iran (Fallahzadeh *et al.*, 2008).

Remarks. It has been recorded on *P. ficus* (Fallahzadeh *et al.*, 2008).

11. *Chartocerus kurdjumovi* (Nikol'skaya) (Hym.: Signiphoridae)

Material examined: 19♀, May 13 – July 8, 2012, Sampling area 1; 3♀, July 14, 2011, New side area; 13♀, May 13 – July 8, 2012, Sampling area 2.

Distribution: Central Asia, Hungary, India, Italy, Moldova, Russia, Sicily and Ukraine (Noyes, 2003) and Iran (Asadeh and Mossadegh, 1993).

Remarks. This species has been recorded as hyperparasitoid of *N. viridis* (Asadeh and Mossadegh, 1993 and Novin, 2000) and *P. ficus* (Fallahzadeh *et al*., 2008).

Discussion

In this study the coccinellid *N. arcuatus* was found to be the most important predator of PHM in Ahvaz. Other coccinellids were also observed, but with low populations and during a short period. Hesami and Fallahzadeh (2004) reported eight species of coccinellids as predators of PHM in Jahrom region (Fars province), of which two species (*E. nigripennis* and *H. polita*) were also collected in this research. According to their study, *E. nigripennis* had high population, but in our study we collected this coccinellid only once on April 17, 2011. They also collected five parasitoid species on *M. hirsutus*. We collected an *Anagyrus* sp., which is probably a new species for the science (Noyes, 2012, personal communication). It seems that *N. arcuatus* plays a considerable role in reducing mealybug populations under the conditions of our study. The coccinellid *N. arcuatus* started to build up activity from early May (Figs. 2 and 3). Its feeding on eggs as well as on first and second instars of PHM was observed in laboratory and in the field. Thereafter, the population of *N. arcuatus* decreased with decreasing of pest population (Figs. 2 and 3). In the fall, as population of the pest began to increase due to favorable conditions, the parasitoid *Anagyrus* sp. began to build up its population (Fig. 2). It seems that *Anagyrus* sp. suppressed the pest population because the populations of the pest and its parasitoid changed in the reverse order. During winter, neither pest nor natural enemy was found in the samples. In the spring of 2012, *N. arcuatus* and *Anagyrus* sp. were observed together and in high populations (Figs. 2 and 3). It is good to note that on September 24, 2011, the stems of the shrubs and the soil surrounding them were sprayed (by the authorities of the residential area) against ants associated with PHM, thinking that control of the ants may lead to increase in natural enemies' activities. However, in a similar way spraying the soil around the trunk and crown of citrus in Dezful against symbiotic ants with *N. viridis* increased *Cryptolaemus montrouzieri* Mulsant activity (Mossadegh *et al*., 2008). Cultivation of sunflowers under the bushes as trap plant on August 21, 2011, helped change the preference of the mealybug to sunflower plants over the Chinese hibiscus plants which were dried up due to excessive hot weather and pest infestation. Finally, eliminating sunflowers caused a drastic reduction of the pest population, and consequently reduced the population of natural enemies (Figs. 3 and 5). Also pruning of shrubs on December 11, 2011, had little effect on subsequent reduction of pest and natural enemies' populations. (Figs. 3 and 5). Populations of the coccinellids *H. polita* and *S. syriacus* were lower than *N. arcuatus*. These cocclinellids had also lower population at Sampling area 1 compared to Sampling area 2 in spring 2012 (Figs. 4 and 5). All these natural enemies, maybe effective in control of PHM, but it seems that *N. arcuatus* and *Anagyrus* sp. due to high population and longer periods of activity could be more effective than the other natural enemies and could be mass produced for biocontrol of this mealybug. This, however, requires further investigation.

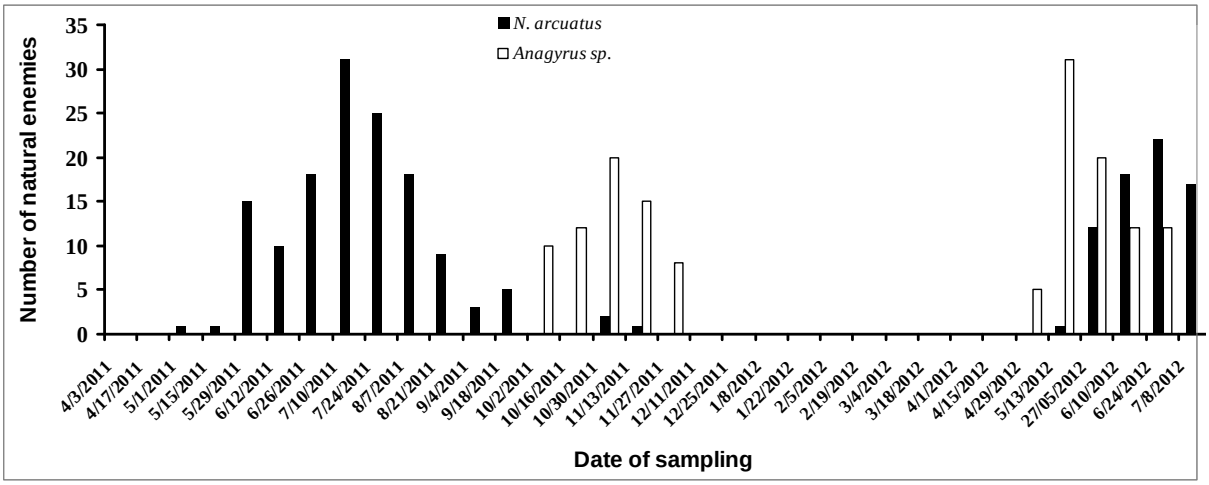

Figure 2 Population fluctuations of natural enemies (*Nephus arcuatus* and *Anagyrus* sp.) of *Maconellicoccus hirsutus* in 2011-2012, at sampling area 2.

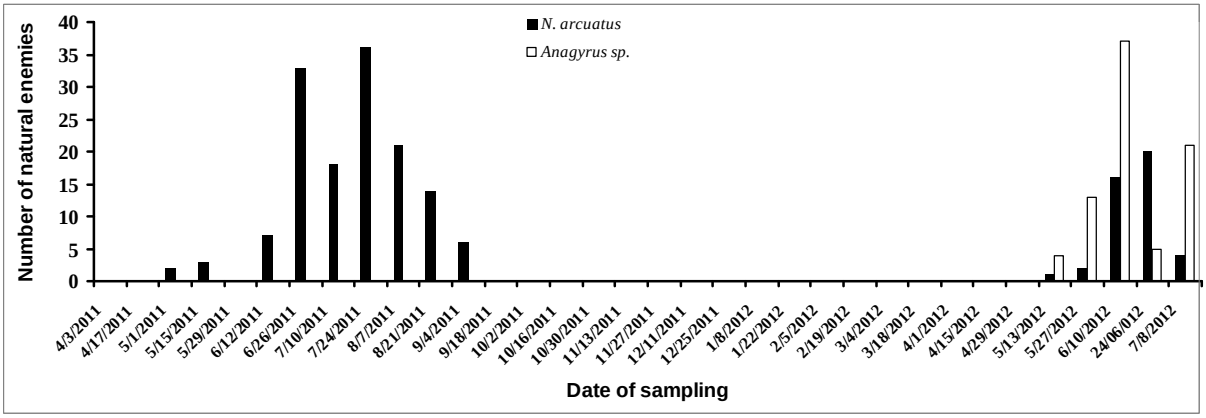

Figure 3 Population fluctuations of natural enemies (*Nephus arcuatus* and *Anagyrus* sp.) of *Maconellicoccus hirsutus* in 2011- 2012, at sampling area 1.

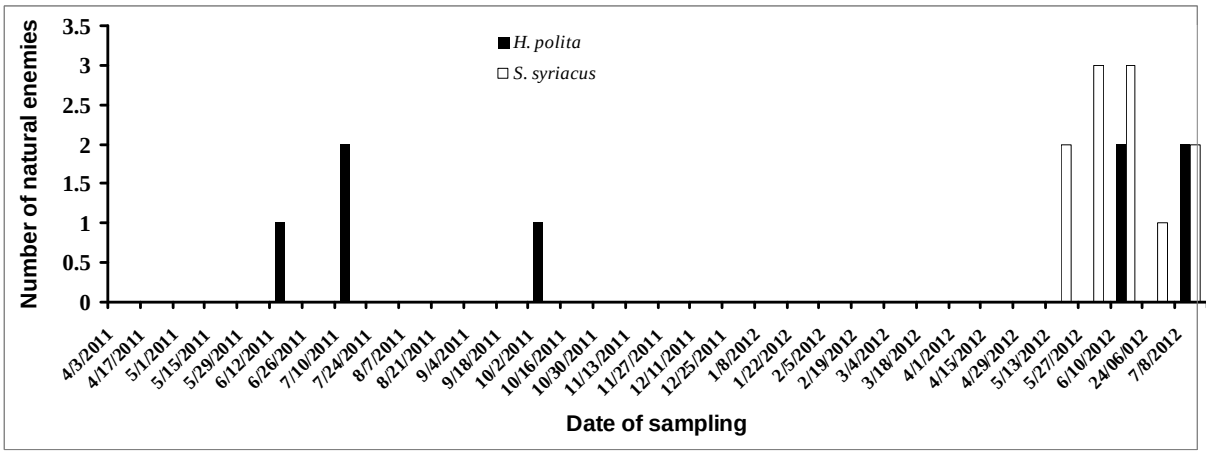

Figure 4 Population fluctuations of natural enemies (*Hyperaspis polita* and *Scymnus syriacus*) of *Maconellicoccus hirsutus* in 2011-2012, at sampling area 2.

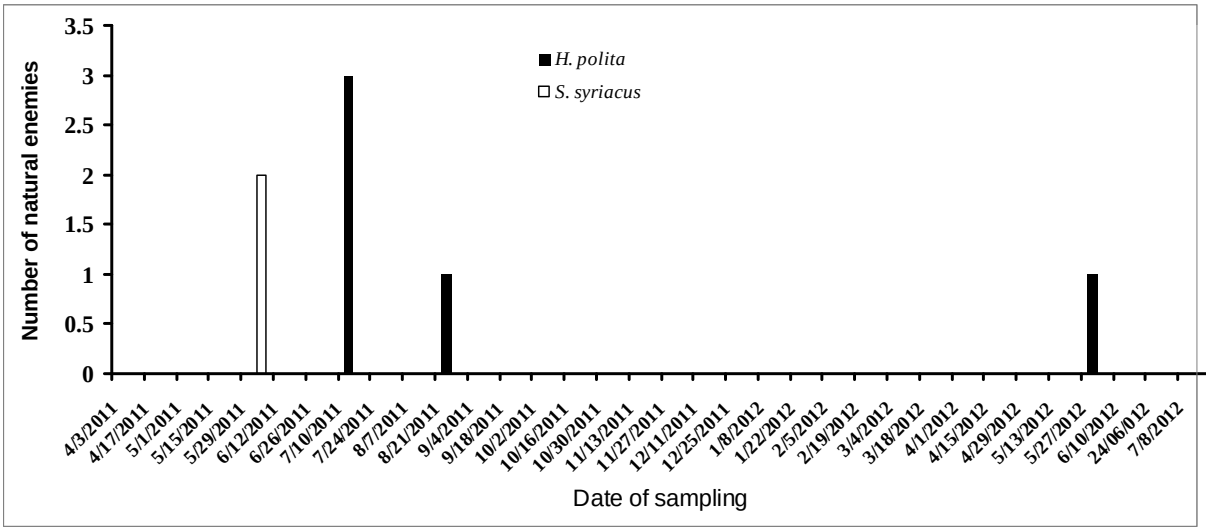

Figure 5 Population fluctuations of natural enemies (*Hyperspis polita* and *Scymnus syriacus*) of *Maconellicoccus hirsutus* in 2011- 2012, at sampling area 1.

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دشمنان طبیعی شپشک آردآلود صورتی (Green) *Maconellicoccus hirsutus* و تغییرات جمعیت آن‌ها در اهواز

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چکیده: شپشک آردآلود صورتی *Maconellicoccus hirsutus* (Green) یک تهدید اقتصادی جدی در مناطق گرمسیری و نیمه‌گرمسیری است و به بسیاری از محصولات کشاورزی، جنگلی و گلخانه‌ای خسارت می‌زند. به‌منظور شناسایی دشمنان طبیعی این آفت در سال‌های ۹۱-۱۳۹۰ هر دو هفته یک‌بار از نقاط آلوده در اهواز نمونه‌برداری صورت گرفت. جهت تعیین تغییرات انبوهی دشمنان طبیعی شپشک از درختچه‌های ختمی‌چینی نیز در دو منطقه در اهواز به همین صورت نمونه‌برداری انجام شد. همچنین به‌منظور جستجوی دشمنان طبیعی از سایر گیاهان آلوده نیز نمونه‌برداری انجام شد. دشمنان طبیعی شناسایی شده در این بررسی به شرح زیر است:
Nephus arcuatus Kapur, *Hyperaspis polita* Weise, *Hyperaspis vinciquerrae* Capra, *Exochomus nigripennis* Erichson, *Scymnus* (*Pullus*) *syriacus* Marseul (Col., Coccinellidae) _ یک *Chrysoperla carnea* (Stephens) (Neu., Chrysopidae) – *Anagyrus* sp. (Hym., Encyrtidae).
پارازیتوئید لارو کفشدوزک و سه هیپرپارازیتوئید نیز به شرح زیر شناسایی شد:
Homalotylus quaylei Timberlake پارازیتوئید لارو کفشدوزک *Prochiloneurus aegyptiacus* (Mercet), *Prochiloneurus bolivari* Mercet (Hym., Encyrtidae) و *Chartocerus kurdjumovi* (Nikol'skaya) (Hym., Signiphoridae).
از این میان گونه‌ی *H. vinciquerrae* برای فون ایران جدید بود. در بین دشمنان طبیعی جمع‌آوری شده، کفشدوزک *N. arcuatus* و زنبور *Anagyrus* sp. بیشترین جمعیت و تولیدمثل را در طول سال روی درختچه‌های آلوده به شپشک داشتند.

واژگان کلیدی: شپشک‌های آردآلود، *Maconellicoccus hirsutus*، دشمنان طبیعی، *Hyperaspis vinciquerrae*، ایران