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Orijinal araştırma (Original article)

Mealybug (Hemiptera: Pseudococcidae) species on weeds in *Citrus* (Rutaceae) plantations in Çukurova Plain, Turkey

Çukurova Bölgesi'nde turunçgil alanlarındaki yabancıotlar üzerinde bulunan unlubit (Hemiptera: Pseudococcidae) türleri

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Summary

Citrus fruits (*Citrus* spp., Rutaceae) are grown in more than 140 countries all over the world while they are well known crops in the subtropical areas of the world. Weeds in citrus plantations may reduce citrus production through competition for nutrients and water in one hand, and also may act as alternative host plants of many harmful pest species of *Citrus* plants in the ecosystem. The purpose of this study was to investigate the mealybugs (Hemiptera: Pseudococcidae) that occur on weeds associated to *Citrus* orchards. The study was conducted in six orange orchards in Adana province during 2014–2015. These citrus orchards were chosen according to different ecological characteristics and were visited at two weeks intervals. Leaves, stems, root crown and roots of weeds were examined for any mealybugs. In the study, a total of 117 samples were collected from six different citrus orchards. Among these samples, five mealybug species were found on 25 weed species belonging to 14 plant families. These mealybug species were *Chorizococcus rostellum* (Lobdell), *Peliococcus turanicus* Kiritshenko, *Phenacoccus solani* Ferris, *Phenacoccus solenopsis* Tinsley and *Planococcus citri* (Risso). The citrus mealybug *P. citri* was the main harmful species in citrus. This mealybug was found on Common mallow *Malva sylvestris* L. (Malvaceae), Redroot pigweed, *Amaranthus retroflexus* L. (Amaranthaceae) and Black night shade (*Solanum nigrum* L.) (Solanaceae), Common purslane *Portulaca oleracea* L. (Portulacaceae), Crimson clover, *Trifolium incarnatum* L. (Fabaceae), Toadflax, *Linaria* sp. (Plantaginaceae). *Chorizococcus rostellum* is for the first time recorded in Turkey.

Keywords: *Citrus*, Coccomorpha, integrated pest mangement, host plant

Özet

Turunçgillerin subtropikal alanlarda yetiştiriciliği yapılmakta, tüm dünyada da 140'dan fazla ülkede turunçgiller yetiştirilmektedir. Yabancı otların, turunçgil ağaçlarıyla besin için rekabet etmesine rağmen, bir yandan da su için de rekabet ederek turunçgil üretimini azaltmaktadır. Yabancı otlar, turunçgil zararlıları için alternatif konukçu olabilir. Bu çalışma yabancı otlar üzerinde yer alan unlu bitleri araştırmak için 2014–2015 yıllarında Adana bölgesinde yer alan altı farklı portakal bahçesinde yürütülmüştür. Bu turunçgil bahçeleri farklı ekolojik özelliklere göre seçilmiştir. Bahçeler iki haftaya bir ziyaret edilmiş ve yabancı otların yaprakları, gövdesi, kök ve kök boğazı herhangi bir unlubit türü için kontol edilmiştir. Altı farklı portakal bahçesinden toplamda 117 örnek toplanmıştır. Toplanan bu örnekler, 14 bitki familyasına ait 25 farklı yabancı ot türünden toplanmış olup, bu örnekler arasında beş farklı unlubit türü bulunmuştur. Bunlar: *Chorizococcus rostellum* (Lobdell), *Peliococcus turanicus* Kiritshenko, *Phenacoccus solani* Ferris, *Phenacoccus solenopsis* Tinsley, *Planococcus citri* (Risso)'dir. Turunçgillerde ana zararlı olan turunçgil unlu biti, *Planococcus citri* Risso, Ebegümeci, *Malva sylvestris* L. (Malvaceae), Kırmızı Köklü Horoz İbiği, *Amaranthus retroflexus* L. (Amaranthaceae), İt Üzümü, *Solanum nigrum* L. (Solanaceae), Semiz Otu, *Portulaca oleracea* L. (Portulacaceae), Kırmızı Üçgül, *Trifolium incarnatum* L. (Fabaceae), Keten Otu, *Linaria* sp. (Plantaginaceae) üzerinde tespit edilmiştir. *Chorizococcus rostellum* Türkiye için ilk kayıt niteliğindedir.

Anahtar sözcükler: Turunçgil, Coccomorpha, entegre zararlı yönetimi, konukçu bitki

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Introduction

Citrus fruits, *Citrus* spp. (Rutaceae) are grown in more than 140 countries all over the world while they are well known crops in the subtropical areas of the world 35°N and 35°S latitudes with cultivation and production concentrated in major regions in the Northern Hemisphere (Ramana et al., 1981). The Mediterranean Basin, including Turkey, has favorable conditions for growing citrus (Liu et al., 2012). Turkey has the ninth largest citrus growing area with 172.723 ha in the world (total citrus growing area worldwide 1.353.762 ha), according to statistics in 2012 (Anonymous, 2016). Citrus fruits are consumed as fresh and processed as juice in Turkey. And also it is one of the exported crops. Çukurova Plain (mostly Adana) is the main producer area (nearly 90%) for citrus cultivation.

Along with the increase of citrus planted area in the world, there are many problems related to agricultural production such as control of citrus pests. Several pest species such as weeds (Uygur et al., 1990) insects, mites, fungal, bacterial and viral diseases are a problem for citrus production. Although many control strategies, including cultural, chemical, biological, biotechnical, etc., can be used to reduce their damage, chemical control is the most used control strategy because of its quick response against pest species (Davarcı, 1996). Even though chemical control is very useful to control pest species, the use of chemicals cause undesired effects on the environment in many aspects, such as a detrimental effect on biodiversity, beneficial organisms in the agroecosystem, residual problems on the crops and they cause soil, water and air pollution (Uygur et al., 1990). For this reason, some different strategies such as Integrated Pest Management (IPM) and Sustainable Agriculture have been developed in last decades (Uygur et al., 1990). Both IPM and Sustainable Agriculture strategies use all possible promising control strategies to manage pest species on cultural plants. Sustainable Agriculture is regarded as more environmental friendly and considers all environmental conditions to manage the ecosystem (Uygun & Şekeroğlu, 1984; Uygur et al., 1984).

Although weeds in citrus plantations compete with trees for nutrients, water and light and are believed to reduce production in one hand, they may also act as alternative host plants of many harmful pest species in the ecosystem. For this reason weeds should be considered not only as pests in the citrus plantation, but also as main or alternative plant hosts, alternative food or an overwintering place for many arthropods, plant pathogens, antagonists and nematodes. For this reason, to improve a successful management strategy under the view of sustainable agriculture in citrus plantations, each biotic factor and its role in the agroecosystem must be studied and the weed fauna in the citrus plantation may serve as important background knowledge for the specialist.

The citrus mealybug, *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae) is regarded one of the most important pest species in citrus plantations all over the world as well as in Çukurova Plain, Turkey. It has a worldwide distribution with more than 270 host plant records from numerous plant genera including many weeds that are found in the citrus plantations (Garcia et al., 2016). Although many studies on the biology of this species have been carried out in citrus plantations in the world as well as in Turkey, there is no such a study that has determined alternative host plants regarded as weeds in the plantation (Uygun, 2001; Erkılıç & Demirbaş, 2007). On the other hand, there are no studies concerning mealybug species as alternative hosts of natural enemies of most citrus mealybugs on the weed flora in citrus plantations. Considering that biological control is one of the most effective control methods for controlling citrus mealybugs, this information is very important for further studies.

For these reasons, this study was aimed to determine the mealybug fauna on weed species in citrus orchards in the Çukurova Plain in the Mediterranean region of Turkey.

Materials and Methods

This study was conducted in six orange orchards in Adana province between 2014–2015. These citrus orchards were chosen according to different ecological characteristics. The orchards were visited at two weeks interval. Mealybug samples were taken from leaves, stems, root crowns and roots of the weeds found in the citrus orchards. Plant parts with mealybugs were put into a plastic bag and taken to the laboratory for examination (Uygur, 1991). Mealybugs on weeds were put into Eppendorf tubes with 70% alcohol for further examination.

Specimens were prepared for light microscopy using the slide-mounting method given by Kosztarab & Kozár (1988). Morphological terminology follows that of Kaydan et al. (2015) and Williams (2004).

Earlier distribution and host plant data are given according to information taken from ScaleNet (Garcia et al., 2016).

Dry and slide-mounted specimens are deposited at Çukurova University, Agricultural Faculty, Plant Protection Department, Balcalı, Turkey.

Results and Discussion

In this study, a total of 117 samples were collected from six different citrus orchards. Among these samples five mealybug species were found on 26 weed species belonging to 14 plant families.

***Chorizococcus rostellum* (Lobdell)** (Figure 1)

Synonyms: *Trionymus angustus* Cockerell & Bueker, *Trionymus rostellum* Lobdell, *Erium angustum* (Cockerell & Bueker), *Erium rostellum* (Lobdell), *Trionymus vallis* Ferris, *Allotrionymus rostellum* (Lobdell).

Material examined: 2 ♀♀, *ex. Setaria viridis* (L.) P. Beauv. (Poaceae), 09.VI.2015, Imamoglu – Kozan.

Comments: This species has been recorded from Argentina, Australia, Brazil, Canada, Crete, France, Guadeloupe, Hawaiian Islands, Hungary, Italy, Jamaica, Martinique, Mexico, Peru, Sardinia, South Africa and USA (Garcia et al., 2016).

Herein, *C. rostellum* is for the first time recorded in Turkey.

***Peliococcus turanicus* Kiritshenko**

Synonyms: *Phenacoccus turanicus* Kiritshenko, *Peliococcus turanicus* Kiritshenko, *Phenacoccus hilarius* Kiritshenko, *Peliococcus terrestris* Borchsenius, *Peliococcus perfidiosus* Borchsenius, *Peliococcus unispinus* Borchsenius & Ter-Grigorian, *Eupeliococcus tragopogoni* Săvescu, *Eupeliococcus drabae* Săvescu.

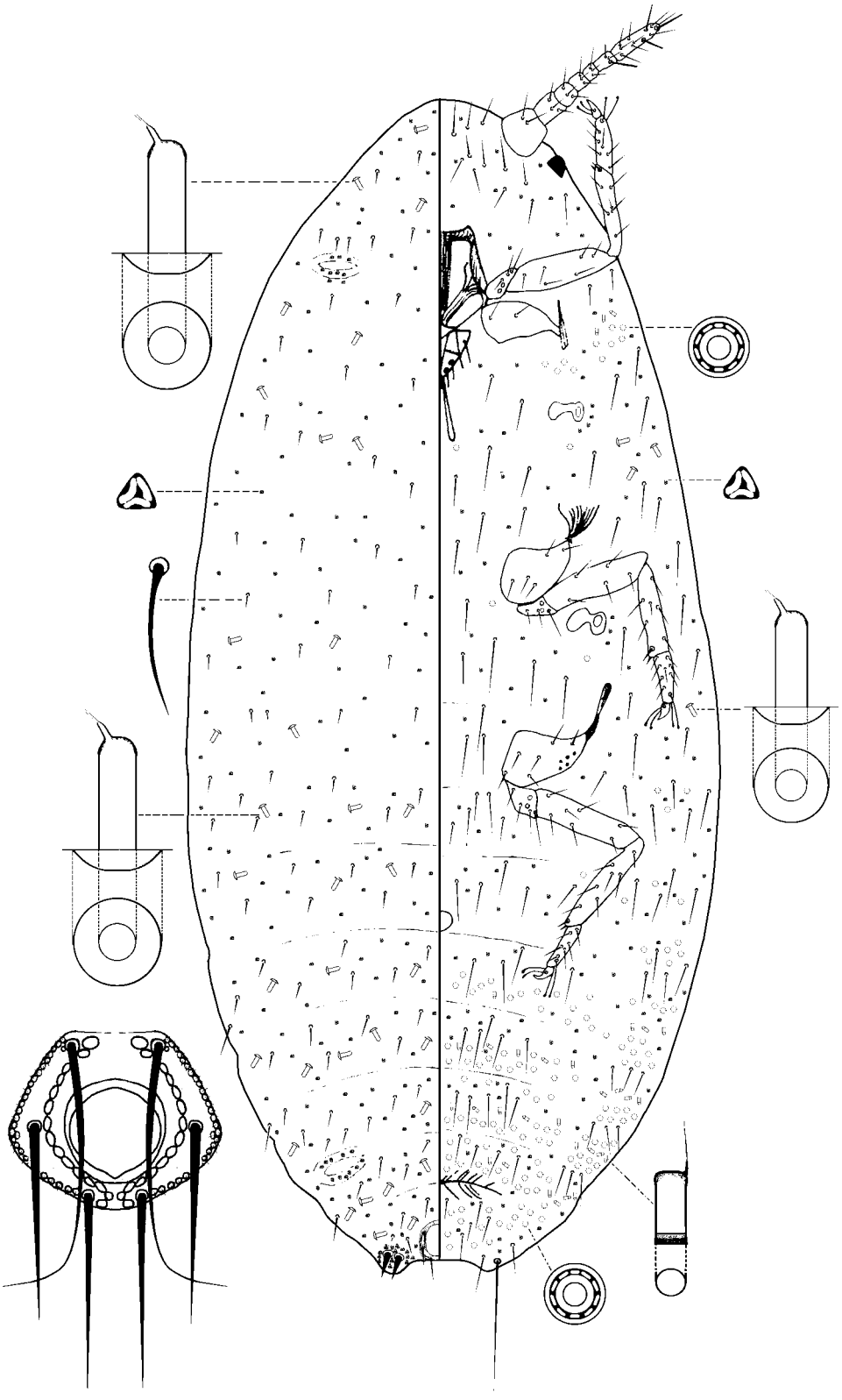

Figure 1. *Chorizococcus rostellum* (Lobdell), after Kosztarab & Kozár (1988) with additions.

Material examined: 3 ♀♀ *ex. Convolvulus arvensis* L. (Convolvulaceae), 21.IV.2015, Karataş – Dogankent; 1 ♀ *ex. Euphorbia helioscopia* L. (Euphorbiaceae), 21.IV.2015, Karataş – Dogankent; 9 ♀♀ *ex. Malva sylvestris* L. (Malvaceae), 21.IV.2015, Karataş – Dogankent; 4 ♀♀ *ex. M. sylvestris*, 04.VI.2015, Karataş – Dogankent; 2 ♀♀ *ex. M. sylvestris*, 07.VII.2015, Karataş – Dogankent; 2 ♀♀ *ex. Ranunculus arvensis* L. (Ranunculaceae), 21.VI.2015, Karataş – Dogankent; 1 ♀ *ex. R. arvensis*, 05.V.2015, Imamoglu - Kozan; 9 ♀♀ *ex. Ammi majus* L. (Apiaceae), 21.IV.2015, Karataş – Dogankent; 2 ♀♀ *ex. A. majus*, 12.V.2015, Karataş – Dogankent; 2 ♀♀ *ex. A. majus*, 25.V.2015, Imamoglu - Kozan; 3 ♀♀ *ex. A.majus*, 09.VI.2015, Imamoglu - Kozan; 2 ♀♀ *ex. Conyza canadensis* (L.) Cronquist. (Asteraceae), 05.VI.2015, Karataş – Dogankent; 1 ♀ *ex. C. canadensis*, 07.VII.2015, Karataş - Dogankent; 3 ♀♀ *ex. C. canadensis*, 30.VI.2015, Imamoglu - Kozan; 3 ♀♀ *ex. C. canadensis*, 14.VII.2015, Imamoglu - Kozan; 3 ♀♀ *ex. Polygonum aviculare* L. (Polygonaceae), 04.VI.2015, Karataş - Dogankent; 2 ♀♀ *ex. Euphorbia nutans* Lag. (Euphorbiaceae), 04.VI.2015, Karataş – Dogankent; 2 ♀♀ *ex. E. nutans*, 18.VIII.2915 Karataş – Dogankent; 1 ♀ *ex. E. nutans*, 16.VI.2015, Karataş – Dogankent; 1 ♀ *ex. Euphorbia peplus* L. (Euphorbiaceae), 21.VII.2015, Karataş – Dogankent; 1 ♀ *ex. E. peplus* L. (Euphorbiaceae), 18.VIII.2015, Karataş – Dogankent; 1 ♀ *ex. Linaria* sp. (Plantaginaceae), 04.VI.2015, Karataş – Dogankent; 3 ♀ *ex. Linaria* sp., 21.VII.2015, Karataş – Dogankent; 3 ♀♀ *ex. Linaria* sp., 14.VII.2015, Imamoglu - Kozan; 3 ♀♀ *ex. Linaria* sp., 28.VII.2015, Imamoglu - Kozan; 1 ♀ *ex. Linaria* sp., 11.VIII.2015, Imamoglu - Kozan; 6 ♀♀ *ex. Linaria* sp., 25.VIII.2015, Imamoglu -Kozan; 2 ♀♀ *ex. Cichorium Cichorium intybus* L. (Asteraceae), 09.VI.2015, Imamoglu - Kozan; 3 ♀♀ *ex. C. intybus*, 30.VI.2015, Imamoglu - Kozan; 6 ♀♀ *ex. C. intybus*, 14.VII.2015, Imamoglu - Kozan; 3 ♀♀ *ex. C. intybus*, 28.VII.2015, Imamoglu - Kozan; 3 ♀♀ *ex. Lactuca serriola* L. (Asteraceae), 14.VII.2015, Imamoglu - Kozan; 1 ♀ *ex. L. seriola*, 28.VII.2015, Imamoglu - Kozan; 1 ♀ *ex. L. seriola*, 09.VI.2015, Dogankent – Imamoglu; 2 ♀♀ *ex. Setaria verticillata* L. (Poaceae), 11.VIII.2015, Imamoglu – Kozan; 2 ♀♀ *ex. Picris echioides* L. (Asteraceae), 26.V.2015, Dogankent – Imamoglu; 1 ♀ *ex. Sonchus oleraceus* L. (Asteraceae), 11.VIII.2015, Dogankent – Imamoglu; 2 ♀♀ *ex. S. oleraceus*, 25.VIII.2015, Dogankent – Imamoglu; 2 ♀♀ *ex. Xanthium strumarium* L. (Asteraceae), 09.VI.2015, Dogankent – Imamoglu; 3 ♀♀ *ex. X. strumarium*, 14.VII.2015, Dogankent – Imamoglu; 3 ♀♀ *ex. X. strumarium*, 25.VIII.2015, Dogankent – Imamoglu.

Comments: Living on the roots of various perennial herbs and bushes: *Achillea* sp., *Artemisia* sp., *Centaurea* sp., *Tragopogon* sp. (Asteraceae), *Euphorbia* sp. (Euphorbiaceae), *Lamium* sp. (Lamiaceae), *Astragalus* sp. (Fabaceae), *Atraphaxis* sp. (Polygonaceae), *Physalis* sp. (Solanaceae) and others; sometimes also on the roots of wheat and wild grasses. This species is widely distributed in Southern Europe, Transcaucasia, Anatolia and Central Asia. The most common mealybug species on weeds in citrus orchards was *P. turanicus* in this study, being found on 15 different plant species belonging to seven families. This species has been recorded in Eastern Anatolia region on various herbaceous plant species (Kaydan et al., 2013).

***Phenacoccus solani* Ferris**

Synonyms: *Pseudococcus solani* Essig; *Phenacoccus herbarum* Lindinger.

Material examined: 3 ♀♀ *ex. Amaranthus spinosus* L. (Amaranthaceae), 08.IX.2015, Imamoglu – Kozan.

Comments: Although the Solanum mealybug is widely distributed in the Afrotropical, Australasian, Neotropical Region and Oriental Region, it has also been recorded in the Palaearctic Region (Ben-Dov, 2005, Mazzeo et al., 1999, Moghaddam, 2004). Recently, *P. solani* was recorded on *Portulaca oleracea* (Portulacaceae) in Adana for first time in Turkey by Kaydan et al. (2008) and Çalışkan et al. (2016, in press) found this species on *G. rigens* var. *rigens, Chrysanthemum* sp. (Asteraceae) in Adana.

***Phenacoccus solenopsis* Tinsley**

Synonyms: *Phenacoccus cevalliae* Cockerell; *Phenacoccus gossypiphilous* Abbas, Arif & Saeed; *Phenacoccus gossypiphilous* Abbas, Arif, Saeed & Karar.

Material examined: 1 ♀ *ex. Daucus carota* L. (Apiaceae), 30.VI.2015, Imamoglu – Kozan; 1♀ *ex. Malva sylvestris* L. (Malvaceae), 30.VI.2015, Dogankent – Imamoglu.

Comments: The distribution of this mealybug is almost cosmopolitan (it is found in the Australasian, Afrotropical, Nearctic, Oriental and Neotropical regions), however, in the Palaearctic region it is recorded in Cyprus, Egypt and Iran (Ben-Dov *et al.,* 2015) in the last decade. *Phenacoccus solenopsis* was recorded in Adana for the first time in Turkey by Kaydan *et al.* (2013). Çalışkan *et al*. (2013) reported that this species is very common on ornamental plants belonging to Malvaceae and Solanaceae.

***Planococcus citri* (Risso)**

Synonyms: *Dorthesia citri* Risso; *Coccus tuliparum* Bouche; *Coccus citri* Boisduval; *Coccus citry* Alfonso; *Dactylopius alaterni* Signoret; *Dactylopius ceratoniae* Signoret; *Dactylopius citri* Signoret; *Dactylopius cyperi* Signoret; *Dactylopius robiniae* Signoret; *Dactylopius tuliparum* Signoret; *Lecanium phyllococcus* Ashmead; *Coccus citry* Targioni Tozzetti; *Dactylopius brevispinus* Targioni Tozzetti; *Dactylopius destructor* Comstock; *Dactylopius farinosus* Cockerell; *Dactylopius secretus* Hempel; *Phenacoccus spiriferus* Hempel; *Pseudococcus citri* Cockerell; *Pseudococcus cyperi* Fernald; *Pseudococcus robiniae* Fernald; *Pseudococcus tuliparum* Fernald; *Pseudococcus alaterni* Fernald; *Pseudococcus ceratoniae* Fernald; *Pseudococcus citri coleorum* Marchal; *Dactylopius* (*Trechocorys*) *citri* Newstead; *Pseudococcus citri phenacocciformis* Brain; *Pseudo-Coccus citris* Gomez-Menor Ortega; *Planococcoides cubanensis* Ezzat & McConnell; *Planococcus citricus* Ezzat & McConnell; *Planococcus cucurbitae* Ezzat & McConnell.

Material examined: 2 ♀♀ *ex. Malva sylvestris* L. (Malvaceae), 07.IV.2015, Karataş - Dogankent; 1♀ *ex. M. slyvestris*, 09.VI.2015, Imamoglu - Kozan; 1♀ *ex. Amaranthus retroflexus* L. (Amaranthaceae), 09.VI.2015, Imamoglu - Kozan; 1♀ *ex. Portulaca oleracea* L. (Portulacaceae), 09.VI.2015, Imamoglu - Kozan; 1♀ *ex. Trifolium incarnatum* L. (Fabaceae), 09.VI. 2015, Imamoglu - Kozan; 1 ♀ *Solanum nigrum* L. (Solanaceae), 26.V. 2015, Imamoglu - Kozan*;* 1♀ *Linaria* sp. (Plantaginaceae), 07.VII.2015, Karataş – Dogankent.

Comments: This species has a worldwide distribution with more than 270 host plant records from numerous plant genera. It is regarded as one of the most important pest species of *Citrus* crops all over the world as well as in Adana region in Turkey.

A total of five mealybug species were belonging to four genera were found on various weeds in six citrus orchards in Adana, Turkey in this study. This is the first study on the mealybugs present on weeds in citrus orchards in the Adana region. Of the five mealybugs collected on weeds in the citrus orchards, only *P. citri* is known as a pest species of citrus crops. Based on this results, it can be said that although weeds in a citrus orchard can be considered a bad thing because they can serve as alternative hosts for *P. citri,* aiding it to continue its presence in the citrus orchard; weeds in citrus orchards that harbor *P. citri* and the other mealybug species may also serve as alternative hosts of natural enemies (predators and parasitoids) that may control those mealybugs found on the citrus trees in the orchard. It is thus important to consider the scale insect and natural enemies' dynamics in order to improve sustainable agriculture strategies in citrus growing areas.

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