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Population Fluctuation of Thrips Species (Thysanoptera: Thripidae) in Nectarine Orchards and Damage Levels in East Mediterranean Region of Turkey

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ABSTRACT

The occurence and population fluctuation of thrips (Thysanoptera) and damage to nectarines were studied in four orchards at two locations Adana and Mersin in the east Mediterranean Region of Turkey during 2005 and 2006. Direct sampling of nectarine flowers before petal fall revealed 12 thrips species with, western flower thrips, *Frankliniella occidentalis* (Pergande) the most common and abundant species followed by *Thrips tabaci* Lindeman and *Thrips major* Uzel. Adult thrips were first recovered from flowers during early bloom whilst thrips larvae (first instars) were first detected at the beginning of petal fall. The highest average number of thrips per flower (0.65 adults, 0.45 larvae in 2005; 3.80 adults, 4.92 larvae in 2006) were in an orchard located in Mersin where the most thrips damage to fruit was recorded. Damage was the least in an orchard in Adana where the thrips abundance in the flowers were the lowest. Therefore, a direct correlation between damage to fruit and abundance of thrips in the flowers could be inferred. Thrips were also counted from sticky traps from flowering until trap catches ended in the Fall. Thrips populations generally peaked once in all orchards except Alifakılı/Mersin where up to 4 peaks occured until harvest. The highest trap catches during the bloom period were recorded in Alifakılı orchard where the most fruit damage was noted in both years. It is concluded that the data from direct counts in flowers and trap counts during the bloom period could be a suitable prediction method for estimating fruit damage. In the trial orchards, fruit damage for both years ranged between 17.7% and 73.8 % depending on the orchard. This study indicated that two insecticide applications during flowering period; one at the beginning and one at the end of petal-fall stage is needed and therefore suitable insecticides should be registrated for thrips control in nectarines.

Key words: Frankliniella occidentalis, *Thrips tabaci*, *Thrips major*, nectarine, fruit damage.

INTRODUCTION

Thrips (Thysanoptera) are an economic problem in nectarine, plum, citrus, loquat, strawberry, and grape crops in Turkey. If the infestation occurs during flowering period and early fruit development, oviposition activity in the flower buds and the feeding by thrips larvae and adults on developing fruitlets in nectarines will cause severe russetting and brown scars on the fruit surface. Thrips infestations on ripening fruit (at the time of fruit swell) 15-20 days before harvest results in superficial smooth and pale surface blemishes referred to as silvering of fruit (Lewis, 1973; Yonce *et al*., 1990;

Ripa and Rodriguez, 1993; Guarino and Tocci, 1994; Gonzales *et al*., 1994; Felland *et al*., 1995; Teulon *et al*., 1994; Grasselly and Lacasa, 1995; Pearsall, 2000a; Tomassini *et al*., 2004; Sengonca *et al*., 2006; Tavella *et al*., 2006, Hazır, 2008, Atakan, 2008). Both types of damage result in economic losses to growers through culling of fruit. Previous works on thrips species revealed that *Frankliniella occidentalis (Pergande), Frankliniella cestrum* Moulton*, Frankliniella intonsa* (Trybom)*, Thrips tabaci* Lindeman*, Thrips major* Uzel*, Thrips meridionalis* (Priesner)*, Thrips angusticeps* Uzel*, Thrips minitissimus* Linnaeus*, Thrips obscuratus* Crawford (absent in Turkey), *Taeniothrips inconsequens* Uzel, and *Taeniothrips meridionalis* Priesner were associated with fruit damage on nectarines (Kourmadas *et al*., 1982; Cravedi and Molinari 1984; McLaren 1992; Cinti *et al*., 1993; Ripa and Rodrigez 1993; Teulon and Pennmann 1994; Felland *et al*., 1995; Gargani 1996; Rouzet *et al*., 1997; Pearsall 2000a, 2000b, 2001; Marullo 2001; Reuveni ve Vierbergen 2005; Sengonca *et al*., 2006; Tommasini and Ceredi, 2007). There were some studies in a few Mediterranean countries associated with fruit damage levels of thrips. In one study in Spain, Gonzales *et al*., (1994) determined that 0,02 thrips/flower part caused more than 10% damage on fruit. In another study, according to data of Sengonca *et al*., (2006), the rate of non-marketable fruit of an early nectarine variety was 37.8% in north Cyprus. In the east Mediterranean Region of Turkey, little was known about the species of thrips causing damage on nectarine fruit, population fluctuation, and the rate of damage. Thus, the main objectives of this study were: (1) to determine the species, (2) to obtain information on the population fluctuation of thrips both in flowers and on sticky traps, (3) to determine the damage rates, and (4) to examine the predictive ability of counts on sticky traps and flowers for estimating the damage.

MATERIAL AND METHODS

Study Area

This study was carried out in four nectarine (*Prunus persica nucipersicae* C. K. Schneid) orchards in Adana and Mersin provinces in southern Turkey (East Mediterranean Region). Orchards Yunacık (B1) and Alifakılı (B2) were located in Tarsus/Mersin. Orchard B1 consisted of 3 hectares planted with six-year-old nectarines (variety Silverking); orchard B2 was 6 hectares in size planted with four-year-old nectarines (variety May Glo) and loquats. Orchards Hadırlı (B3) and Koyuncu (B4) were located in Seyhan/Adana. Orchard B3 consisted of 4.5 hectares, planted with four-year-old nectarines (variety NectaRed) and citrus, whilst orchard B4 was 5.5 hectares, planted with seven-year-old nectarines of an unkown variety and citrus. With the exception of orchard B1, which was in the second year of conversion to organic production, all orchards were operated conventionally, receiving various pesticides against Mediterranean fruit fly, Peach twig borer, Oriental fruit moth, Peach scale, Shoot hole, Peach powdery mildew, and Peach leaf curl throughout the growing season. Orchards B1 and B2 did not have any weeds on the ground, while orchards B3 and B4 had flowering weeds.

Population fluctuation of thrips in nectarine flowers

Changes in thrips abundance in nectarine flowers was monitored between 3-31 March in 2005 and 21 February -12 April in 2006 in all four orchards. In each orchard 10 trees were randomly selected and 10 flowers were picked from each tree (100 flowers/orchard) from pink bud to husk-fall stage. Seven bud counts were made in 2005. But in 2006 eleven counts were done due to longer flowering period. Immediately after picking, flowers were placed into marked paper bags for later analysis. In the laboratory, a piece of cotton treated with ethyl acetate was placed into each paper bag to immobilize any thrips present in flowers. Thrips inside the flowers were collected by vigorously knocking the flowers into a white, plastic container for about 5 seconds. Flowers were then teased apart to collect the hidden individuals inside the buds. The number of adult and larval thrips per orchard at each sampling date were recorded in order to get the data for population density in flowers. The extracted adult thrips were picked up with a fine brush and stored in a plastic vial (2 ml) containing 8 parts 60% ethyl alcohol +1 part acetic acid +1 part glycerin for later identification. Adults were identified to species by İrfan Tunç and Ekrem Atakan.

Population fluctuation of thrips on yellow sticky traps

To determine the aerial population fluctuation of adult thrips, yellow colored plexiglass traps (15 cm X 20 cm) coated with adhesive (Stickem Special) were used. Traps were placed 1-1.5 m high in the southern canopies of five randomly selected trees (one in the center of the orchard and one tree in the middle near each edge on the four sides of the orchard) on 22nd February in 2005 and 14th February in 2006 in each orchard. Tree phenology was in bud swell stage (flower buds were 0.2 inch) at trap hanging dates. Traps were counted and replaced weekly before harvest and every two weeks after harvest until no more thrips were caught on traps. The thrips on traps were counted by using a 10X hand loop and recorded. Trapped thrips were not identified into species because it was nearly impossible to separate thrips intact (undamaged) from the sticky traps. Therefore, only the amount of total adult thrips was evaluated. Adult flight activity was estimated by averaging the number of adults caught on the five traps for each orchard on each sampling date.

Weed Sampling

In this study, flowering weeds on the orchard floor among the nectarine trees that serve as alternative feeding, egg-laying, and overwintering sites for Thysanopteran species were sampled. Weeds were sampled on the periodic sampling days of nectarine flowers. Samples were wrapped with paper then placed in a plastic bag and brought to the laboratory for later analysis. After identification to species (by Eda Aksoy), weeds were tapped in a white bowl to collect the thrips within the flowers. Thrips in the bowl were picked with a brush and preserved in the alcohol mixture until identification.

Damage assessment

This study was conducted 10 days before harvest. In each orchard (B1, B2, B3, B4) 100 trees were randomly selected and 10 fruits from each tree (for a total of 1000 fruits/orchard) were scrutinized to rate for the injury caused by thrips. Fruits weren't picked but monitored on the tree. Rating for injury wasn't conducted by using a scale. Any fruit having russeting or silvering injury larger than 0.2 inch was accepted as damaged. By this study, damage level percentage for each orchard was determined.

Statistical analysis

A correlation analysis was applied to determine the relation between thrips adult and larvae density in nectarine flowers; adult density on traps, and fruit damage (%) ($P<0.05$). All statistical analysis was performed using SPSS software version 11.0 Windows (SPSS Inc.,2003).

RESULTS

Species

Seven thousand flowers were sampled during the two-year-study. A total of 12 Thysanopteran species were collected from flower samples. These species were *Frankliniella occidentalis* (Pergande), *Frankliniella intonsa* (Trybom), *Thrips tabaci* Lindeman, *Thrips meridionalis* (Priesner), *Thrips major* Uzel, *Thrips minutissimus* Linnaeus, *Thrips angusticeps* Uzel, *Isoneurothrips australis* Bagnal, *Melanthrips* sp., *Melanthrips pallidior* Priesner, *Tenothrips frici* (Uzel), and *Tenothrips discolor* (Karny) with four species - *F. occidentalis* (35.3% in 2005 and 65.3% in 2006), *T. tabaci* (29.9 % in 2005 and 23.1% in 2006), *T. major* (12.9 % in 2005 and 7.1% in 2006) and *T. meridionalis* (4.0 % in 2005 and 3.0 % in 2006) comprised 82-98 % of the total individuals caught. *Isoneurothrips australis* Bagnall (13.9 %) was abundant in flower samples collected in 2005 but absent in 2006 samples. The weeds in the orchards were of family Brassicaceae (*Brassica rapa* L, *Capsella bursa pastoris* L , *Raphanus raphanistrum* L., *Sinapis arvensis* L.); Asteraceae (Taraxacum *officinale* Weber, *Senecio spp. (S. vernalis, S. vulgaris)*; Lamicaceae (*Lamium sp.)* and Fabaceae (*Trifolium repens* L). Thrips species found on weeds were *T. tabaci* and *F. occidentalis* comprised 72.8% and 15.8% respectively of total individuals in 2005.

Population fluctuation of thrips on yellow sticky traps

In 2005, the first thrips in the orchards in Mersin (B1 and B2) were caught on traps on 28 February. During flowering period between 7-31 March, high amounts of adult thrips were caught on traps in B2 orchard while lower amounts were caught in B1(Fig.1, Fig. 2). One small peak occured in B1 until petal fall stage on 31 March while two larger peaks occured in B2. In Adana orchards (B3 and B4), adult thrips were first caught on 16 March. During flowering period of nectarines, the amount of adult thrips on traps were very low in both orchards (Fig. 3, Fig. 4). Thrips populations peaked in the beginning of May in Mersin orchards and at the end of May in Adana orchards. In

all orchards, amount of thrips on traps decreased after harvest. Harvest commenced on the last days of May in B1 and B3 orchards while it was in the beginning of June in B2 and B4 in both years. Zero counts within the orchards B1, B2 and B3 occured in August and in B4 in September.

In 2006, the first thrips were caught on 21 February, at the bud period of flowers, in all orchards. During flowering period between 7 March-12 April, there were an increasing population of adult thrips in Mersin orchards while very little amounts were caught in Adana orchards (Fig.5,6,7,8). The first peak was occured in B2 on the last days of April. In all orchards, population peaks occured in the beginning and at the end of May and in the first days of June. Population continued with diminishing numbers in B1 and B3 orchards while adult thrips on traps decreased to very low numbers in B2 and B4 after harvest.

Population fluctuation of thrips individuals in nectarine flowers

The mean number of adult and larval thrips in nectarine flower buds varied depending on location, with thrips more abundant in orchards in Mersin (B1 and B2) than orchards in Adana (B3 and B4). Adult thrips were first collected on 7 March in 2005 and on 14 March in 2006 during early bloom (Fig.1-8). Adult numbers increased at full bloom and peaked at the beginning of petal fall. Thrips larvae (first instars) were first detected in the flowers on 25 March in 2005 and on 7 April in 2006 during petal fall (Fig.1-8). More adult thrips were collected from orchard B2 than all other orchards in both years while B4 had the lowest adult numbers. The highest larvae numbers were recorded in B1 orchard in 2005. Larvae density was very high in the flowers of B2 in 2006 when compared with B3 and B4. The lowest larval numbers were recorded in B3 in both years.

Damage assessment

Primary type of fruit damage to nectarine fruit was scarring of the fruit surface which occured during the flowering period. This damage was directly related to the thrips numbers in flowers. B2 orchard, which had the highest numbers of thrips in flower buds, also had the highest amount of damaged fruit. Orchard B3 had the lowest larval densities in the flower buds and presented the lowest fruit damage (Table 1). Silvering injury occured less than scarring in the region. The fruit damage was found lower in the orchards B3 and B4 that had weeds and wild flowers on the base than the orchards B1 and B2 that didn't have any weeds in and around the orchard.

Table 1. Correlation between average number of thrips (adult+larvae) per flower, per trap (during flowering period) and damage rates in the orchards examined in 2005 and 2006.

Province	Orchard	YEAR					
		2005			2006		
		Average number of thrips/flower (adult+larvae)	Average number of thrips/trap (adult)	Damage rates (%)	Average number of thrips/flower (adult+larvae)	Average number of thrips/trap (adult)	Damage rates (%)
Mersin	B1	0.15±0.09	15.80±6.06	34.70	0.75±0.38	32.82±11.78	48.50
	B2	0.40±0.13	109.51±46.39	60.10	1.74±0.85	48.60±21.76	73.80
Adana	B3	0.04±0.03	4.14±2.48	17.70	0.06±0.04	3.91±1.40	15.60
	B4	0.07±0.04	5.20±2.64	18.80	0.03±0.02	1.42±0.47	19.80

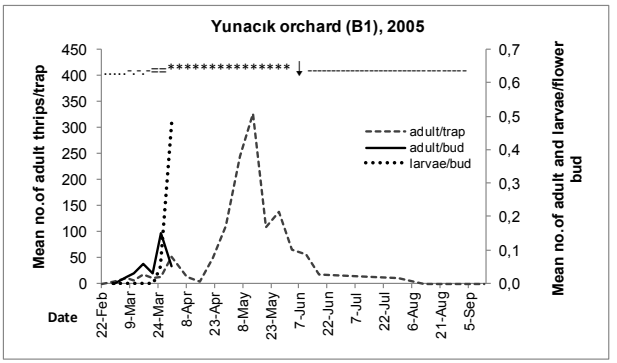

Fig. 1. Population fluctuation of thrips adults and larvae in flower buds and adults on sticky traps in Yunacık orchard (B1) in 2005. (……pink; .-.-.-.-.-full bloom; ===petal fall; ****fruit growing; ↓ harvest; ------post harvest)

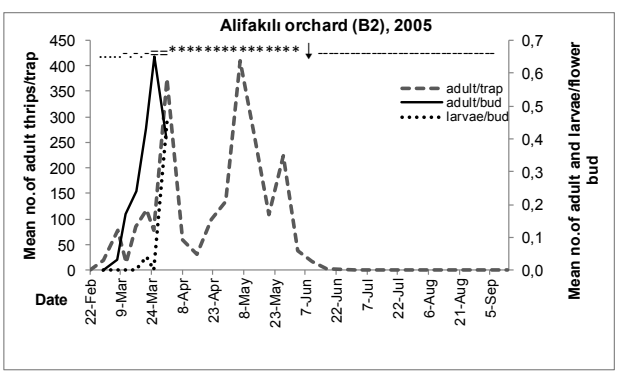

Fig. 2. Population fluctuation of thrips adults and larvae in flower buds and adults on sticky traps in Alifakılı orchard (B2) in 2005. (…..pink, .-.-.full bloom,===petal fall, ***fruit growing; ↓ harvest, -----postharvest)

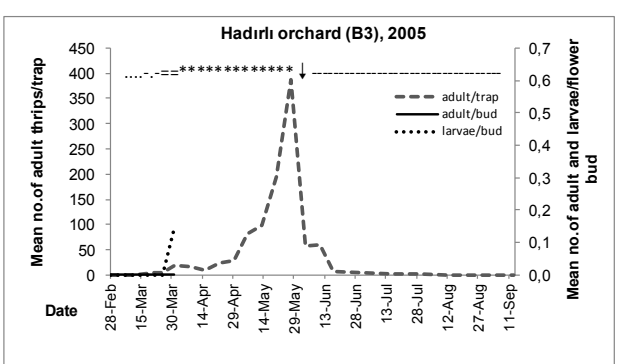

Fig. 3. Population fluctuation of thrips adults and larvae in flower buds and adults on sticky traps in Hadırlı orchard (B3) in 2005. (…..pink, .-.-.full bloom,===petal fall, ***fruit growing; ↓ harvest, -----postharvest)

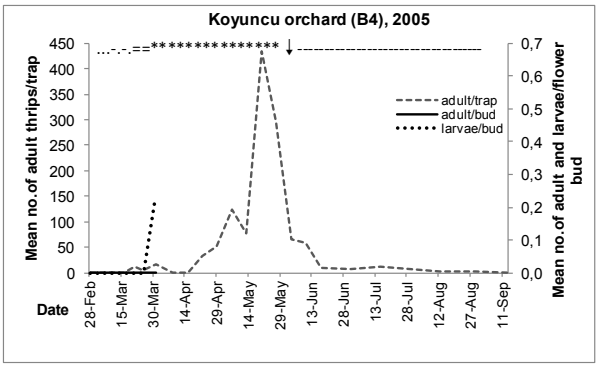

Fig. 4. Population fluctuation of thrips adults and larvae in flower buds and adults on sticky traps in Koyuncu orchard (B4) in 2005. (…..pink, .-.-.full bloom,===petal fall, ***fruit growing; ↓ harvest, -----post-harvest).

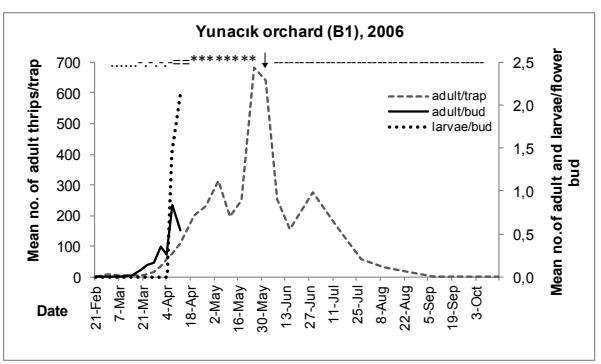

Fig. 5. Population fluctuation of thrips adults and larvae in flower buds and adults on sticky traps in Yunacık orchard (B1) in 2006. (……pink; .-.-.-.-.-full bloom; ===petal fall; ****fruit growing; ↓ harvest; ------post harvest)

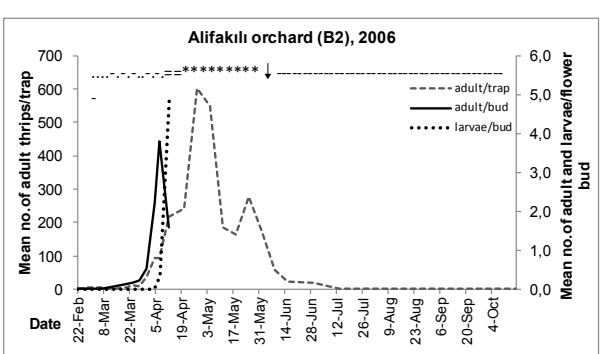

Fig. 6. Population fluctuation of thrips adults and larvae in flower buds and adults on sticky traps in Alifakılı orchard (B2) in 2006. (……pink; .-.-.-.-.-full bloom; ===petal fall; ****fruit growing; ↓ harvest; ------post harvest)

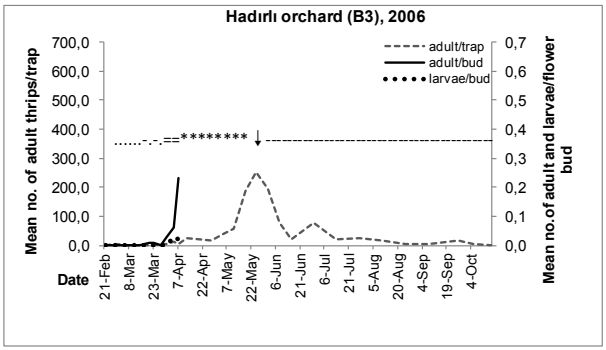

Fig. 7. Population fluctuation of thrips adults and larvae in flower buds and adults on sticky traps in Hadırlı orchard (B3) in 2006. (……pink; .-.-.-.-.-full bloom; ===petal fall; ****fruit growing; harvest; ------post harvest)

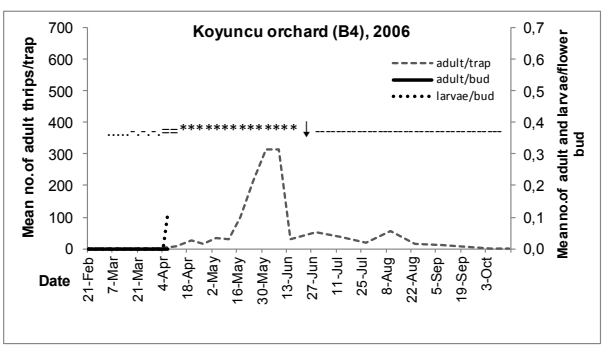

Fig. 8. Population fluctuation of thrips adults and larvae in flower buds and adults on sticky traps in Koyuncu orchard (B4) in 2006. (……pink; .-.-.-.-.-full bloom; ===petal fall; ****fruit growing; harvest; ------post harvest)

DISCUSSION

Twelve thrips species were collected from nectarine flowers during this study, with western flower thrips (*F. occidentalis*), onion thrips (*T. tabaci*), and rose thrips (*T. major*) the most common and abundant species. *Isoneurothrips australis* Bagnall was also recorded from flowers sampled in 2005, which appears to be the first record of this species in nectarine in the region. In Adana, Atakan (2008) found that *F. occidentalis* and *T. major* were the most prevailing thrips species in flowering shoots of nectarine in 2007. In north Cyprus, Sengonca (2006) found that *T. tabaci*, *F. occidentalis* and *T. major* were the most abundant species respectively on nectarine branches between January and June 2004-2005.

Effect of temperature on thrips abundance

Based on trap and flower collection data, it is determined that the abundance of thrips species and economic damage to nectarine crops in Turkey is influenced by air temperature and by the nectarine phenological stage. In Turkey, thrips are active

as adults on plants(especially on weeds) in the field with populations increasing in Spring (Atakan and Uygur, 2004). Our study suggests that thrips adults on weeds in adjacent fields migrate to nectarine orchards in early Spring at the blooming period of nectarines. Low adult numbers were recorded on sticky traps before bud burst in February. Based on mean air temperatures available for our study regions, we suggest that air temperatures were probably too low (9-10°C) for flight activity during this period. But flight activity increased during March to April as mean daily air temperature increased. Trap catches increased after 20 April in 2005, and on 4 May in 2006. In north Cyprus, Sengonca *et al.,* (2006) found that thrips were caught on sticky traps in nectarines from the end of January to the beginning of February, increasing from March onwards, which agrees with our results. Pearsall and Myers (2000) and Lewis (1973) suggest that thrips flight activity is correlated with air temperature. In their study of thrips in nectarine orchards in British Columbia, Canada, Pearsall and Myers (2000) found that *F. occidentalis* started to be caught on sticky traps when mean daily minimum and maximum air temperatures reached 9°C and 15°C respectively (Pearsall and Myers, 2001). Lewis (1973) suggests that the threshold temperatures for flight activity in thrips populations in temperate regions is usually between 17-20°C, depending on the species. In our study, adult thrips became more active and started to be caught on traps in increasing numbers with increasing air temperature (>17°C), peaking at the end of March/beginning of April when the bloom period ended. During the fruit development period, thrips caught on traps increased in all orchards and regions, peaking in May in both years.

Development of larvae also appeared to be influenced by temperature. According to McDonald *et al*., (1998), duration of the developmental stages of *F. occidentalis* from egg to adult was 37.1 days while larvae developed into adults in 28 days at 15°C under laboratory conditions. Adults were first recovered from flowers on 7 March in 2005, and on 14 March in 2006 at full bloom, whilst larvae were first detected at petal fall on 31 March in 2005 and 7 April in 2006, when air temperatures were approximately 15°C. The new generation adults developed from larvae at the end of April which explain the increases in trap catches in the last days of April and in the beginning of May in both years.

The orchards having high densities of thrips caught on sticky traps during nectarine blooming stage had higher fruit damage in both years. Correlation analysis indicated that there was a significant relationship between adult density in traps and fruit damage ($r=0.955$, $r^2=0.913$, $P=0.045$ in 2005; $r= 0.989$, $r^2=0.978$, $P=0.011$ in 2006). With regard to this finding, it can be said that the number of thrips caught on sticky traps during bloom could be a suitable predictive method for estimating final fruit damage due to positive and good relation between each other. However, thrips populations on traps around harvest did not appear to be associated with fruit damage.

Direct sampling of nectarine flower buds revealed that adult thrips were not present in dormant buds (early petal show stage). Adults were first detected at the middle or late petal show stage, and the larvae were first detected around petal fall. Pearsal and Myers (2000), similarly found that *F. occidentalis* did not enter buds until the early

petal show stage, and first-generation larvae were only found on flowers when these were present. The feeding activity of thrips individuals intensified on the ovary at the end of the bloom period, when flower parts desiccate and are shed. Feeding scars occured on the ovary and grew with the swell of the fruit.

Thrips damage to fruit

Most damage in the region was apparent as scarring of the fruit surface, caused by oviposition and feeding activity of thrips at the time of bloom and petal fall. Cultivation of early season nectarine varieties are preferred in the region. Besides weeds, early nectarines are the only vegetation as food for the flower thrips in February. This makes nectarines the “center of attraction” for thrips. There isn’t any insecticide registered against thrips for nectarines in the country so various and unsuitable insecticides are used. The critical time for spraying isn’t known clearly by growers and the pest develops resistance against insecticides. Therefore scarring type of damage is a serious problem in the region. Silvering was the secondary type of damage. This type of damage occurs by thrips feeding in the protected sites such as between two fruits touching each other. Thinning is made manually when the fruit are 0.4-0.6 inch in size. During thinning, twin fruits and fruits touching are picked that reduces silvering damage.

The level of fruit damage appeared to be related with thrips numbers in flower buds (Table 1). Correlation analysis indicated that there was a significant relationship between adult and larvae density in flowers and fruit damage ($r=0.991$, $r^2=0.982$, $P=0.009$ in 2005; $r=0.988$, $r^2=0.975$, $P=0.012$ in 2006). The highest levels of fruit damage occured in B2 orchard, which also had the highest number of larvae (4.92 larvae/flower), whilst B3 orchard had the lowest larval density in flower buds and the lowest amount of damaged fruit. Even though the abundance of thrips in Adana orchards (B3 and B4) per flower were very low, up to 20% fruit damage was determined which showed that very little amounts of thrips populations can cause considerable damage. Similarly, Sengonca(2006) found moderate to severe damage up to 37.9% in orchards with low amount of thrips in north Cyprus. Already, Pearsall (2000) mentioned that even a single larvae may result in serious damage because damage tresholds for adults were very low and zero tolerance level existed for larvae.

Fruit damage was 13.7 % higher in 2006 than 2005, due to a higher number of adult thrips and larvae as a result of higher air temperatures in 2006.

Effect of weeds on thrips abundance

Two orchards (B3 and B4) had flowering weeds [*Brassica rapa* L., *B. orientalis* L., *Capsella bursa pastoris* L. (Medicus), *Raphanus raphanistrum* L., *Sinapis arvensis* L.; Family:Cruciferae (Brassicaceae)] under and among the nectarine trees throughout the nectarine flowering period while no weeds were detected in B1 and B2 orchards because of regular weed control. Thrips species determined in weed flowers were *T. tabaci* and *F. occidentalis* which were also found in nectarine flowers. When the orchards were compared with each other in terms of fruit damage, we concluded that the orchards having weeds on the base had lower damaged fruits than the ones which

didn't have weeds. Considering this information, we suggest that thrips prefered weed flowers over nectarine flowers, and fruit damage was therefore less in weedy orchards. In Canada, Pearsall (2000) found that there was a consistent preference by thrips in the Spring for flowers located at ground level, which agrees with our results. But there are also many other studies conducted in various countries which didn't agree with our results. However, in order to make a precise comment on the relation of flowering weeds and the thrips damage on nectarines, detailed studies must be conducted.

In conclusion, thrips damage is a serious problem for nectarine production of the region. *Frankliniella occidentalis* has been identified as the most abundant species collected from flower samples. In addition to causing economic damage, by decreasing the market value of the fruit, it is also a quarantine pest. Worldwide, *F. occidentalis* is a difficult species to control, since it develops insecticide resistance (REF). In Turkiye, no pesticides are currently registered for the control of thrips in nectarines and, for this reason, growers use pesticides registered for thrips in crops other than nectarine. Pesticide registration is urgently required and should be based on an insecticide resistance management strategy. This should take into consideration any existing resistance in populations of *F. occidentalis* present in Turkiye.

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