Chapter

Aphid on Almond and Peach in Tunisia: Species, Bioecology, Natural Enemies and Control Methods

Lassaad Mdellel, Rihem Adouani and Monia Ben Halima Kamel

Abstract

Aphids are among the most obnoxious pests of almond and peach in Tunisia. Accurate control of these insect pests requires the determination of their major species as well as the thorough understanding of the biology and identification of their major natural enemies. The scope of this chapter is to identify the main aphid species infesting almond and peach in Tunisia, to describe their biology, to determine their natural enemies and to study their efficiency as biological agents. A field survey was carried out during 2007–2016 period at Almond and Peach orchards in Tunisia. Results demonstrated the presence of *Hyalopterus pruni* Geoffroy, *Hyalopterus amygdali* Blanchard, *Brachycaudus amygdalinus* Schouteden, *Myzus persicae* Sulzer, *Brachycaudus schzartwi* Borner and *Pterochloroides persicae* Cholodkovsky. Biological study of recorded species demonstrated the presence of holocyclic and anholocyclic life cycle depending on host trees and aphid species. For predators, four families (Coccinellidae, Syrphidae, Chrysopidae, Cecidomyiidae) and one parasitoid and two entomopathogenic fungi species were identified. For control of *Pterochloroides persicae*, results showed that *Pauesia antennata* Mukergi was more efficacy than *Coccinella algerica* Kovar. This parasitoid should be reared and used in future integrated pest management program in almond and peach orchard in Tunisia.

Keywords: almond, peach, aphids, biology, predators, parasitoids

1. Introduction

Peach and almond are being considered as the most important fruit trees in Tunisia covering more than 22714.5 and 22139.9 hectares, respectively [1]. These fruit trees are tolerant to stress conditions (salinity, water deficiency) and still bear good yields. Nevertheless, a wide range of insect pests infest almond and peach trees reducing yield's quantity and quality. Among them, *Ceratitis capitata* Wieddeman (Diptera; Tephritidae), *Ruguloscolytus amygdali* Guerin (Coleoptera; Scolytidae) and aphids are considered as the major insect pests that affect almond and peach [2–8]. Of them, aphids are considered as the most destructive [3–5]. There are sap-sucking insects, which feed in colonies, cause

yellow leaf spots and deformity in leaves and flowers, transmit viruses, exude honeydew upon which sooty mold grows, but it also attracts ants. The ants, in return for the honeydew, they facilitate dissemination of aphids and carry wingless form to the trees carried the aphids to the trees when they are wingless [9–11]. In Tunisia, *Myzus persicae* Sulzer, *Hyalopterus pruni* Geoffroy, *Brachycaudus amygdalinus* Schouteden and *Pterochloroides persicae* Cholodokovsky are the most common aphid species that infest peach and almond [5–7, 12, 13]. Currently, protection of peach and almond orchards is mainly achieved by preventive and intensive chemical control. However, excessive pesticide misuse and selection of inappropriate active ingredients result in more crop diseases, auxiliary fauna destruction and environmental pollution. For that reason, selection of resistant cultivars and use of aphids' natural enemies (predators, parasitoids, entomopathogens) as pest-control alternatives probably provide the best long-term solution for aphid pest control [14–16]. Aphid biological control programs need the choice of natural enemy (predator, parasitoid, entomopathogen) based on their efficacy and climate adaptation and specificity. Some species of ladybird, hoverfly, ladybird, hover fly, green lacewing, true bugs and wasps are known as aphid natural enemies and considered as potential biological agents.

In Tunisia, extensive traditional growth of almond and peach trees in large cultivated areas can result in a flourishing habitat for attracting several aphid species and their natural enemies. In this chapter, we define the composition of aphid fauna and their natural enemies on almond and peach in Tunisia, and describe bioecology of defined aphid species and control methods of *P. persicae* using *Coccinella algerica* (Coleoptera; Coccinellidae) and *Pauesia antennata* (Hymenoptera; Lachninae).

2. Survey of aphid species in almond and peach trees

This study was held in 11 sites of north, center and south of Tunisia, where wild almonds and peach distributed there. This study lasted ten years: 2006 until 2016,

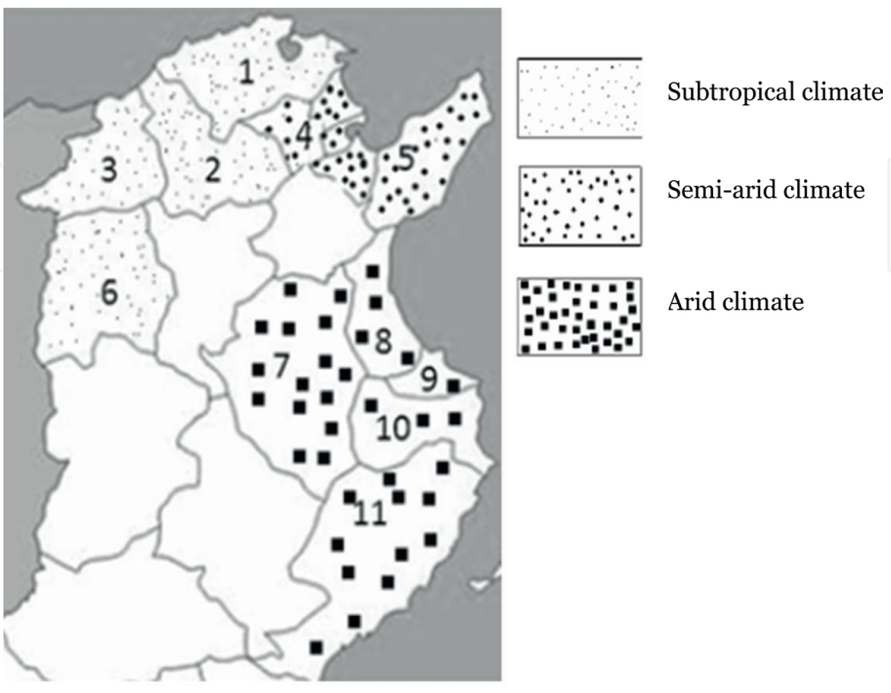

Figure 1.
Tunisia map representing sites of study.

throughout the aphid injury presence on almonds and peach. Several almond and peach varieties have been chosen (**Figure 1**).

3. Aphids species on almond and peach in Tunisia

Aphid species were identified according to Blackman and Eastop and using taxonomy keys [17–19]. Our results demonstrated the presence of six species that belonged to the Aphidinae and Lachninae subfamilies. For the Aphidinae, species *Hyalopterus pruni* Geoffroy (**Figure 2A** and **B**), *Hyalopterus amygdali* Blanchard (**Figure 2C** and **D**), *Brachycaudus amygdalinus* Schouteden (**Figure 2E** and **F**), *Brachycaudus schwartzi* Borner (**Figure 2G** and **H**) and *Myzus persicae* Sulzer (**Figure 2K** and **L**) were identified. These species usually feed on the young leaves almond and peach causing a stunted growth [20]. For Lachninae, we identified only the *Pterochloroides persicae* Kolodkovsky species that attacks the bark and trunk of almond and peach trees (**Figure 2I** and **J**) [20–24]. Of them, *H. pruni*, *M. persicae* and *P. persicae* are the most abundant species causing extensive damages on peach and almond [5, 6, 7, 13]. In Egypt and Syria, similar studies on almond and peach demonstrated the presence of the same species that were identified in this work [25–27]. Other aphid species (*Aphis gossypii* Glover, *Macrosiphum rosae* L., *Brachycaudus prunicola* Kaltenbach, *Aphis spiraecola* Patch, *Brachycaudus helichrysi*

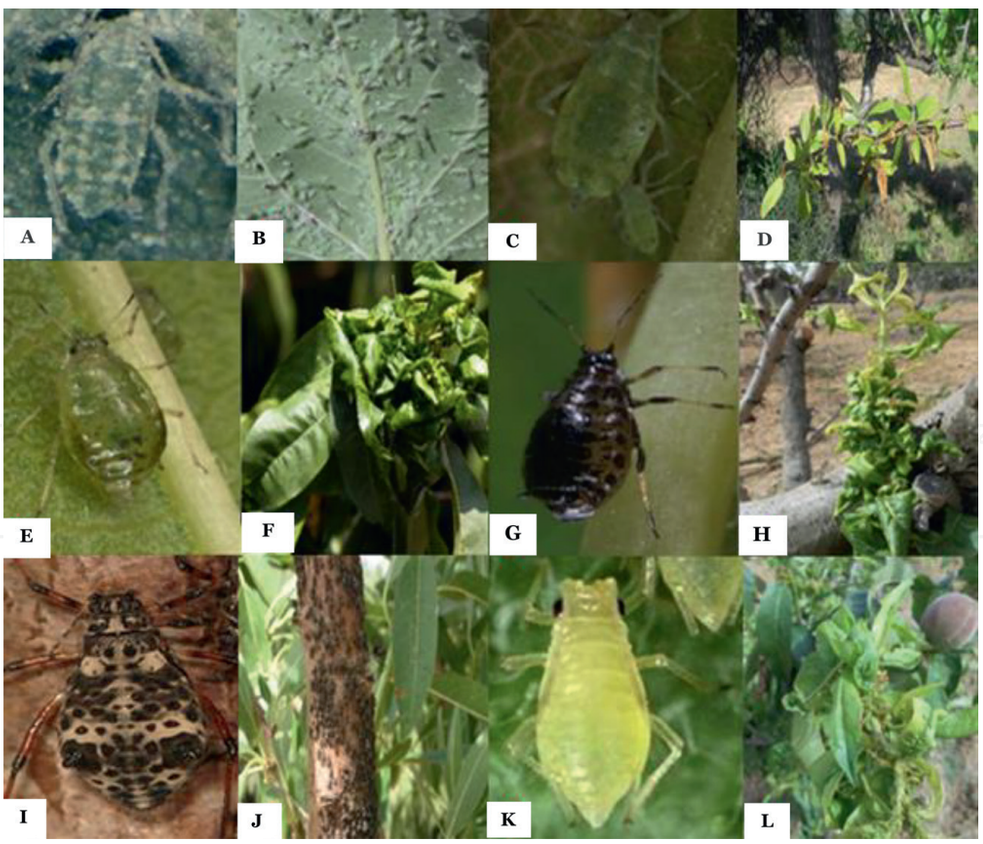

Figure 2.
Aphid species on almond and peach in Tunisia. (a: Hyalopterus pruni, *b:* Hyalopterus pruni *on almond leaf, c:* Hyalopterus amygdali, *d: Symptoms of* Hyalopterus amygdali *attack on almond, e:* Brachycaudus amygdali, *f: Symptoms of* Brachycaudusamygdalinus *attack on almond, g:* Brachycaudus schwartzi, *h: Symptoms of* Brachycaudus schwartzi *attack on peach, i:* Pterochloroides persicae, *j:* Pterochloroides persicae *population on peach trunk, k:* Myzus persicae, *l: Symptoms of* Myzus persicae *attack on peach).*

Kaltenbach, *Brachycaudus persicae* Passerini, *Brachycaudus schwartzi* Borner, *Hysteroneura setariae* Thomas, *Macrosiphum euphorbiae* Thomas, *Myzus cerasi* Fabricius, *Myzus varians* Davids and *Hyalopterus persikonus* M. were also observed on peach and almond) could be observed on almond and peach and classified as rare [13, 28–30].

4. Aphids bioecology infesting peach and almond trees in Tunisia

Biology of infestation of different species that were identified in this study was recorded during the four seasons of each year. For *Hyalopterus* species, an ovoid green egg (**Figure 3**) was observed around dormant buds of almond and peach during November, December and January [20]. *Hyalopterus* was also observed on herbaceous plant *Phragmites spp* (Poales; Poaceae) in the rivers. This indicated that *Hyalopterus* species were dioeciously holocyclic, colonizing peach and almond as primary hosts and *Phragmites spp.* as secondary host. For the green peach aphid (*M. persicae*), ovoid and white eggs were found around dormant buds and the trunks of peach (**Figure 4**). The presence of eggs of *M. percicae* on dormant buds and trunks proved their holocyclic life cycle. Results considering egg-laying period were similar to those of the Jerraya's [4, 5]. However, Hulle et al. [31] showed that eggs of *M. persicae* were shiny black. However, Strathdee et al. [32] demonstrated that color of fertilized eggs can change. Holocyclic life cycle of *M. persicae* was demonstrated in several others studies [4, 5, 31]. In contrast, on herbaceous plants, only viviparous parthenogenetic females of *M. percicae* are present throughout the year (anholocyclic life cycle) [33, 34]. It is also an heteroecious holocyclic specie [35]. The study on *B. amygdalinus* bioecology showed that almond is the preferential host for this aphid species compared with the peach tree ones. This aphid is holocyclic dioecic, which was

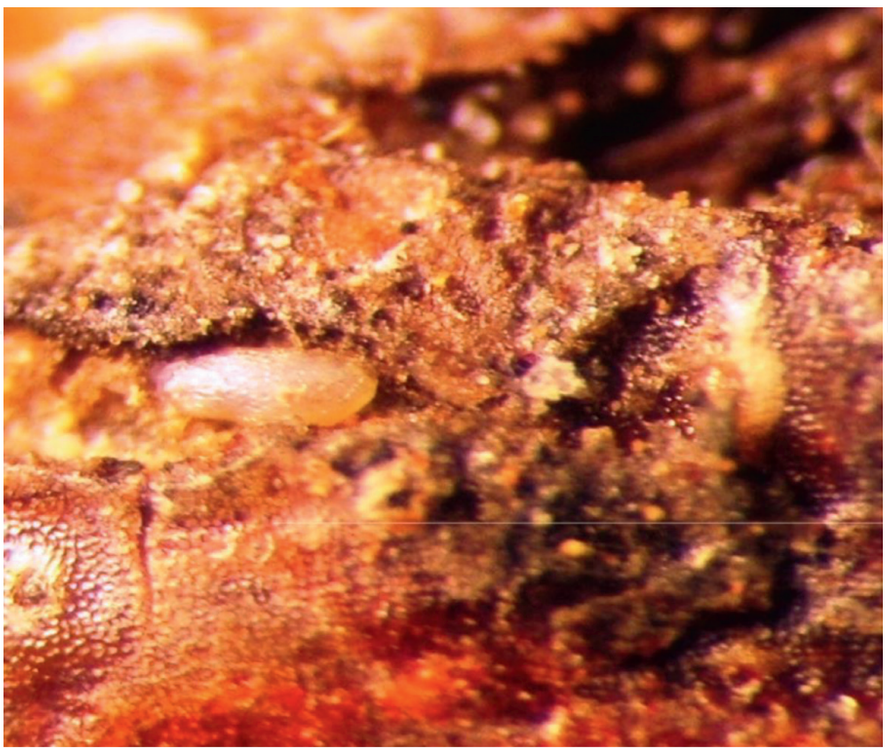

Figure 3.
Hyalopterus pruni *egg.*

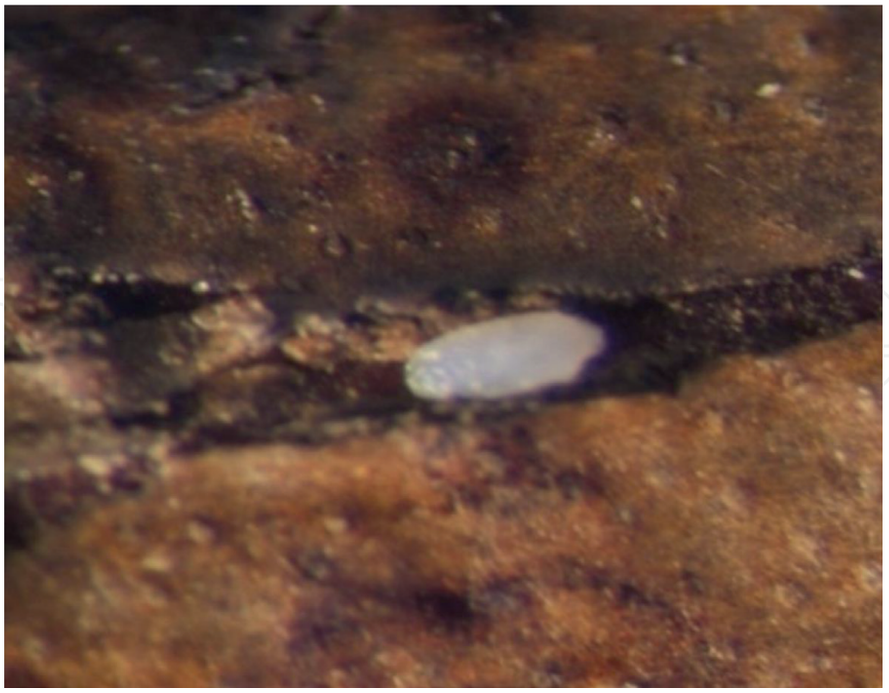

Figure 4.
Myzus persicae *egg.*

observed on different spontaneous plants such as *Polygonum persicaria* (Caryophyllales; Polygonaceae) [31]. *B. schwartzi* was observed infesting both almond and peach without preference. *P. persicae* was observed on different parts of peach and almond (root, trunk, branch), and it is a parthenogenetic species in temperate regions and holocyclic species in cold regions [21]. Anholocyclic cycle of *P. persicae* in Tunisia was demonstrated in several studies [6, 13, 36]. In other countries, the anholocyclic cycle of this species was demonstrated [26, 37, 38]. The holocyclic cycle was also demonstrated [19, 39, 40].

5. Aphids natural enemies

Our survey on aphid taxonomy infestating almond and peach orchards in Tunisia revealed the co-existence of a wide range of natural enemies living in the same habitat. Insect natural enemies were collected and identified in laboratory according to Le Monnier and Livory [41], Chandler [42], Rotheray [43], Stary [44] and Lawrence [45]. Our results demonstrated the presence of four families of predators (Coccinellidae, Cecidomyiidae, Syrphidae and Chrysopidae). For Coccinellidae, we identified the following species *Coccinella algerica* Kovar (Coleoptera; Coccinellidae) (**Figure 5**), *Hyppodamia variagata* Goeze (Coleoptera; Coccinellidae) and *Scymnus apetzi* Mulsant (Coleoptera; Coccinellidae). Concerning population abundance, *C. algerica* is the most popular predator of the lady beetle species observed near all aphid colonies [20]. For Syrphidae family, *Episyrphus balteatus* De Geer (Diptera; Syrphidae) larvae (**Figure 6**) and adults (**Figure 7**) and *Metasyrphus carollae* Fabricius adult (**Figure 8**) were the two identified species. Larvae of *Aphidoletes aphidimyza* (Diptetra, Cecidomyiidae) (**Figure 9**) were the observed ear populations of *Hyalopterus species*, *M. persicae* and *P. pericae*. *Chrysoperla carnea* Stephens eggs and larvae were observed on aphid colonies at the end of April, May and June (**Figure 10**). *Aphidius transcaspicus* Telenga (Hymenoptera: Braconidae) (**Figure 11**) was the only identified parasitoid species on *Hyalopterus* species.

Figure 5.
Coccinella algerica *Kovar.*

Figure 6.
Syrphid larva on Pterochloides persicae *population.*

Figure 7.
Episyphus balteatus *Degeer.*

Figure 8.
Metasyrphus carollae *Stephens.*

Figure 9.
Aphidoletes aphidimiza *larva.*

Figure 10.
Chrysoperla carnea *larva.*

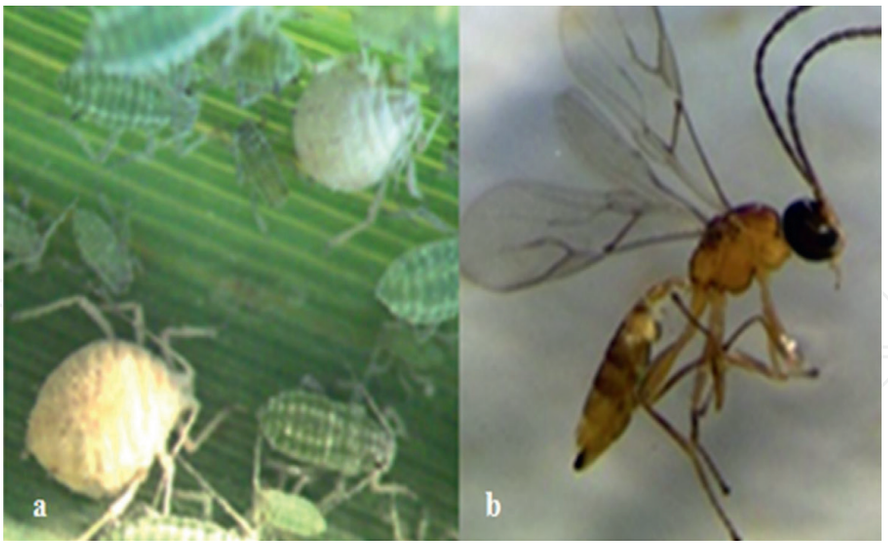

Figure 11.
Aphidius transcaspicus *Telenga. a): mummies, b) adult.*

Entomopathogenic fungi naturally infecting *P. persicae* were collected and identified according to Humber [46] and Barnett and Hunter [47]. Two entomopathogenetic fungus were identified: *Beauveria bassiana* (Balsamo) Vuillemin (Ascomycota: Hypocreales, *Cordycipitaceae*) and *Metacordyceps liangshanensis* (Ascomycota: Hypocreales, *Clavicipitaceae*) [48]. In the word, *Capnodium spp*. in Central Asia and *Entomophthora thaxteriana* (Entomophthorales; Entomophthoraceae) were also identified on *P. persicae* population [47].

6. Control methods

6.1 Efficiency of *Coccinella algerica* Kovar

Efficiency of *C. algerica* to control *P. persicae* under laboratory conditions was studied. *C. algerica* eggs were collected. Emerged larva was separated and placed in test tube. Each larva instar was fed with *P. percicae* adults. Results demonstrated that the mean predation rate of *C. algerica* larvae during larval development time (9.8 ± 4.8 days) was of 30.13 ± 1.65 individuals of adult *P. persicae*. Of them, 72.3% were consumed by the first and second instar. Adults consumed daily 9.18 ± 0.088 *P. persicae* individuals. As for the efficiency of natural enemies, the predation of *P. persicae* by fourth instar larvae and adults of *C. algerica* demonstrated that both larvae and adults feed successfully on *P. persicae*. Several works demonstrated that predation rate of *C. septempunctata*, which is similar to *C. algerica* in morphology and biology [49], reared on *A. gossypii* in the same conditions of temperature and photoperiod was 9.7 aphids per day [50].

6.2 Efficiency of *Pauesia antennata* Mukerji (Hymenoptera, Braconidae, Aphidiinae)

P. persicae mummies were collected at May/2011 from almond trees from Iran and imported to entomology laboratory of Higher Agronomic Institute of Chott Mariem,

Chott Mariem, Sousse, 4042, Tunisia. Emerged parasitoids were reared and efficiency was studied. Results demonstrate that longevity of adult parasitoids is of 3 to 4 days. Cross and Poswal [51] showed that *P. antennata* has a very short life span (5–6 days). Longevity of *P. antennata* seems much shorter than that of *Aphidius ervi* Haliday, which was 12.29 ± 0.43 days at 20°C [52]. Parasitism and emergence rates were of 40.5 ± 12.4% and 36.4 ± 17.2%, respectively. The study of impact of aphid density on parasitism and emergence rates demonstrated that parasitism and emergence rates decreased by increasing aphid densities (45 ± 16.1, 36.4 ± 9.9 and 27.5 ± 8.1, for the three densities of *P. persicae*, D1 (50 aphids), D2 (100 aphids), and D3 (150 aphids), respectively). Similarly, emergence rate decreased when aphid density increased (40.8 ± 1.6, 31.2 ± 11.2 and 27.3 ± 12.2 on D1, D2 and D3 densities respectively). The study of aphid's population effect on *P. antennata* parasitism rate demonstrated that, upon introduction of one couple of *P. antennata*, parasitism and emergence rates decreased when the aphid population densities were high (D2 and D 3). Similar results were demonstrated for *Aphidius ervi* when the mean number of parasitized aphids and laid eggs during *A. ervi* female's life time increased with the increase of host density and the daily parasitism rate decreased when the host density increased to 50/cylinder [53]. These results indicate that the parasitoid can adjust the oviposition strategy in response to host density. Effect of parasitoid number on parasitism rate increased when the number of released parasitoids increases. This is demonstrated also after using *Lysiphlebus testaceipes* parasitoid. Parasitism rate of this parasitoid species increased after release of eight *L. testaceipes* (four males and four females) for a density of 80 individuals of *A. gossypii* compared to parasitism rate after release of four parasitoid individuals [54].

7. Conclusions

This chapter highlighted the major aphid on almond and peach in Tunisia (species, bioecology, natural enemies and control methods). Among six aphid identified species, *H. pruni*, *M. persicae* and *P. persicae* were the most damaged species. These species can be multiplied either by parthenogenesis or by sexual form. For natural enemies, six predator's species, one parasitoid and two entomopathogenic fungus are identified. Among predators, *C. algerica* is the most widespread. However, this ladybird (larva and adult) is inefficient to control *P. persicae*. The introduction of specific parasitoid *P. antennata* and its use to control *P. persicae* showed efficiency. It can be used in future program for control of aphid on almond and peach. Future studies should focus on efficiency of *Aphidius transcaspicus* to control *Hyalopterus pruni* and on pathogenicity of *Beauveria bassiana* and *Metacordyceps liangshanensis* to *M. persicae* and *P. persicae* must have realized and used in integrated pest management program.

Conflict of interest

No conflict of interest to declare.

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