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Original article (Orijinal araştırma)

Seasonal population dynamics of *Aceria oleae* (Nalepa, 1900) (Acari: Eriophyidae) in generative organs of olives in Hatay Province, Turkey[1]

Hatay İli'nde zeytinin generatif organlarında *Aceria olea* (Nalepa, 1900) (Acari: Eriophyidae)'nın mevsimsel popülasyon değişimi

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Abstract

Olive, *Olea europaea* L., is an evergreen tree native to areas with Mediterranean climates. Its fruit and oil are key ingredients in the Mediterranean cuisine. Olive gall mite, *Aceria oleae* (Nalepa, 1900) (Acari: Eriophyidae) is a mite species that feeds on olive leaves, buds or flowers. This study was conducted to determine the population dynamics of *A. oleae* in generative organs of olive in Altınözü, Antakya and Samandağ Districts of Hatay between in April and October 2017 and 2018. The highest mite density was detected in Altınözü during the flowering period in 2017 and the budding period in 2018; and a second peak was seen during fruiting period for both years. A peak occurred in samples collected from Antakya for both years (in fruit stage, June 2017, and in budding stage, April 2018) but no prominent peak was noted Samandağ samples. A high rate of flower and fruit dropping was observed and this concurred with noticeable decreases in *A. oleae* population in Altınözü and Antakya Districts in both years. Three phytoseiid species, *Typhlodromus* (*Anthoseius*) *athenas* Swirski & Ragusa, 1976 (44%), *Typhlodromus* (*Anthoseius*) *rapidus* Wainstein & Arutunjan, 1968 (29%) and *Typhlodromus* (*Typhlodromus*) *athiasae* Porath & Swirski, 1965 (26%) (Acari: Phytoseiidae) were detected in these orchards. It is thought they probably fed on *A. oleae* since their primary prey, tetranychid mites were unavailable. Correlation results showed that population sizes of *A. oleae* did not decrease significantly with temperature and humidity in 2017. In 2018, the population was negatively correlated with temperature, but no significant increase occurred as humidity rose.

Keywords: Olive, olive gall mite, population dynamics, Turkey

Öz

Zeytin, *Olea europaea* L., Akdeniz iklimine sahip bölgelere özgü, yaprağını dökmeyen bir ağaçtır. Meyvesi ve yağı, Akdeniz mutfağının temel malzemeleridir. Zeytin tomurcuk akarı, *Aceria oleae* (Nalepa, 1900) (Acari: Eriophyidae) zeytinin yaprakları, tomurcukları veya çiçekleriyle beslenen bir akar türüdür. Bu çalışma, Hatay'ın Altınözü, Antakya ve Samandağ ilçelerinde bulunan zeytinlerin generatif organlarında, 2017-2018 yıllarının Nisan-Ekim ayları arasında *A. oleae*'nin popülasyon dalgalanmalarını belirlemek amacıyla yapılmıştır. Altınözü'nde en yüksek popülasyon yoğunluğu 2017'de çiçeklenme döneminde, 2018'de tomurcuk döneminde tespit edilmiştir. Altınözü'nde her iki yılda meyve döneminde ikinci pik görülmüştür. Antakya'dan toplanan örneklerde her iki yıl için de tek pik meydana gelmiştir (Haziran 2017'de meyve döneminde ve Nisan 2018'de tomurcuk döneminde). Ancak Samandağ örneklerinde belirgin bir tepe noktası belirlenmemiştir. Altınözü ve Antakya ilçelerinde her iki yılda da yüksek oranda çiçek ve meyve dökümü görülmüş ve bu durum *A. oleae* popülasyonunda meydana gelen gözle görülür düşüşlerle uyumlu olmuştur. Bu bahçelerde, *Typhlodromus* (*Anthoseius*) *athenas* Swirski & Ragusa, 1976 (44.44%), *Typhlodromus* (*Anthoseius*) *rapidus* Wainstein & Arutunjan, 1968 (29.17%) ve *Typhlodromus* (*Typhlodromus*) *athiasae* Porath & Swirski, 1965 (26.4%) (Acari: Phytoseiidae) olmak üzere üç phytoseiid akar türü belirlenmiştir. Bu türlerin muhtemelen birincil avları olan tetranychid akarları mevcut olmadığı için *A. oleae* ile beslendikleri düşünülmektedir. Korelasyon sonuçları, *A. oleae* popülasyon büyüklüğünün 2017'de sıcaklık ve nem ile önemli düzeyde azalmadığını göstermiştir. 2018'de popülasyon, sıcaklıkla negatif korelasyon gösterirken, nemin yükselmesi ile önemli bir artış meydana gelmemiştir.

Anahtar sözcükler: Zeytin, zeytin tomurcuk akarı, popülasyon değişimi, Türkiye

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Introduction

Olive (*Olea europaea* L., Oleaceae) is a broadleaved evergreen tree native to the Mediterranean basin and other areas with Mediterranean climates. Its fruit and oil are highly valued and of major agriculture importance, especially in Mediterranean countries. Olives are one of the oldest known cultivated plants that spread from the original Mesopotamia Region of Turkey, which is considered as its origin in the Mediterranean basin. For more than 10 years, the Turkish government has implemented a comprehensive program to support and promote olive growing and production on suitable uncultivated areas. Turkey is the fourth largest producer of olives in the world with 1.5 Gt produced per year, followed by Spain, Italy and Morocco (FAO, 2018). Hatay Province has 6.3% of the olive production areas in Turkey and is ranked sixth among the provinces in the country in terms of olive production (Anonymous, 2015).

Olive-infesting eriophyid mites are economically important agricultural pests that have been reported on olives in Egypt and Tunisia (Abou-Awad et al., 2005; Chatti et al., 2017) from North Africa; in Albania and Greece (Hatzinikolis, 1986; Shahini et al., 2009) from Europe and in Israel (Avidov & Harpaz, 1969) from the Middle East. Tzanakakis (2003) indicated that 12 of the 30-mite species reported from olives belong to the family Eriophyidae. Among these mites, Hatzinikolis (1971) reported that species like *Aceria oleae* (Nalepa, 1900) (Acari: Eriophyidae) damage olive flowers and young fruits, and significantly inhibit growth of olive trees in olive plantations.

Many previous studies have determined the plant feeding pests affecting olive trees and their distribution in olive groves of Turkey; however, only a few of these studies have focused on phytophagous mites, especially eriophyid mites, in such olive plantations. For instance, the first records of the presence of *A. oleae* in Turkey were by Alkan (1952) and İyriboz (1968). The other studies that have studied the presence and have reported the economic importance of eriophyoids, *A. oleae* in particular, in different provinces of Turkey, report that it is in Bursa (Kumral & Kovancı, 2004), in Mersin together with *Aculus olearius* Castagnoli, 1977 (Acari: Eriophyidae) (Çetin & Alaoğlu, 2006) and in seven provinces of the Eastern Mediterranean Region (Kaçar et al., 2010). Çetin et al. (2012) found this species mixed with populations of *A. olearius* in İzmir, Manisa and Balıkesir Provinces. They determined a 26-82% infestation rate of trees and an 8-59% injury rate of fruit by these mites. Also, recently, Ersin et al. (2020) found *A. oleae* mixed with *Tegolophus hassani* (Keifer, 1959) (Acari: Eriophyidae) populations in the same provinces.

Although a study by Kaçar et al. (2010) reported the presence of *A. oleae* in Hatay Province, no detailed information was provided regarding their population dynamics on olive trees. This study was conducted to determine the population dynamics of *A. oleae* in olive orchards in three districts that are the most important districts in terms of production areas in Hatay Province of Turkey. Concurrently, we aimed to detect phytoseiid species on olives in the study area.

Materials and Methods

The study was conducted in Altınözü (36°07'10"N, 36°15'59"E, 269 m), Antakya (36°14’34"N, 36°09'38"E, 90 m) and Samandağ Districts (36°09'27"N, 36°00'40"E, 207 m) in Hatay (Turkey), between the months of April and October in 2017 and in 2018 (Figure 1).

From each district, an orchard with trees infested with only *A. oleae* species were randomly selected, and five trees located at different points in such orchards were sampled. The sampled trees were Gemlik cultivars that were about 25 years old in Altınözü and Antakya, and 15 years old in Samandağ. These cultivars were not irrigated and had no chemical pesticides sprayed on them to control any pests and diseases during this study. According to the phenological stage of the plants, 20 cm long shoots containing buds, flowers or fruits were collected every 2 weeks from the four cardinal directions of each selected tree (20 shoots from each orchard). A pole pruner was used to collect these shoots from a height of 1-1.5 m aboveground. Samples were collected from 11 April to 24 October 2017 and from 29 March to 10 October 2018. Shoot samples were brought to the laboratory and kept in a refrigerator at ~4°C until their inspection. From each of these shoots, five buds or flower clusters or fruits (100 samples of generative organs for each orchard) were taken randomly and examined, and mobile stages of *A. oleae* on these samples were counted directly under a stereomicroscope. Population curves were plotted using averages of the mite populations on five trees for each district.

Eriophyid specimens were collected with insect pins or parts of the plants with mite colonies were cut with a lancet under a stereomicroscope. Collected specimens were preserved in 70% ethanol until identification. Preparations and identifications were made as Keifer (1975 a, b). Identification of the mite was made by Assoc. Prof. Evsel Denizhan (Trakya University, Faculty of Science, Department of Biology, Edirne, Turkey).

Predatory mites (Phytoseiidae) were also collected during the study. Phytoseiid specimens were collected with a fine brush under stereomicroscope. Collected specimens were preserved in 70% ethanol until their preparations. Specimens were cleared in lactophenol solution and mounted in Hoyer medium. The phytoseiids were identified by Prof. Dr. Nabi Alper Kumral (Uludağ University, Faculty of Agriculture, Department of Plant Protection, Bursa, Turkey) according to Çobanoğlu (1997), Swirskii & Ragusa (1976), and Chant & Yoshida-Shaul (1987) for *Typhlodromus* (*Anthoseius*) *rapidus* Wainstein & Arutunjan, 1968, *Typhlodromus* (*Anthoseius*) *athenas* Swirski & Ragusa, 1976 and *Typhlodromus* (*Typhlodromus*) *athiasae* Porath & Swirski, 1965 (Acari: Phytoseiidae), respectively. Identified samples were kept in the collection of Kamuran Kaya at the Department of Plant Protection, University of Hatay Mustafa Kemal, Turkey. Daily and monthly average meteorological data collected by meteorological stations in each district were taken from the Central Hatay Meteorological Station. Correlations between climatic factors and the mite population was performed using SPSS software (SPSS, 2012).

Figure 1. Map showing the three districts where the study was conducted in Hatay Province

Results and Discussion

In Altınözü District, *A. oleae* (Eriophyidae) had similar population density curves in both years of study with two peaks occurring in each year (Figures 2 & 3). These peaks were observed in 9 May and 20 June 2017 (514 mites/20 flower clusters and 232 mites/20 fruits, respectively); and on 12 April and 21 June 2018 (923 mites/20 buds and 558 mites/20 fruits, respectively). The highest density of population was detected during the flowering and budding stages of 2017 and 2018, respectively. The first 4 months of

2018 had higher average temperatures and relative humidity compared to the previous year; this might be the reason for the higher population density. For example, the humidity and temperature values in February were 53.4% and 8.7°C for the year 2017, and 80% and 11.3°C for the 2018 (Figure 4). Similarly, Ersin et al. (2020) found that the highest population densities of eriophyid mites on buds were in April and on leaves and fruits in May and June during their 2016-2017 survey in Western Turkey. In contrast, Abou-Awad et al. (2005) reported the highest population densities of *A. oleae* and *T. hassani* on leaves occurred in mid-July in Egypt. Shahini et al. (2009) also reported that the highest population densities of *A. oleae* on flowers of olive trees were in May and on fruits in June, 2001 in Albania. This information supports our findings. In our present study, the first peak and the highest population were observed on flowers in May (2017) and on buds in April (2018). Second peak in both years were observed in June on fruits, but then the population started to decrease. During this period, the average relative humidity (RH) and temperature values were 62.5% and 24.9°C in 2017 and 66.6% and 24.6°C in 2018, respectively. Vacante (2015) established that *A. oleae* moves to the leaves as the fruit grows and forms denser populations there during the summer. Likewise, we reasoned that the majority of the population moved to the leaves in the presence of optimal conditions for eriophyid mites (data not shown).

The population density of *A. oleae* in Samandağ District was quite low during the whole season. This may be due to the low initial mite population density on the buds since the olive trees in Samandağ were much younger than the ones grown in other districts. Also, Samandağ is located on the coast and such harsh climatic conditions on olive trees, pruning time, and pressure of phytoseiid mite as a result of feeding, may have influenced the population densities of *A. oleae*. While there was no prominent peak for both years, the highest population occurred in 23 May 2017 (38 mites/20 flower clusters) and in 12 April 2018 (51 mites/20 buds) (Figures 2 & 3).

A single peak occurred in Antakya District in both years (Figures 2 & 3); on 20 June 2017 with 201 mites/20 fruits and on 12 April 2018 with 860 mites/20 buds. Also, the higher average temperatures and RH in the first 4 months of 2018 compared to the previous year caused higher population densities in Antakya and this peak population density was reached earlier during these months. Shahini et al. (2009) also detected that between April 2001 and September 2002 the highest *A. oleae* population on fruits for the two consecutive years was in June. Although the climatic factors affect the eriophyid mite population, the reason for different population densities may be due to the local abundance of eriophyids on leaves, buds or fruits (Ersin et al., 2020).

In 2018, the olive trees started their budding, flowering and fruiting periods 2 weeks earlier than in the previous year for all districts. Consequently, *A. oleae* populations were generally higher in 2018 and reached the first peak in Altınözü about a month earlier compared to 2017. In Antakya, the only peak that occurred in both years was in April during the budding period in 2018, which was earlier than the previous year. All of these differences regarding the time of phenological periods, time of peaks and size of mite population may be related to differences in climatic conditions, especially between January-April (Figure 4).

Considerable declines were observed in the populations of the pest starting the end of June in 2017 in the three districts where the study was conducted. In the following year (2018), these declines occurred at the end of April in Antakya and at the end of June in Altınözü. As temperature started rising, the majority of the mite populations moved to the leaves. Also, the high rate of flower and fruit dropping observed in both years resulted in significant decreases in population of the mite in both Altınözü and Antakya. Similar declines were also reported by Çetin et al. (2012). Although the population sizes were apparently declined with temperature and RH in 2017 there was no significant correlation (Table 1). In 2018, the population also was negatively correlated with the temperatures for each district, but at a significant level ($p < 0.05$ for Altınözü and Antakya; $p < 0.01$ for Samandağ). The population was not significantly correlated with humidity in any districts in 2018.

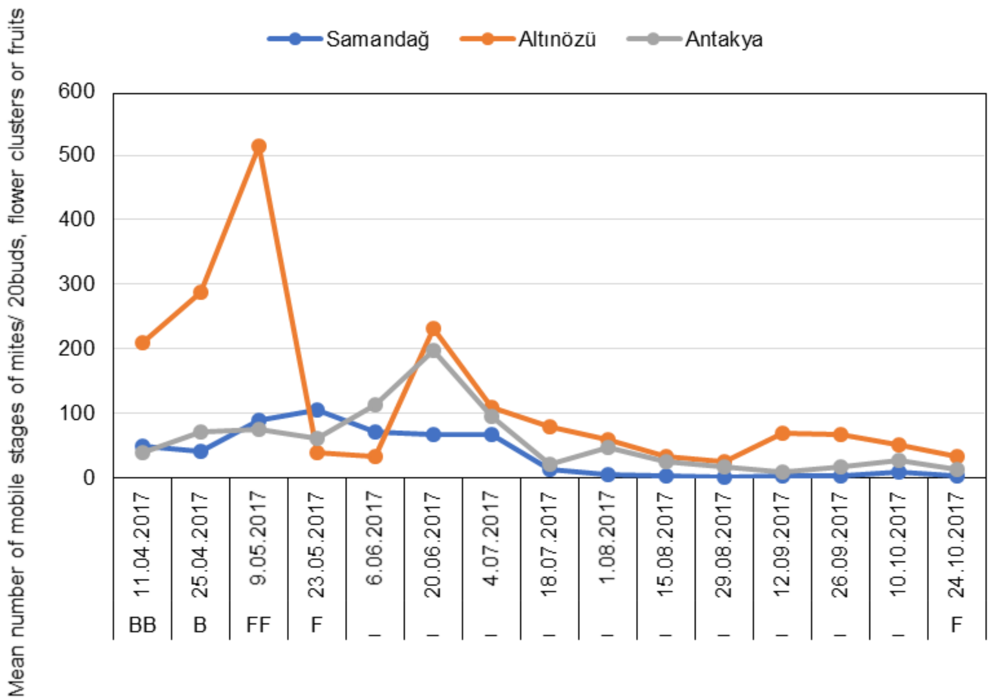

Figure 2. Population dynamics of *Aceria oleae* in three districts of Hatay Province in 2017 (BB, beginning of budding; B, budding; FF, flowering; and F, fruit).

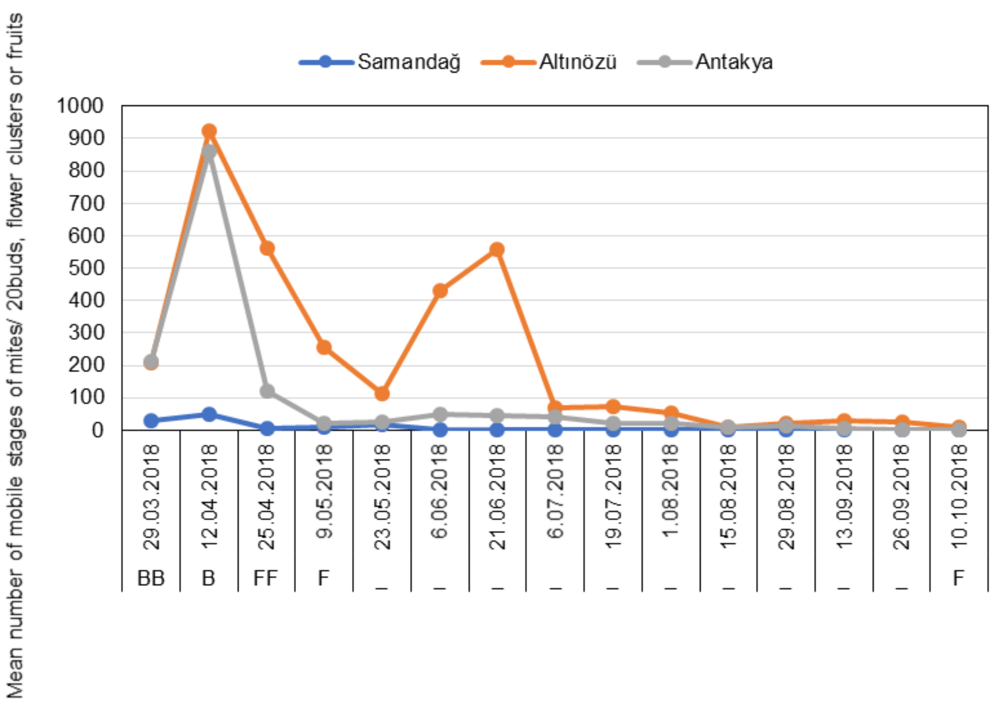

Figure 3. Population dynamics of *Aceria oleae* in three districts of Hatay Province in 2018 (BB, beginning of budding; B, budding; FF, flowering; and F, fruit).

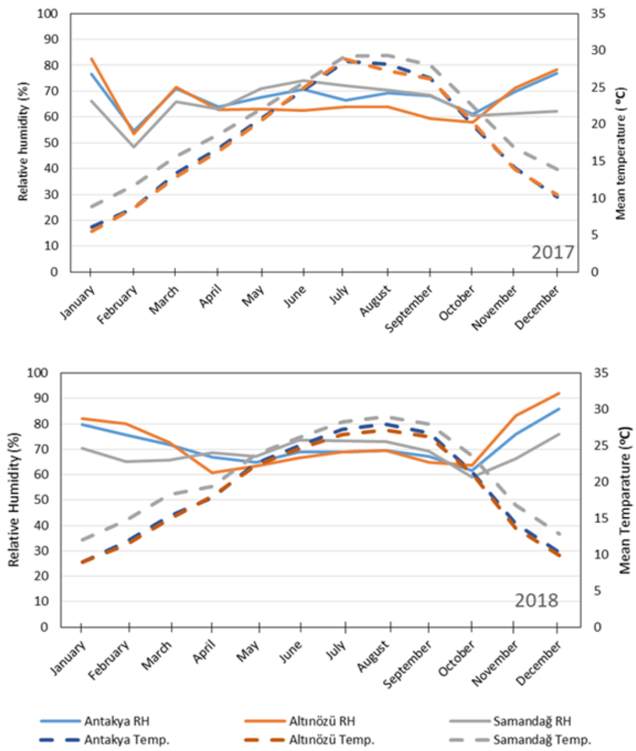

Figure 4. Meteorological data values (RH, relative humidity; and Temp., mean temperature) in three districts in 2017 and 2018.

Table 1. Correlation coefficient between temperature, relative humidity and eriophyid mite population sizes during two consecutive years

	Correlation coefficient values			
	2017		2018	
	Temperature	Humidity	Temperature	Humidity
Altınözü	-0.323	-0.353	-0.581*	0.133
Samandağ	-0.445	-0.151	-0.780**	0.186
Antakya	-0.035	-0.317	-0.612	0.420

* p<0.05; ** p<0.01.

Hatzinikolis (1971) and Shahini et al. (2009) also reported that about 90% of the mites were found in flower clusters. They suggested that the attacks on flowers and fruits resulted in drying and dropping of flowers or premature dropping of fruits. Similar results about flower and fruit dropping were reported by Hatzinikolis (1981), Lindquist et al. (1996) and Denizhan et al. (2015). Also, Çetin & Alaoğlu (2006) reported that *A. oleae* populations were at the highest during budding period, especially close to the bud-burst period; and this high population caused the dropping of buds. In the current study, the olive trees in Altınözü and Antakya were observed to frequently drop their buds during the budding period of 2018.

It was observed that the high population of mite feeding on the olive fruits caused split, deformed and/or small fruits, and also there were silvery or brown spots on and around the stem pit of the fruits. The symptoms observed on fruits collected from Altınözü in 21 June 2018 are shown in Figure 5. Similar symptoms were indicated by many other researchers (Laccone & Nuzzaci, 1977; Lindquist et al., 1996; Elhadi & Birger, 1999; Çetin & Alaoğlu, 2006).

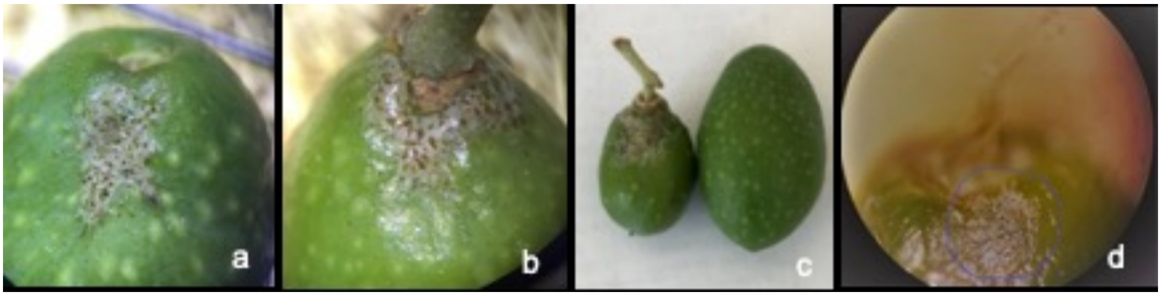

Figure 5. a-b) Symptoms caused by A*ceria oleae* feeding on olive fruit, c) *A. oleae* infested and healthy olive fruit, d) *A. oleae* colony on fruit.

Three phytoseiid mite species were obtained in the orchards where the population dynamics of *A. oleae* were followed. These species and the orchards they collected are given in Table 2.

Table 2. Phytoseiid species and their collection dates in the olive orchards in three districts of Hatay Province in 2017-2018.

	Altınözü		Antakya		Samandağ	
	2017	2018	2017	2018	2017	2018
Typhlodromus (*Anthoseius*) *athenas*	01.08 (1)* 24.08 (1) 10.10 (1)	09.05 (1) 06.07 (1) 19.07 (2) 01.08 (3) 15.08 (2)	05.04 (1) 09.05 (1) 04.07 (1) 26.09 (2) 10.10 (1) 24.10 (2)	25.04 (1) 06.07 (1) 19.07 (3) 01.08 (2) 15.08 (3)	04.07 (1)	01.08 (1)
Typhlodromus (*Anthoseius*) *rapidus*				22.06 (1) 06.07 (1) 19.07 (1) 01.08 (1) 15.08 (9)	04.07 (1)	06.06 (1) 06.07 (1) 19.07 (5)
Typhlodromus (*Typhlodromus*) *athiasae*		09.05 (1)	18.07 (9)		09.05 (2) 24.08 (3)	19.07 (2) 01.08 (1) 15.08 (1)

* The numbers in parentheses indicate the number of individuals.

All three species were observed in Samandağ and *T. athenas* was observed in all districts in both of the years. *T. rapidus* was found in Antakya in 2018 while it was not observed in Altınözü. *Typhlodromus athiasae* was detected in Antakya in 2017 and in Altınözü in 2018. The most common species were *T. athenas* in Antakya and Altınözü, and *T. athiasae* in Samandağ. According to the collected samples, incidence rates of *T. athenas*, *T. rapidus* and *T. athiasae* were 44, 29 and 26%, respectively. Previous studies have determined that *T. athiasae* is the most common species in Turkey. It was found for first time on citrus orchards in Turkey (Antalya) by McMurtry (1977). In subsequent studies, while *T. athiasae* was detected on many host plants, it was reported as one of two most abundant species in olive orchards only in Bursa (Kumral et al., 2010). Kumral (2005) found *T. athiasae* on trees of six different pome and stone fruits and specified that the species was commonly found in areas where the Tetranychidae species were found. These phytoseiid mite species we detected prefer tetranychid mites as food but as no tetranychid mites were on the olive trees we studied, we reasoned that these phytoseiids fed on *A. oleae*. Ersin et al. (2020) also reported that the phytoseiids detected in their survey probably feed on eriophyid mites since their primary prey (tetranychid mites) were not found in these olive orchards.

Also, it has been determined that some phytoseiids are capable of reducing populations of *A. oleae* in olive production (Abou-Awad et al., 2005). Momen (2009) reported that developmental periods of *T. athiasae* were similar when reared on *Eriophyes dioscoridis* Soliman & Abou Awad, 1977 and *Tetranychus urticae* Koch, 1836. Also, a higher net reproduction rate in a shorter mean generation time was observed when reared on *E. dioscoridis*. These results give important information on the superiority of predacious mite *T. athiasae* over eriophyid mite. *Typhlodromus athenas* has been frequently observed on olive trees in previous studies (Chatti et al., 2017). It has been reported that this species is well adapted to high temperatures occurring in the Mediterranean Region and it may be a useful biological control agent (Kolokytha et al., 2011). *Typhlodromus athenas* was first reported on olives from the Western Turkey by Ersin et al. (2020). *Typhlodromus rapidus* was recorded before by Çobanoğlu (1997) on hazel and Çakır et al. (2020) on walnut; however, there is no record on olive in Turkey. This study is the first to report the three phytoseiid species detected in olive growing areas of Hatay. These records are valuable because the phytoseiid mites play an important role in preventing outbreaks of various phytophagous mites, especially tetranychid and eriophyoid mites, in natural habitats (Edland & Evans, 1998).

According to Abou-Awad et al. (2005), differences in eriophyid mite populations can be caused by many factors such as variety, shady/sunny or height from the ground where sample was taken from the tree and leaf age. In addition to these factors, differences in meteorological data between districts and natural enemies are thought to have an impact on these populations. Recently, Ersin et al. (2020), determined that there were differences in the population densities of eriophyid mites in different orchards during the same period. According to their comments, the reason for their high number in some years might be their local abundance on some leaves, buds or fruits. Some phytoseiids were shown to be capable of controlling the population of *A. oleae* in olive nurseries (Abou-Awad et al., 2005). Also, it was reported that *T. athiasae* was successful in controlling tetranychids and eriophyids on some fruit species (McMurtry, 1977; Kumral & Kovancı, 2007). Thus, some authors have reported that there is a stable mite community with a positive relationship between phytophagous mites and their predominant predators (Amano & Chant, 1990; Abou-Awad et al., 2000).

In the current study, the seasonal status of the populations of *A. oleae* in generative organs of olives in three districts of Hatay Province (Turkey) was observed. The highest density of population was detected on flowers in May and fruits in June 2017; and on buds in April and fruits in June 2018. The high rate of bud, flower and young fruit dropping, deformations and smaller fruit formations occurred depending on the mite population. It was also determined that different species of phytoseiid mites were widespread in olive orchards. Further studies on this pest, i.e. resistance or susceptibility to different olive cultivars, effects of the mite on yield and product quality or olive oil obtained, and interactions with its predators, would contribute to fundamental knowledge and also to the implementation of the integrated pest management studies.

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