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## Citrus aphids (Hemiptera: Aphididae): incidence, population fluctuations, host plant and age preferences

Turunçgil yaprakbitleri (Hemiptera: Aphididae): bulaşıklık oranları, popülasyon dalgalanmaları, konukçu bitki ve yaş tercihleri

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### ABSTRACT

Citrus plantations are suffered from many different pest species in East Mediterranean Region. Among them, aphids (Hemiptera: Aphididae) are one of the important groups. Some species such as *Aphis gossypii* Glover, *Aphis spiraecola* Patch, *Aphis craccivora* Koch, *Aphis (Toxoptera) aurantii* (Boyer de Fanscolombe) and *Myzus (Nectarosiphon) persicae* (Sulzer) (Hemiptera: Aphididae) cause harm especially young citrus orchards. This study aimed to investigate regional distribution, seasonal fluctuation, host and host age preferences within citrus species of these aphid species in 15 sub-regions from Adana, Hatay, Osmaniye and Mersin between 2007 and 2009. While the mandarin was more preferred than other citrus species, grapefruit was the least preferred citrus species among in all the three provinces. Among the citrus species in the Mersin region, *A. spiraecola* was the most common in lemons, while *A. (T.) aurantii* preferred mandarin compare to others. In Adana and Hatay regions, mandarin was the most preferred citrus species for all aphid species except *M. (N.) persicae*. Aphid preferences depending on the age showed differences in citrus age scale by region. *A. (T.) aurantii*, on the other hand, had the highest rate of presence between the ages of 11-20 in Hatay and between the ages 21-40 in Mersin. The prevalence of citrus varieties in Adana and Hatay parallely affected the distribution of aphids. However, *A. spiraecola* was dominant aphid species on the lemon. Adana, which has a richer flora compared to Mersin and Hatay regions, has been determined the highest aphid density in different species. The fact that *Aphis goosypii* and *A. spiraecola* create up to 30-40% infections rate in citrus orchards not only in spring, but also in July, and intense again in autumn have made these pests harmful for four seasons.

### INTRODUCTION

Citrus is one of the essential exporting crops of Turkey, and its plantation area is rapidly increasing in the agricultural

sector. Its production is limited to coastal areas of Turkey that are West, South, and North East of Turkey under

the Mediterranean climate. Parallel to this development, the number and the population of pests, diseases, and weeds, causing significant crop losses, are escalating. *Aphis gossypii* Glover, *A. spiraeicola* Patch, *A. craccivora* Koch, *Aphis (Toxoptera) aurantii* (Boyer de Fonscolombe), and *Myzus (N.) persicae* (Sulzer) (Hemiptera: Aphididae) were considered as important pest group of citrus orchards (Satar et al. 2014, Uygun and Satar 2008). The literature studies show that *A. gossypii*, *A. spiraeicola* are the most common species and *A. gossypii* especially has many parasitoid species at Mediterranean Region (Kavallieratos and Lykouressis 1999, Mendoza et al. 2001, Satar et al. 2014, Stary et al. 1988, Toros et al. 2002, Tremblay et al. 1980). Aphids damage to plants by sucking the sap directly, by causing fumagin, and transmitting virus and virus-like organisms indirectly. The pest group is especially harmful to newly planted areas by preventing the development of the plant, because of preferring young shoots. The pest also causes losses at cotton and vegetables are generally controlled by intensive insecticide usage that gives rise to the development of insecticide resistance (Ulusoy et al. 2018). Because of the wide distribution and insecticide-resistant peculiarity of *A. gossypii* in this group, they are difficult to control. To get rid of all the negative effects of chemical control and benefiting from the high number of natural enemies of *A. gossypii* in nature, the farmers are forced to evolve a biological control program in the Integrated Pest Management (IPM) strategy.

Biology, population dynamics, and the ecology of the pest should be considered for successfully control in the IPM strategy. Researches about seasonal changing provide many ideas like interactions between an insect and its environments, such as creating efficient sampling programs for population estimation, pest management, and the development of population models (Dubey and Singh 2011). Yumruktepe and Uygun (1994) and Satar et al. (1998) emphasized that grapefruits are less preferred by the common two aphid species, *A. spiraeicola* and *A. gossypii*, on citrus. Satar and Uygun (2008, 2011) observed two species at the different periods which *A. gossypii* is between May and July, *A. spiraeicola* is from the beginning of August till the end of September in citrus orchards in Adana.

Studies on aphids are generally carried out on population density in a few sub-regions. This study was planned and conducted at all citrus production areas in the Eastern Mediterranean Region have different ecologies. In this way, it has been possible to compare the distribution of aphid species, which are a significant pest in the whole region, with each other. Thus, many ecological characteristics of aphid species, which are harmful in citrus fruits, such as host plant

preference, plant age, regional distribution, regional age, and plant species preference, have been determined and the effect of climate on these characteristics has been discussed.

## MATERIALS AND METHODS

The East Mediterranean Region separated 15 sub-regions; Center, Silifke, Erdemli, Mezitli-Kuyuluk, Tarsus, Yenice from Mersin; Yüreğir, Seyhan, Karataş, Ceyhan, Kozan, Kadirli-Toprakkale from Adana; Erzincan, Dört Eylül, İskenderun-Arsuz from Hatay in three provinces concerning their ecology and geography to detect the prevalence and distributions of aphid species according to Bora and Karaca (1970). These sub-regions were surveyed one time per month from May 2007 to June 2009 (Figure 1). Minimum ten citrus orchards that were detected in each sub-region were visited monthly. During the study, the orchard were selected randomly in each sub-region. But generally citrus growing area in each region accumulated in some locations of the each sub-region. Therefore, all the time visited orchards was on the same layer in every month.



**Figure 1.** The GPS coordinates of the citrus orchards where citrus aphids are studied in the Eastern Mediterranean Region of Turkey (Satellite image from Google Earth)

These orchards were traversed crosswise, and a total of 100 shoots were checked three shoots from each tree. The density of each aphid species was determined using the 0-6 scale given in Table 1 (Anonymous 1990).

**Table 1.** The scale used in aphid counting in citrus aphid survey

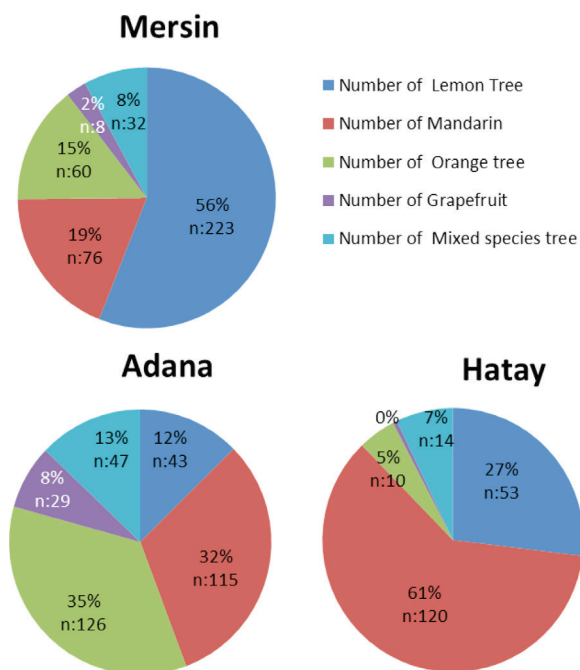
Scale value	Number of aphids		
	Lower limit	Upper limit	Limit average
0	0	0	0
1	1	2	2
2	3	10	7
3	11	30	20
4	31	100	70
5	101	300	200
6	301	1000	700

Preparation of the aphids collected from the field was done by Hille Ris Lambers (1950) methods and they were identified by researchers in this project, unidentified materials were sent to Dr. Işıl Özdemir.

The percentage rate of each aphid species according to plant age and species and the provinces were calculated by dividing the number of an aphid species to total aphid number for each condition.

## RESULTS AND DISCUSSION

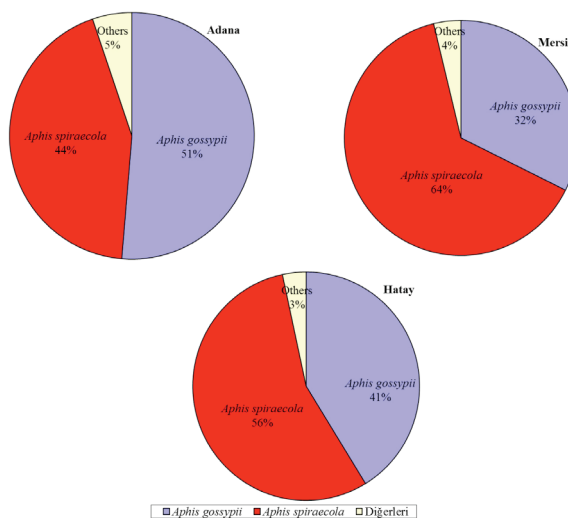
This study aimed to detect aphid species and population fluctuation in the East Mediterranean Region. For this aim, the total 4000 visits to 953 citrus orchards in Mersin, Adana, and Hatay provinces were conducted. 1597 visits to 359 orchards from six subregions in Adana and 1610 visits to 398 orchards from six sub-regions in Mersin, and 793 visits to 196 orchards from three sub-regions in Hatay were investigated to detect the citrus aphid species and their densities with their orchards specifications from the middle of 2007 to 2009. Lemon (56%) in Mersin, orange (35%) and mandarin (32%) in Adana, and mandarin (61%) in Hatay was the dominant citrus plantations (Figure 2).



**Figure 2.** Surveyed citrus orchard percentage and distribution according to species between 2007-2009 in East Mediterranean Region

*A. gossypii*, *A. spiraecola*, *A. craccivora*, *A. (T.) aurantii*, and *M. (N.) persicae* were five common aphid species in the East Mediterranean Region while *A. gossypii* and *A. spiraecola* were detected as dominant ones. *Aphis spiraecola* was found

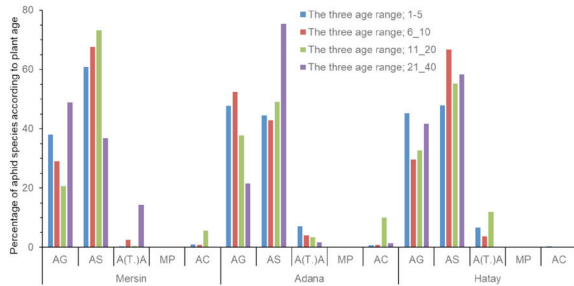
in the highest with 64% in the province of Mersin, with 56% in Hatay, and 44% in Adana. *Aphis gossypii* has detected at the highest rate with 51% in Adana followed by Hatay and Mersin. Other species were detected at a very low rate (Figure 3). Many researchers in their country supported these findings. Hermoso de Mendoza et al. (1998) also stated that the dominant aphid species in citrus areas in the Eastern Mediterranean were *A. spiroecola* and *A. gossypii*. Pelosi et al. (1996) carried out aphid population fluctuation with traps in the orange orchard in the province of Florida, USA. The results revealed that the most common species were *Aphis spiroecola* (49.3%), *A. gossypii* (14.1%), *A. craccivora* (3.4%), for *A. (T.) aurantii* (2.9%), *Macrosiphum euphorbiae* (1.4%), and *M. (N.) persicae* (1.3%), respectively. In the region, *A. spiroecola* and *A. gossypii* have also reported a higher population than other species (Satar and Uygun 2008, 2011, Yumruktepe and Uygun 1994) indicated that *A. spiroecola* and *A. gossypii* stand out in citrus orchards in their study.



**Figure 3.** Densities of *Aphis gossypii*, *Aphis spiroecola*, *Aphis craccivora*, *Aphis (Toxoptera) aurantii*, and *Myzus (N.) persicae* in Adana, Mersin, and Hatay provinces 2007-2009 in East Mediterranean Region

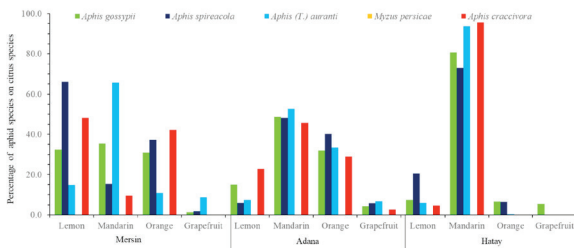
The age preference evaluation were assessed as ratio of present aphid species depending on orchards age preferred by aphid species (Figure 4). *Aphis spiraecola* was detected a maximum of 73.2% on 11-20 age trees while *A. gossypii* was 20.7%, *A. craccivora* was 5.6%, *A. (T.) aurantii* was 0.44% and *M. (N.) persicae* was 0.1% in citrus orchards of Mersin province. Moreover, *A. spiraecola* was not only high at 11-20 age but also it was highest for all other age range too. This dominance followed by 67.6% on the 6-10 age, and 60.8% on the 1-5 age, 36.8% on the 21-40 age trees in Mersin. In Adana province, *A. gossypii* was high at 1-5 age (47.7%) and 6-10 age (52.4%) ranges, but *A. spiraecola* was the highest by 48.9% and 75.4% on the 11-20 age and 21-40 age, sincerely. In the province of Hatay, at the age range 1-5, *A. spiraecola*

was recorded 47.9%, *A. gossypii* was 44.5%, *A. (T.) aurantii* was 6.6% and *A. craccivora* was 0.2%. Rate of *A. (T.) aurantii* was 14.3% on the age of 21-40 tree in Mersin, 12% on the age of 11-20 in Hatay, and 7% on the 1-5 age in Adana. *Aphis craccivora* has been found highest in the 11-20 age trees in Adana and Mersin. When all data evaluated, *A. spiraeocola* and *A. gossypii* preferred the 6-11 years old trees in Adana, the 1-5 years old trees in Mersin. However, *A. craccivora* came forward on the 11-20 age trees in Adana and Mersin. *Myzus persicae*, detected very low rate only in Mersin, reached higher numbers on the 10-20 years old trees (Figure 4).



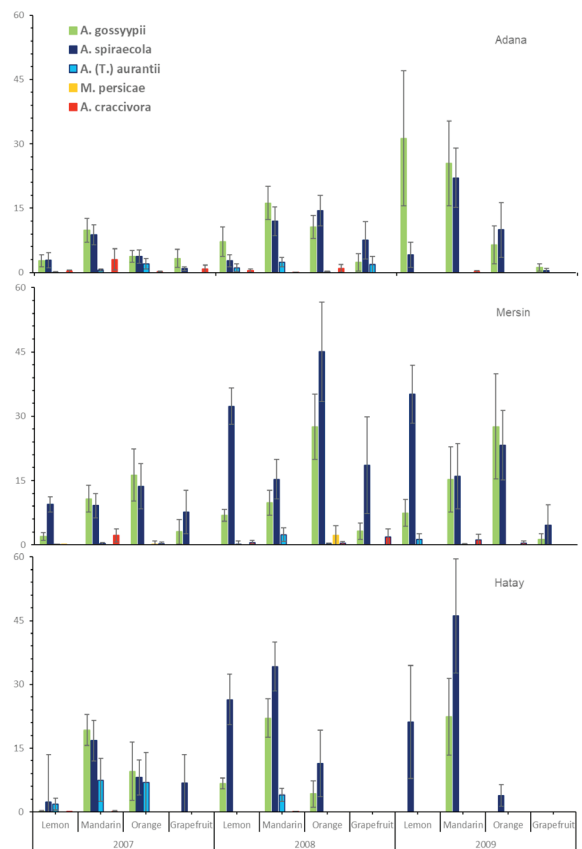
**Figure 4.** Percentage by *Aphis gossypii*, *Aphis spiraeocola*, *Aphis (Toxoptera) aurantii*, *Myzus (N.) persicae*, and *Aphis craccivora* in Mersin, Adana, and Hatay provinces according to preferring citrus trees age

From another aspect, the most preferred citrus variety was mandarin, while grapefruit become unfavourable citrus species compared to the others in all three provinces. It was followed by orange in Adana, by lemon in Mersin. Because of less plantation of other citrus varieties, the mandarin was the primary host for aphids in Hatay followed by lemon. Overall, *A. gossypii* preferred lemon (32.4%), mandarin (35.4%), and orange (%31) with relatively equal ratio. The population of *A. spiraeocola* was observed densely on lemon (66.0%) compare to mandarin (15.2%), orange (37.3%) and grapefruit (1.8%), while *A. (T.) aurantii* populations intensified on mandarin (66%) (Figure 5). Caballero et al. (1992) also reported in their study in citrus orchards in Spain that aphids prefer more mandarin trees than other citrus varieties.



**Figure 5.** Percentage by *Aphis gossypii*, *Aphis spiraeocola*, *Aphis (Toxoptera) aurantii*, *Myzus (N.) persicae*, and *Aphis craccivora* in Mersin, Adana, and Hatay provinces according to preferring citrus trees age

*Aphis gossypii* in Adana province reached 25.41 mean number of aphid/shoot on mandarin and 6.46 individuals in orange during the season of 2009. However, in the same year, *A. spiraeocola* was detected in orange with 9.93, 22.06 aphids/shoot in mandarin. The mean number of *A. spiraeocola* and *A. gossypii* was higher on the orange trees during the three years except *A. spiraeocola* on lemon in 2009, but it was very low on the grapefruits all over the study. Overall, both species were determined in all varieties in 2007 and 2008, albeit lower than in 2008. *Aphis (T.) aurantii* was observed at lower levels in all varieties in 2007 and 2008 except the grapefruit varieties, but it could relatively higher on the mandarin varieties in 2008. *Aphis craccivora* also detected low level population through the season of 2007 and 2008, while only 0.22 aphids/shoot on mandarin in 2009 were recorded (Figure 6).



**Figure 6.** Mean numbers of *Aphis gossypii*, *Aphis spiraeocola*, *Aphis craccivora*, *Aphis (Toxoptera) aurantii*, and *Myzus (N.) persicae* per shoot on the lemon, mandarin, orange, and grapefruit in Mersin, Adana, and Hatay from May 2007 to June 2009

Aphid population was dramatically higher in 2008 and 2009 in Mersin province. *A. spiraeocola* was determined to have a 32.32 and 35.12 mean number of aphid/shoot in lemon, 27.59 and 27.62 individuals/shoot on oranges and 15.31 and

16.03 individual/shoot in mandarin the season of 2008 and 2009, respectively. The mean number of aphid/shoot of *Aphis gossypii* was determined 10-27 individual in lemon, orange, and mandarin. *Aphis (T.) aurantii* and *A. craccivora* were detected at lower than 3 individuals in Mersin in respect of citrus species. *Myzus persicae* was observed 2.25 individuals in orange in 2008, and this number was the highest for all district and all the seasons (Figure 6).

The population of *A. gossypii* in Hatay province was slightly higher than *A. spiraecola* in 2007. *A. gossypii* was found a maximum of 19.26 aphids/shoot while *A. spiraecola* was a maximum of 16.74 aphids/shoot in mandarin. The mean number of *A. spiraecola* was dramatically increased on the mandarin in (34.21) 2008 and (46.10) 2009. Also, the maximum number of *A. (T.) aurantii* were reached to 7.51 aphids/shoot and 3.98 aphids/shoot in mandarin in 2007 and 2008, respectively, but it did not detect in 2009 (Figure 6).

*Aphis spiraecola* was common in Mersin and Hatay, while *A. gossypii* was detected at a higher rate in Adana. Concerning host plant preference, *A. spiraecola* preferred the lemon in Mersin, orange in Adana, mandarin in Hatay. Because, Adana province has rich plant pattern such as cotton, cucurbits, host plants of *A. gossypii*, around citrus production areas, the population of *A. gossypii* may increase in Adana.

*Pyracantha coccinea* Roem and *Eriobotrya japonica* (Thunb.) (Rosaceae) are alternative hosts of *spiraecola* (Satar et al. 2008). The researchers determined that the species active on citrus varieties from April to December. *Pyracantha coccinea* is also the host of *A. spiraecola* at this season. Mersin is a significant touristic area, and this species is common as a landscape plant in the area. Whereas, *E. japonica*, an early-season plant, has a wide cultivation area and is a landscape plant in home gardens in Mersin province. *A. spiraecola* is active on the plant between November to May at out of the citrus season (Satar and Uygun 2008). However, tomato production in greenhouses is dominant in Erdemli district, where lemon cultivation is mainly in Mersin province (Anonim 2012). It may be the reason for being of *M. (N.) persicae*, mainly in Mersin province. Satar (2003) stated that *A. spiraecola* and *A. gossypii* are prominent in citrus in their study, and these species prefer grapefruit less. In another study, Yumruktepe and Uygun (1994) reported that the species that constitute a high population were *A. spiraecola* and *A. gossypii*. Therefore, the researcher also stated that grapefruit was less preferred variety in citrus by the aphids as detected in the study.

The percentage of *A. gossypii*, *A. spiraecola*, *A. craccivora*, *A. (T.) aurantii*, and *M. (N.) persicae* on citrus shoots from May 2007 to May 2009 were examined in three provinces. Besides, the monthly numbers of *A. gossypii* and *A. spiraecola*, which

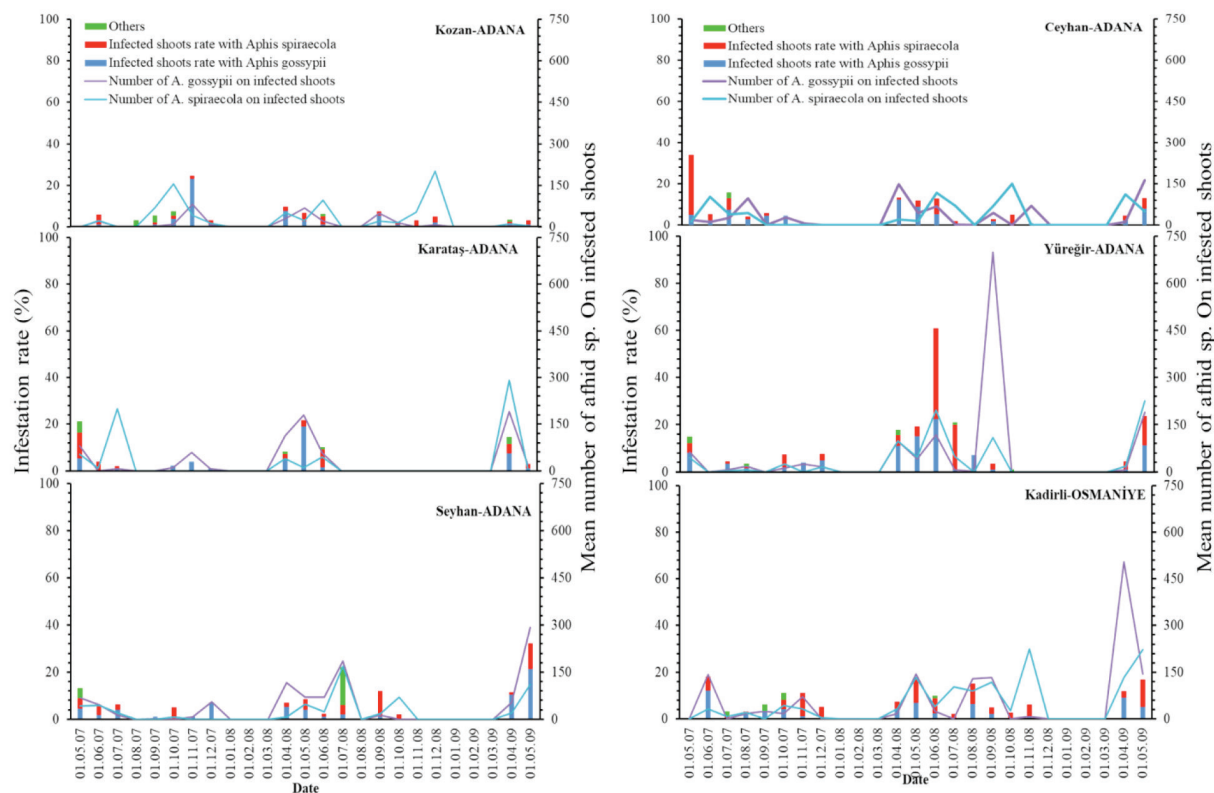


Figure 7. *Aphis gossypii*, *Aphis spiraecola*, and others in Adana province with monthly average numbers and percentage concentrations from May 2007 to June 2009

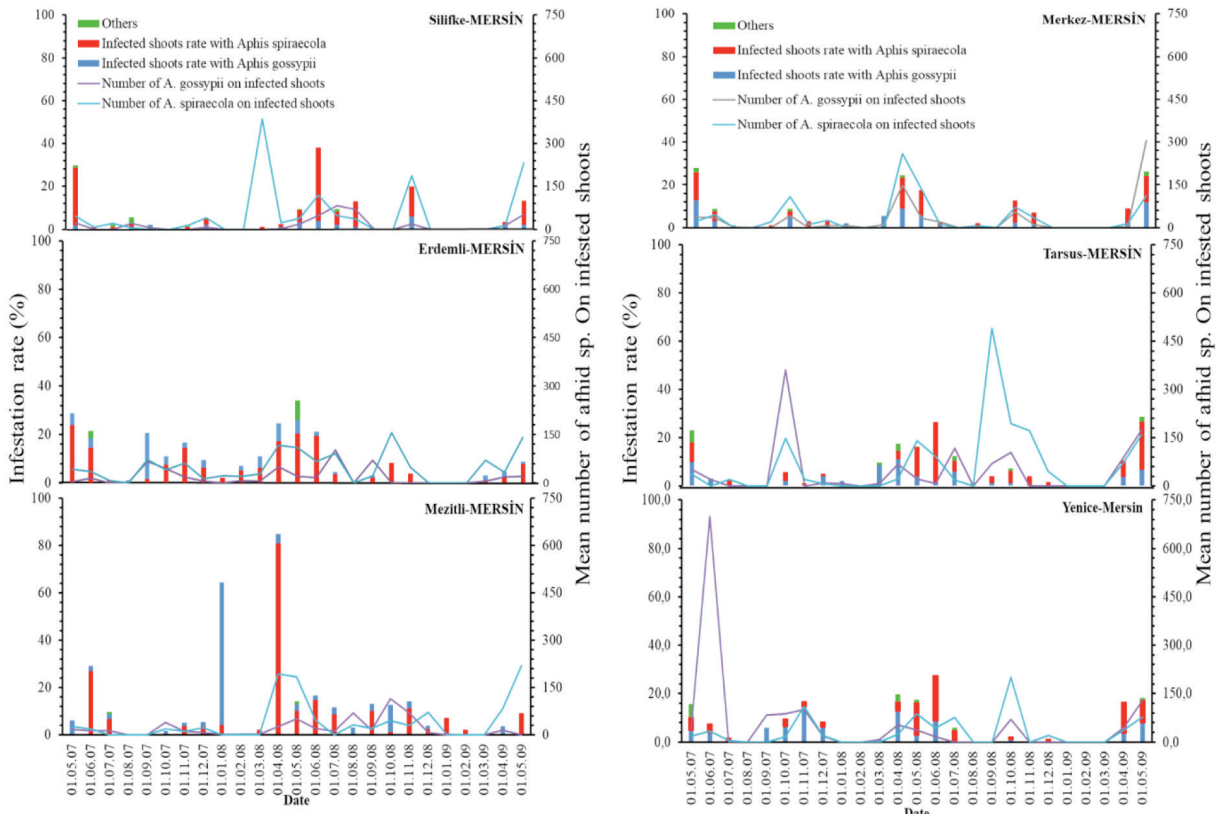


Figure 8. *Aphis gossypii*, *Aphis spiraecola*, and others in Mersin province with monthly average numbers and percentage concentrations from May 2007 to June 2009

were common species in the same years, were determined (Figure 7, 8, 9). While *A. gossypii* was 24.8 aphids/shoot in November in Yüreğir district in 2007, it was determined as

the highest number of individuals as 700 aphids/shoot in September in 2008, and the population reached 189.7 aphids/shoot in May in 2009 (Figure 7). This sub-region has intensive

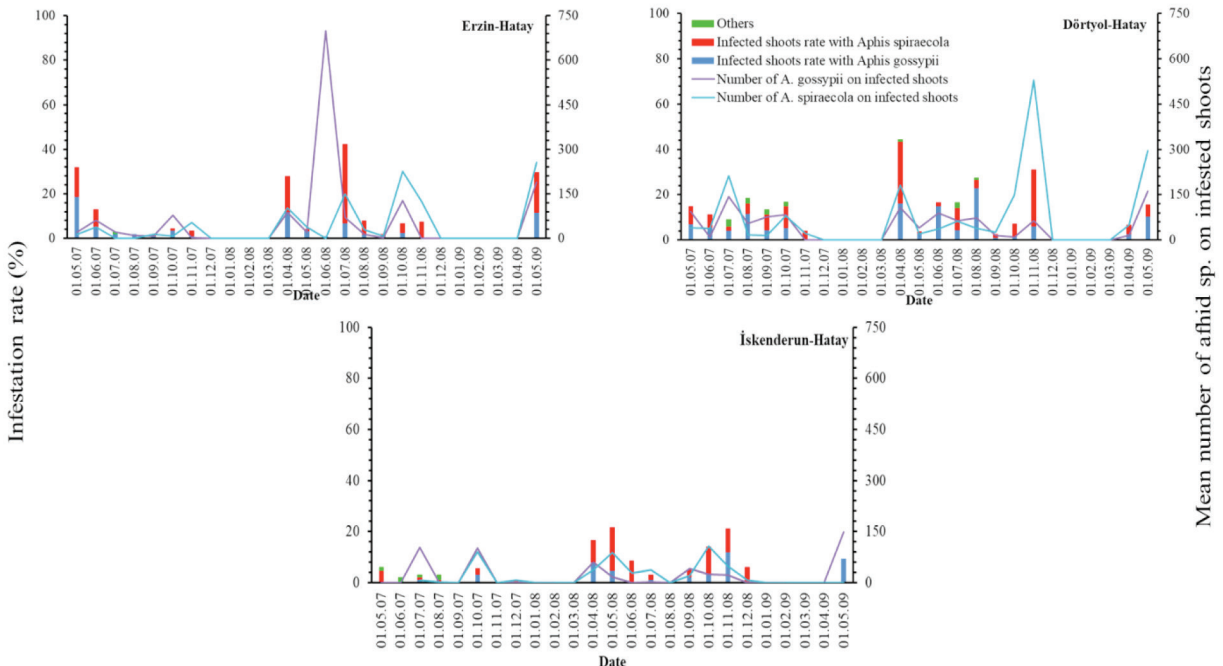


Figure 9. *Aphis gossypii*, *Aphis spiraecola*, and others in Hatay province with monthly average numbers and percentage concentrations from May 2007 to June 2009

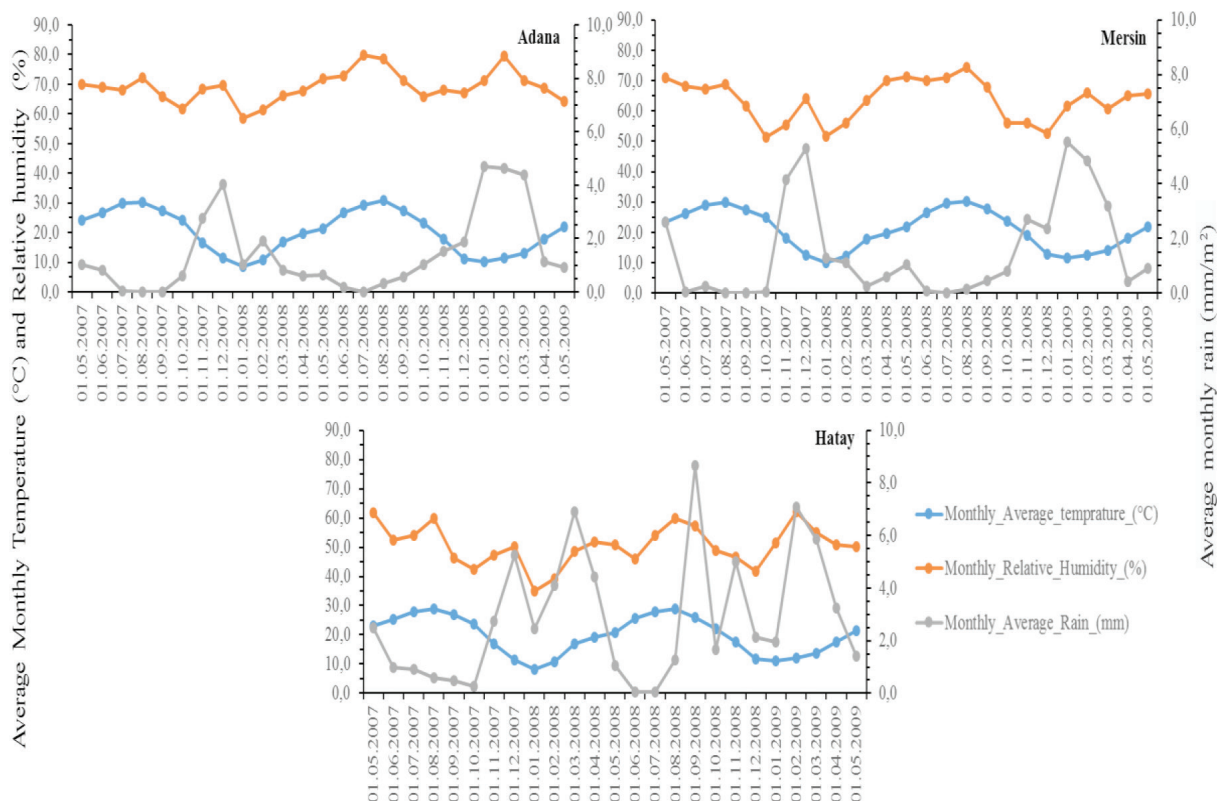


Figure 10. Weather condition in Adana, Mersin and Hatay provinces in from May 2007 to May 2009

cotton production near citrus production areas, so *A. gossypii* population found higher in Karataş than other sub-regions (Anonim 2012). Atakan and Özgür (1996) stated that *A. gossypii* was frequently encountered in May, June, and July in their study in cotton fields in Çukurova. In the following period, such as September, as there are no young leaves on cotton to attract aphids, they migrate to other hosts. These findings confirm the population formed in September in the study. Zeren (1989) reported that *A. gossypii* was present in the detection of aphid parasitoids in vegetable fields in the Çukurova region. *A. spiraeicola* was determined as the highest mean number of aphids (196.4) on shoot in June 2008. About contamination percentage, *A. gossypii* was determined as 11, 15.1, and 22.5 aphids/shoot respectively in April, May, and June 2008. *A. spiraeicola* also remained high in the same months. The other species was observed at low levels in May and August in 2007, and in April in 2008. In the study carried out in Greece, *A. (T.) aurantii*, *A. gossypii*, and *A. spiraeicola*, especially in citrus orchards, were determined in late spring-early summer (Katsoyannos et al. 1997). The population was determined at the end of the spring months and in the first months of summer.

*A. spiraeicola* in Silifke district of Mersin province had the highest mean 387 individuals on 01.03.2008, followed with 187 aphids/shoot on 01.11.2008, and reached the third-highest point with 232 aphids/shoot on 01.05.2009. In the other two

years surveyed in Silifke, *Aphis spiraeicola* population was observed as low (Figure 8). *Aphis gossypii* populations were 700, 101, 38, 70 and 128 aphids/shoot in another sub-region was Yenice on 01.06.2007, 01.11.2007, 01.05.2008, 01.10.2008 and 01.05.2009, respectively. *Aphis spiraeicola* population 34, 110, 88, 200 and 78 aphids/shoot were determined on the same dates, respectively. These findings show that different aphid species caused a higher population in different sub-region of Mersin. Different aphid species also caused a higher population at different years in the same sub-region. For example, *A. gossypii* was high in 2007 in the Tarsus sub-region, the *A. spiraeicola* population was high in other years.

*Aphis spiraeicola* reached pick level as 212 aphids/shoot in July in 2007, 181 aphids/shoot in April and the highest 530 aphids/shoot in November in 2008, and 296 aphids/shoot in May in 2009 at Dörtyol, one of the sub-regions of Hatay province (Figure 9). In the same sub-region, *A. gossypii* reached a peak in the same months, but it was lower than *A. spiraeicola*, the highest was 161 aphids/shoot, in May 2009. The population in Erzin of *A. spiraeicola* was high as in Dörtyol, and the highest was determined as 256 individuals in May 2009 (Figure 9). The highest *A. gossypii* population (700 individuals/shoot) was in June 2008 in the Erzin sub-region, but it also remained high in October 2007 and 2008 (77 and 127 aphids/shoot). Interplanting of vegetables between the young citrus orchards in the region may have led to an increase in the population of

*A. gossypii*. Zeren (1989) reported that *A. gossypii* was found in vegetable fields in Dörtöyl district of Hatay.

Despite tens of natural enemies on aphids (Satar and Uygun 2008, Satar et al. 2014), they can become the main pests of citrus orchards not only in young plants but also in middle and old age orchards in favorable seasonal conditions, especially in periods when late spring rains are abundant (Figure 10). Besides *A. gossypii* and *A. spiraecola*, *A. craccivora* is sometimes become a problem, especially in middle-age orchards. Moreover, the short development period of aphids and their ability to produce 100 nymphs in the following 5-10 days after becoming adult, they become harmful on the plants and build up big aphid population before natural enemies putting pressure on aphids (Satar et al. 1998, Satar et al. 2005). Therefore, contrary to the classical view, biological control should be re-planned include methods to be applied as an area-wide rather than on an orchard basis. Also, research should be carried out on applications that will support biological control factors such as intermediate planting among citrus fruits, selection of plants to be selected as hedge plants.

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#### ÖZET

Doğu Akdeniz Bölgesi turuncğil bahçeleri pek çok böcek ve hastalık etmeninden dolayı zarar görmektedir. Bunların içinde yaprakbitleri (Hemiptera: Aphididae) önemli gruplardan bir tanesidir. *Aphis craccivora* Koch, *Aphis gossypii* Glover, *Aphis spiraecola* Patch, *Aphis (Toxoptera) aurantii* Boyer de Fonscolombe ve *Myzus (Nectarosiphon) persicae* (Sulzer) gibi türler genç turuncğil bahçelerinde zarara sebep olabilmektedir. Bu çalışmada bu yaprakbiti türlerinin bölgesel dağılımı, mevsimsel yoğunlukları, turuncğil türleri arasındaki tür ve yaş tercihleri Adana, Mersin, Osmaniye ve Hatay illerinde belirlenen 15 alt bölgede 2007 ve 2009 yılları arasında çalışılmıştır. Mandarin turuncğil türleri arasında en fazla tercih edilen tür olurken, altıntop ise bu türler arasında en az tercih edilen tür olmuştur. Mersin bölgesi turuncğil türleri içinde *A. spiraecola* en fazla limonda gözükürken, *A. (T.) aurantii* tüm turuncğil türleri içinde en fazla mandarinde tespit edilmiştir. Adana ve Hatay bölgesinde ise mandarin *A. craccivora*, *A. gossypii*, *A. spiraecola* ve *A. (T.) aurantii* türleri için en fazla tercih edilen turuncğil türü olmuştur. Farklı turuncğil yaşlarında yaprakbiti yoğunluklarında bölgelere göre farklılık görülmüştür. *A. (T.) aurantii*

11-20 yaş aralığında Hatay'da, 21-40 yaş aralığında ise Mersin'de en yüksek bulunma oranına sahip olmuştur. Turuncğil türlerinin varlığına paralel olarak yaprakbiti tür ve dağılımı da etkilenmiştir. Limon bu turuncğil türleri içinde *A. spiraecola* tarafından en çok tercih edilen tür olmuştur. Mersin ve Hatay bölgesine göre daha zengin bir bitki desenine sahip olan Adana'da farklı türlerde en fazla yaprakbiti yoğunluğu tespit edilmiştir. *Aphis gossypii* ve *A. spiraecola*'nın bahçelerde sadece bahar aylarında değil haziran ve temmuz aylarında da %30-40'lara varan bulaşıklık oluşturmaları ve yine sonbahar aylarında da yoğun gözükmeleri bu zararlıları dört mevsimin zararlısı yapmış durumdadır.

Anahtar kelimeler: *Aphis*, konukçu tercihi, popülasyon dalgalanması, yaş tercihi, *Aphis (Toxoptera) aurantii*, *Myzus persicae*

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