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Color Preference, Distribution and Damage of Thrips Associated with Lemon and Orange in Adana, Turkey

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Abstract.- Yellow, white and blue sticky traps were tested in lemon and orange orchards for their attractiveness to thrips in Adana during 2006-2007. Traps were adjusted vertically facing to south at a height of 1.5-2.0 m of trees. Species composition and distribution of thrips in the orchards were investigated by collecting 125 flowers from different directions of the trees. Thrips damage associated with citrus crops was determined by observing 1000 fruits for scars. Blue was the most attractive to thrips in both lemon and orange orchards and can be used to estimate the population density and for properly timing control applications. Fifteen thrips species and unidentified individuals belonging to 3 genera were determined in these orchards. *Frankliniella occidentalis* was the most captured thrips species accounting for 82.0% of the total individuals sampled in both years. Cardinal direction of flowers did not significantly affect the numbers of thrips. Fruit damage for both years ranged between 3.8% and 9.1% depending on the citrus varieties. Lemon was attacked by thrips more than orange.

Key words: Cardinal direction, citrus, sticky trap, fruit damage, *Frankliniella occidentalis*, *Pezothrips kellyanus*, Thysanoptera.

INTRODUCTION

Citrus is an economically important crop in the east Mediterranean region of Turkey where 89% of the country's citrus is produced (Anonymous, 2008). The citrus growing area has considerably increased within last 10-15 years. Parallel to the significant increase of the citrus growing area, not only have there been introductions of exotic pests, but indigenous pest populations have increased. Numerous surveys in citrus orchards in Turkey revealed that thrips are one of the pests that cause damage (Yiğit *et al*., 1991; Tunç, 1992; Tekşam and Tunç, 2007). On fruit, the citrus thrips punctures epidermal cells, leaving scabby, grayish or silvery scars on the rind. This damage, although entirely cosmetic, may result in a reduced quality rating and/or if severe may render the fruit unsuitable for fresh market. Over the past few years, growers have failed to control thrips with insecticides. Reducing thrips densities to low levels by various control methods is considered of vital importance. The use of colored sticky traps for catching thrips could contribute considerably to IPM programs in citrus. Sticky traps may potentially be a rapid, cost-effective tool and provide a simple method of obtaining relative estimates of thrips population densities with little effort. The objective of this work was to address the increasing cases of complaints linked to thrips damage in citrus. This information in conjunction with observations on damage can then be used to determine the relative importance of different thrips species. The status of *Pezothrips kellyanus*, a serious pest of citrus in many countries including those in EPPO region (EPPO, 2005) and *Frankliniella occidentalis* were clarified. Thrips composition, the best trap color for sampling, estimating populations and early detection, citrus species and cardinal direction prefers for the pest thrips were evaluated. Scarred fruit ratio was also determined.

MATERIALS AND METHODS

Study site

The study was conducted in two different citrus orchards at the Çukurova University Research Farm in Balcalı (Adana) in 2006 and 2007. The first one was a lemon orchard with the variety of Kütdiken (2.5 ha, in rows 8 m and between rows 10 m) established in 1966, and the second was a Washington navel orange orchard (2.0 ha, in rows 7 m and between rows 8 m) established in 1971. Lemon and navel orange orchards were chosen for

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experimental sites because of their preference as host for *P. kellyanus* (Blank and Gill, 1997; Baker *et al*., 2001; Conti *et al*., 2001; Vassiliou, 2007). Both orchards were under integrated pest management and during the course of the work no pesticides were applied for any pest control.

Color and citrus variety preferences

Commercially available double-sided sticky cards (Kapar Organic Agriculture Limited Company, Ankara, Turkey) of three different colors were tested for attractiveness to thrips. The colors were yellow (wavelength of 570nm), white (wavelength of 430nm) and blue (wavelength of 480nm). All sticky traps were 470 cm² (23.5 high x 20 wide) and adjusted vertically in the trees before flowering at a height of 1.5-2.0 m (Beaviers *et al*., 1971; Childers and Brecht, 1996) on the outside of the canopy facing to south at the south-west direction of the trees. The experiments were established in a block design; 4 trees were left between the same colored traps (in rows) and 5 trees between the different colored traps (between rows) and conducted with 5 replicates for each trap color. Weekly, traps were removed and changed with the clean ones and returned to the laboratory. Both sides of each trap were counted and the number of thrips was recorded for each trap color and for each citrus variety using a stereomicroscope without looking at its species.

Thrips composition, abundance and distribution

Sampling was concentrated during the flowering period. For the identification of the thrips species, at each sampling date, randomly 125 flowers from different directions (4 cardinal directions and inside-25 from each) of the trees were collected from the orchards, put into polyethylene bags containing paper sheets to absorb excess moisture, transported in ice-boxes to the laboratory. Samples were stored in a deep-freezer for one or two hours to inactive the thrips, then were tapped vigorously on white paper. Thereafter, flower parts were carefully checked and thrips remaining on flower parts were collected by brush. Thrips were stored in glass vials containing a mixture of 9 parts 60% ethyl alcohol with 1 part glacial acetic acid. Adults were identified to species and sex. The number of thrips per flower and the natural enemies were also noted during the examination of the flowers.

Damage assessment

This study was conducted when the diameter of the fruits was ~4-5 cm (in August) (Flint, 1991). In each orchard, 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 observed on the tree by hand lens. Rating for injury wasn't conducted by using a scale. Any fruit deformed by thrips and with scarring on the rind larger than 0.2 inch was accepted as damaged. By this study, damage level percentage for each citrus variety was determined.

Data analysis

Analyses were conducted to determine: 1) if thrips in citrus exhibited significant preferences for specific trap colors, 2) whether citrus variety preference for thrips varied across the trials, 3) if the cardinal direction of flowers influenced thrips population, 4) if there was a relation between thrips density in flowers and fruit damage. Statistical analysis was done by using thrips densities obtained during study (9 weeks). The effect of year, citrus variety, trap color and direction on the population density of thrips was analyzed by General Linear Model (GLM) - Repeated Measure Test (RM ANOVA) statistical analysis followed by multiple Bonferroni's comparison test to compare the number of thrips. The data were subjected to analysis of variance and means were separated by Tukey's honestly significant difference (HSD) test at $P<0.05$. A correlation analysis was applied to determine the relation between thrips adult and larvae density in citrus flowers and fruit damage (%) ($P<0.05$). All analyses were performed using the Microsoft statistics program SPSS 16.0. (SPSS, 2007).

RESULTS

Color and citrus species preferences

In lemon, a total of 5870 thrips were counted from blue traps compared with 3349 thrips and 2288

thrips from white and yellow traps, respectively while in orange 3120, 2569 and 1509 thrips from blue, white and yellow traps were counted, respectively in 2006. In 2007, a total of 17637 thrips were counted from blue traps compared with 7200 thrips and 1547 thrips from white and yellow traps, respectively while in orange 2174, 1830 and 1107 thrips from blue, white and yellow traps were counted.

Table I.- Results of repeated measures analysis of variance for the effects of sampling week, year, citrus variety, trap color and their interactions on the mean number of thrips.

Source	Df	MS	*F*	*P*
Within subject effects				
Week	8	436.263	24.148	0.001
Week x year	8	256.293	14.186	0.001
Week x variety	8	120.927	6.694	0.001
Week x trap color	16	92.109	5.098	0.001
Week x year x variety	8	156.217	8.647	0.001
Week x year x trap color	6	135.401	7.495	0.001
Week x year x variety x trap color	16	69.390	3.841	0.001
Error (week)	384	18.066		
Between-subjects effects				
Intercept	1	466.023	159.824	0.001
Year	1	301.277	103.320	0.031
Variety	1	120.860	41.449	0.018
Trap color	2	70.731	24.258	0.028
Year x variety	1	53.072	18.201	0.017
Year x trap color	2	20.445	7.012	0.012
Variety x trap color	2	42.481	14.569	0.015
Year x variety x trap color	2	24.147	8.281	0.013
Error	48	29.158		

There were significant effects of year (F=14.186, df=8, 384, P<0.001), variety (F=6.694, df=8, 384, P<0.001), trap color (F=5.098, df=16, 384, P<0.001), year x variety (F=8.647, df=8, 384, P<0.001), year x trap color (F=7.495, df=16, 384, P<0.001), variety x trap color (F=3.738, df=16, 384, P<0.001) and year x variety x trap color (F=3.841, df=16, 384, P<0.001) on densities of thrips within the sampling weeks (Table I). More thrips were captured on blue sticky traps, while yellow traps were the least attractive in both years. Mean number of thrips was significantly higher on blue sticky traps between the mid of April till the first part of May in 2006 and between the third week of April till the end of May in 2007 ($P \leq 0.001$) (Table II). The population of thrips was considerably lower at the beginning and end of the flowering period, both in 2006 and 2007. There were significant differences in density of thrips among trap colors (F=24.258, df=2, 48, P=0.028), citrus varieties (F=41.449, df=1, 48, P=0.018) and between years (F=103.320, df=1, 48, P=0.031) (Table I).

The two citrus varieties differed in the mean proportion of thrips (Fig. 1). In total, in lemon during the flowering period, the maximum trap catch was at blue traps with a mean of 130 and 353 individuals/week per trap color in 2006 and 2007, respectively. The data indicated that during the study, statistically more thrips were captured in the traps hung on lemon trees with the exception of yellow traps in 2007.

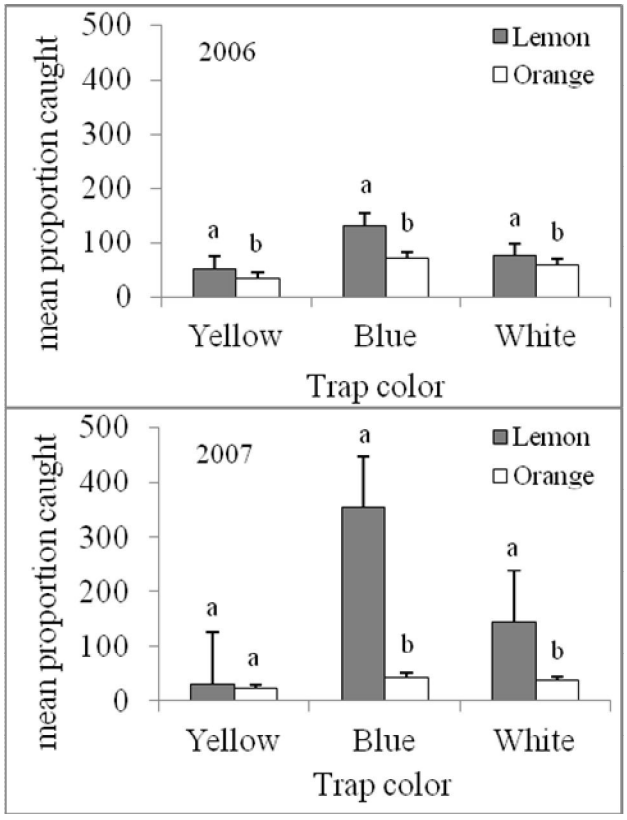

Fig. 1. Mean proportion (± SE) of thrips caught/week on different colored sticky traps hung on lemon and orange trees in Balcalı (Adana) in 2006 and 2007. Means with different letters are significantly different at the 0.05 level within citrus varieties.

Thrips composition, abundance and distribution

A total of 1106 thrips specimens from 38

Table II.- Average number of thrips (± SE) caught on yellow, blue and white colored sticky traps hung on lemon and orange trees in Balcalı (Adana) in 2006 and 2007

Year	Citrus species	Trap color	Average number of thrips (±SE)/trap*								
2006			**2/4**	**8/4**	**14/4**	**21/4**	**28/4**	**5/5**	**12/5**	**21/5**	**28/5**
	Lemon	Yellow	2,00±0,55 a	2,80±1,32 a	91,40±25,33 b	38,00±5,44 a	28,00±8,51 a	200,20±25,71 a	42,40±20,00 a	37,00±6,27 a	5,80±0,58 a
		Blue	1,80±0,73 a	2,60±0,93 a	29,20±12,60 a	67,20±11,19 b	77,40±17,38 b	352,00±98,40 b	642,20±249,30b	44,80±16,62 a	9,20±2,75 a
		White	1,40±0,68 a	1,80±0,97 a	28,00±6,28 a	26,20±13,85 a	25,00±11,38 a	121,80±64,00 a	53,20±8,56 a	24,40± 2,34 a	5,60±0,93 a
	Orange	Yellow	0,00±0,00 a	0,20±0,20 a	5,00± 0,55 a	48,40±12,77 a	39,40±18,91 a	46,40±29,12 a	26,60±11,39 a	8,60±1,44 ab	3,00±0,71 a
		Blue	0,00±0,00 a	0,00±0,00 a	22,80±9,59 ab	156,40±25,39 b	114,40±37,26 b	146,40±5,95 b	351,00±96,01 b	11,00±1,26 b	6,20±0,86 b
		White	0,00±0,00 a	0,00±0,00 a	55,00±14,59 b	82,60±12,92 a	38,20±14,84 a	87,00±31,74 a	69,40±11,81 a	6,20±0,86 a	5,40±0,52 ab
2007			**10/4**	**17/4**	**24/4**	**2/5**	**8/5**	**14/5**	**22/5**	**29/5**	**5/6**
	Lemon	Yellow	3,60±1,21 a	1,20±0,58 a	34,20±4,99 a	89,60±10,51 a	32,80±8,99 a	72,20±8,91 a	22,60±15,19 a	27,60±13,39 a	22,40±11,54 a
		Blue	8,80±1,85 ab	3,20±0,86 a	319,60±55,23 b	1102,00±188,2c	1221,60±358,5c	508,00±208,62c	207,20±32,77 c	77,80±23,81 ab	77,00±8,85 b
		White	10,20±2,03b	4,40±1,72 a	92,60±23,58 a	449,60±142,03b	394,80±185,88b	56,60±42,90 b	126,40±41,91 b	88,40±9,48 b	65,40±7,58 b
	Orange	Yellow	1,40±0,75 a	1,80±0,92 a	24,20±7,15 a	55,20±11,32 a	32,60±13,70 a	52,20±17,45 a	16,80±1,66 a	17,80±4,68 ab	9,40±2,54 a
		Blue	0,80±0,37 a	2,80±0,86 a	42,80±9,49 b	195,40±24,00 b	98,00±9,38 b	97,80±13,94 b	37,00±5,17 b	42,40±15,29 b	25,00±7,14 a
		White	1,40±0,35 a	2,00±0,32 a	28,60±2,82 a	128,20±31,28 a	57,40±15,53 a	33,00±5,52 a	24,40±1,60 a	11,60±2,01 a	12,20±2,22 a

*Means in columns followed by the same letter are not significantly different according to Tukey's HSD test at P<0.05

samples were examined during 2006-2007. Fifteen thrips species and individuals belonging to 3 genera from Thripidae and Phlaeothripidae families were found in these orchards (Table III). All major species were from the family Thripidae; representatives of Aeolothripidae and Phlaeothripidae were relatively less common. The most notable species, present in at least 20% of samples, were in descending order *F. occidentalis*, *T. tabaci*, *P. kellyanus* and *T. major*. *F. occidentalis* was the predominant species being found in 100% of the samples, constituting 82.0% of the specimens recovered in 2006 and 2007. The second major species, *T. tabaci* was present in 44.7% of the samples and constituted 9.6% of the specimens collected. *P. kellyanus* had no significance in citrus as it was detected only in 3.6% and 2.9% of the total in 2006 and 2007, respectively. *Thrips angusciseps*, *Limothrips ceralium* and *Rhipidothrips* sp., *Aelothrips gloriosus* and *Haplothrips distinguendus* were found with very low numbers only on lemon, whereas *F. intonsa*, *A. intermedius*, *H. bolacophilus* were found only on orange. The major thrips species *F. occidentalis, T. tabaci, T. major* and *P. kellyanus* were recorded on both citrus species investigated. *Thrips meridionalis* and *Melanothrips* sp. were also detected on both citrus species, but in lower numbers (Table III).

Cardinal direction where the flowers were did not have a significant effect on mean number of thrips caught. Although thrips population was higher at the south part and lower in the inner part of the trees for both citrus varieties, they were at the same statistical group (Fig. 2). The average number of thrips per flower in lemon in 2006 was 8.54 thrips/flower whereas in orange it was 7.06 thrips/flower. In 2007, it was 10.53 and 9.88 thrips/flower in lemon and in orange, respectively (Table IV). Direction did not have a significant effect on mean number of thrips among citrus varieties (F=0.038, df=1, 88, P=0.846 in 2006 and F=0.556, df=1, 98, P=0.458 in 2007) and among years (F=0.430, df=1, 93, P=0.514 in lemon and F=1.399, df=1, 93, P=0.240 in orange).

For both years, along with the thrips, anthocorid bugs (*Orius* spp.) (Heteroptera), *Chrysoperla carnea* Steph. (Neuroptera: Chrysopidae) and predatory mites, *Cunaxa* sp.

Table III.- Thrips species, their frequency and abundance in citrus orchards in Balcalı (Adana) in 2006 and 2007.

Thysanoptera	2006						2007						Total				
	Citrus species*	♀/♂ L+O	Frequency No.	Frequency %	Abundance No.	Abundance %	Citrus species*	♀/♂ L+O	Frequency No.	Frequency %	Abundance No.	Abundance %	♀/♂ L+O	Frequency No.	Frequency %	Abundance No.	Abundance %
Thiripidae																	
Frankliniella occidentalis	L, O	622/108	18	100.0	730	81.7	L, O	155/22	20	100.0	177	84.3	777/130	38	100.0	907	82.0
Frankliniella intonsa	-	-	-	-	-	-	L, O	2/0	2	10.0	2	1.0	2/0	2	5.3	2	0.2
Thrips major	L, O	17/0	5	27.7	17	1.9	L, O										
Thrips tabaci	L, O	101/1	14	77.7	102	11.4	L, O	4/0	3	15.0	4	1.9	105/1	17	44.7	106	9.6
Thrips meridionalis	L, O	4/0	2	11.1	4	0.4	L, O	1/0	1	5.0	1	0.5	5/0	3	7.9	5	0.5
Thrips angusciseps	-	-	-	-	-	-	L	1/0	1	5.0	1	0.5	1/0	1	2.6	1	0.1
Pezothrips kellyanus	L, O	27/5	7	38.8	32	3.6	L, O	6/0	2	10.0	6	2.9	33/5	9	23.7	38	3.4
Tenothrips discolo	O	1/0	1	5.6	1	0.1	-	-	-	-	-	-	1/0	1	2.6	1	0.1
Limothrips ceralium	-	-	-	-	-	-	L	3/0	1	5.0	3	1.4	3/0	1	2.6	3	0.3
Melanothrips fuscus	L	2/0	1	5.6	2	0.2	-	-	-	-	-	-	2/0	1	2.6	2	0.2
Melanothrips sp.	L, O	1/1	1	5.6	2	0.2	L, O	1/0	1	5.0	1	0.5	2/1	2	5.3	3	0.3
Rhipidothrips sp.	L	1/0	1	5.6	1	0.1	L	1/0	1	5.0	1	0.5	2/0	2	5.3	2	0.2
Aelothripidae																	
Aelothrips gloriosus	L	1/0	1	5.6	1	0.1	-	-	-	-	-	-	1/0	1	2.6	1	0.1
Aelothrips intermedius	-	-	-	-	-	-	O	1/0	1	5.0	1	0.5	1/0	1	2.6	1	0.1
Phlaeothripidae																	
Haplothrips reuteri	-	-	-	-	-	-	O	2/0	2	10.0	2	1.0	2/0	2	5.3	2	0.2
Haplothrips distinguendus	L	1/0	1	5.6	1	0.1	-	-	-	-	-	-	1/0	1	2.6	1	0.1
Haplothrips bolacophilus	-	-	-	-	-	-	O	1/0	1	5.0	1	0.5	1/0	1	2.6	1	0.1
Haplothrips sp.	L	1/0	1	5.6	1	0.1	L, O	2/0	1	5.0	2	1.0	3/0	2	5.3	3	0.3

*L: Lemon, O: Orange
Frequency: total number or percentage of samples in which the species was found
Abundance: total number or percentage of individuals of the species collected

(Cunaxidae), *Paraseiulus talbii* (Athias-Henriot), *P. soleiger* (Ribaga), *Euseius scutalis* (Athias-Henriot), and *Typhlodromus occidentalis* (Nesbitt) (Acarina: Phytoseiidae) were detected in the orchards.

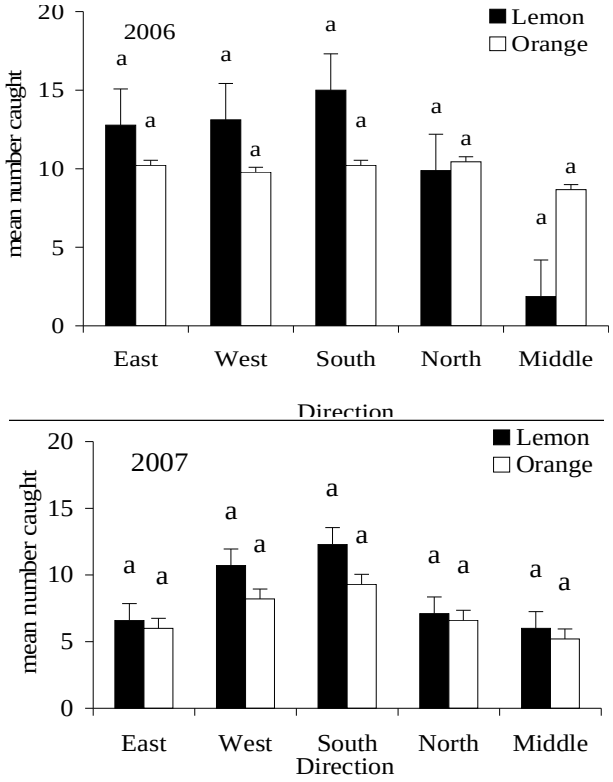

Fig. 2. Mean number (± SE) of thrips collected on flowers from different directions. Means with different letters are significantly different at the 0.05 level within different citrus varieties.

Table IV.- Correlation between average number of thrips (larvae+adult) per flower and damage rates in the orchards examined in 2006 and 2007.

Year	Average number of thrips/flower (larvae+adult)		Scarred fruit (%) (min.-max.)	
	Lemon	Orange	Lemon	Orange
2006	8.54±1.46	7.06±1.34	4.0-7.3	3.9-6.7
2007	10.53±2.76	9.88±2.01	5.3-9.1	3.8-7.9

Damage assessment

Scars caused by thrips on citrus fruits are ring shaped around stem end of the fruit and sometimes may extend downwards along the sides of the fruit which occurs during the flowering period (Broughton and De Lima, 2002). This damage is directly related to the thrips numbers in flowers. Lemon orchard, which had the higher numbers of thrips in flower buds, had the higher amount of damaged fruit. The scarred fruits ranged between 4.0-7.3% in lemon and 3.9-6.7% in orange in 2006, while in 2007 it ranged between 5.3-9.1% in lemon and 3.8-7.9% in orange (Table IV).

DISCUSSION

No insecticides were recommended for thrips in Turkey. Farmers have complained of some scarring on fruit that looks like thrips damages in recent years. In the present study, thrips populations have been monitored and sampled using colored sticky traps. Blue was the most attractive to thrips in both lemon and orange orchards in 2006 and 2007. In the literature the most attractive color was not always this color. Generally, blue and white have been considered as the preferred or the most preferred colors for several species of thrips in citrus (Childers and Brecht, 1996) and under field conditions (Moffitt, 1964; Yudin *et al*., 1987; Chu *et al*., 2000). In some studies similar to ours, blue has been identified as the preferred color for trapping thrips in the greenhouse which was consistent with previous findings (Brødsgaard, 1989; Gillespie and Vernon, 1990; Terry, 1997). Chen *et al*. (2004) and Roditakis *et al*. (2001) indicated that more *F. occidentalis* were attracted to blue sticky card traps compared with yellow or white sticky card traps in the greenhouse. In a survey in eastern Sicily, *P. kellyanus* was the main thrips species and white sticky traps were the most attractive for adult thrips, followed by blue traps in citrus (Conti *et al*., 2001). In some studies, different from ours, yellow has been identified as the preferred color (Moreno *et al*., 1984; Samways, 1986; Blumthal *et al*., 2005).

In this study, lemon appeared to be the preferred citrus species. Data on thrips abundance in relation to different citrus species is lacking. The highest host indices for *F. occidentalis*, *P. kellyanus* and *T. major* were calculated in mandarin, lemon and grapefruit, respectively, in Antalya (west Mediterranean region) (Tekşam and Tunç, 2009).

Lemon was among the preferred host of *P. kellyanus* in New Zealand (Blank and Gill, 1997), in Sicily (Conti *et al*., 2001) also in Cyprus (Vassiliou, 2007), but besides lemon, navel, Valencia oranges and grapefruit were also the most affected varieties (Baker *et al*., 2001). Morse (2006) determined that thrips were a significant problem, especially on navel oranges in California.

The thrips fauna on citrus varies between parts of the world. The species found in the study sites are similar to those in other Mediterranean countries. *F. occidentalis, T. tabaci, P. kellyanus, T. major* and *T. meridionalis* are among species commonly encountered on Mediterranean citrus (Conti *et al*., 2003; Kersting *et al*., 2005; Costa *et al*., 2006). *F. occidentalis* infested all of the sampled trees in the present study. It is the major thrips species in the orchards possibly because of the flowering weeds (generally *Sinapis arvensis* L.), around and sometimes inside the orchards. It is thought that *F. occidentalis* populations increased on these alternative hosts and passed to citrus in spring. Destroying the weeds by using different management tactics before the blooming stage of citrus seems to be crucial. Nas *et al*., (2007) determined 8 thrips species in east Mediterranean region where *F. occidentalis* was the most prevailed species constituting 35.0% of the total thrips. Although their study comprised the whole eastern Mediterranean region, it seems that within a few years *F. occidentalis* increased its population and reached an abundance of 82.0% of all species. *T. tabaci* was the second prevalent species. It is the pest of field crops and vegetables (Tunç, 1998) and, however, rarely considered as a pest of citrus. It was reported to infest the flowers and fruits of Satsuma mandarin (*Citrus unshiu* Marc.) but not cause any damage in the orchard conditions, however, damaging fruits grown in the greenhouse (Tsuchiya, 2002). *T. major* was found in 28.9% of the samples constituting 2.4% of the specimens recovered in Adana, whereas in Antalya, it was the predominant thrips species, constituting 51.1% of the specimens collected (Tekşam and Tunç, 2009). There is not enough data on *T. major* to determine if it is a pest of citrus or not. The only existing record of *T. major* as a pest of citrus is from North Africa where its feeding on flowers and newly formed fruits was reported to cause scars on the rind (Bournier, 1963). *P. kellyanus* was less frequent and abundant than those three thrips species mentioned above in the orchards, but it was the only species amongst those recorded here that is known to feed on very young citrus fruits. Sicily was the first locality in Mediterranean basin where it was reported as a pest of citrus, currently is a key pest of citrus there (Marullo, 1998). Currently *P. kellyanus* is recorded in Greece, Spain, Italy, Israel and Portugal (zurStrassen, 2003). In Turkey it was recorded for the first time in 1995 in İzmir province (zurStrassen, 1996) and later in Hatay and Antalya provinces after 2000's (Nas *et al*., 2007; Tekşam and Tunç, 2007). The reason why this thrips species did not cause significant fruit damages in Turkey before as in some countries is not known. Further studies must be done to identify the effect of climate, natural enemies, hosts, inter specific relations, fauna, flora etc.

Lemon was among the preferred host of *P. kellyanus* in Antalya province (Tekşam and Tunç, 2009), as in this study. Because of its current low abundance, it is thought that *P. kellyanus* has no significance for citrus yet and does not pose any threat in its present status. But the experiences in other countries and the increase in its area of invasion in recent years might mean *P. kellyanus* will need to be controlled. The thrips species from citrus flowers listed in Table III are not generally regarded as citrus pests, and there are very few reports of any of these species damaging this crop. The only thrips that damage citrus fruit are those that feed on the developing fruits, just as, or soon after, the petals fall, not those that feed only on pollen and floral tissues.

Cardinal direction of the flowers did not have a significant effect on thrips number. It is thought that, southerly prevailing wind at the region did not influence the patterns of aerial dispersal. Lewis (1997) indicated that thrips flying activity and directionality of flight is strongly influenced by atmospheric conditions, and some species fly under conditions when flight can be controlled.

Abundance of thrips on citrus flowers in Adana is apparently lower than other citrus growing areas of the world where thrips are pest. Blank and Gill (1997), reported up to 50 *P. kellyanus* and 56 *T.*

obscuratus (Crawford) in New Zealand. In Florida, Childers and Nakahara (2006) counted up to 200 *F. bisbinosa* (Morgan) per citrus flower.

The level of fruit damage appeared to be related with thrips numbers in flower buds (Table IV). Correlation analysis indicated that there was a significant relationship between adult and larvae density in flowers and fruit damage (r^2=0.913, P=0.045 in 2006; r^2=0.978, P=0.011 in 2007). With regard to this finding, it can be said that the number of thrips in flower buds during bloom could be a suitable predictive method for estimating final fruit damage due to positive and good relation between each other. There are not much data available in Turkey regarding the proportion of citrus fruit with scars that might be linked to thrips damage compared to other causes of blemished ones. It should be noted that even the consistent occurrence of a given thrips species on a given citrus species does not necessarily mean that a thrips breeds on it. The proportion of citrus fruit with injuries attributable to thrips in the present study was lower than 10% in both varieties. Lemon was more highly scarred than orange. It is thought that *P. kellynus* is attributable to these scars. In all the samples females were higher in number than males, since females are more responsible for fruit damage due to both feeding and oviposition injuries (Higgins and Myers, 1992; Childers, 1997; Ullah *et al*., 2010). Tekşam and Tunç (2007) reported 0.8-2.4% fruits with scars for different citrus varieties in Antalya province. The scarred fruit ratio attributable only to *P. kellyanus* is higher in some other countries. *P. kellyanus* led to scarred fruit at levels of 20-40% in New Zealand (Blank and Gill, 1997), Australia (Baker *et al*., 2001), Sicily (Conti *et al*., 2001) and Cyprus (Vassiliou, 2007).

Many arthropods are known to be predators of thrips. In this study, the predators were very low in number in both orchards. Among the natural enemies detected, the generalist predator *Orius* spp. is hopeful. *Orius* spp. can prey on all different stages of thrips (Tommasini, 2003). *Euseius scutalis* and the members of genus *Cunaxa* (Araneida) reduce the population of *F. occidentalis* and citrus thrips (Milne, 1977; Kostiainen and Hoy, 1996). It is thought that their effect on the pest was not so important but for future natural biological control, the existence of these natural enemies is gratifying.

In conclusion, effective population monitoring is crucial for successfully implementing insect control programs. Early detection of the thrips in the orchard and more reliable estimation of their population density and effective reduction of their population particularly in early crop growth stages, could result in a much lower density on the crop later in the season and is considered to be one of the best tactics for successful integrated control. Blue sticky traps can be used as an early warning method for detecting increases in aerial numbers of thrips in citrus, and capture rates can be used to initiate control measures to prevent economic crop damage and reduce unnecessary applications of insecticides. Investigations are required to determine the pest status of the most common and abundant species *F. occidentalis*. The abundance of *P. kellynus* is low in citrus in Adana compared to countries where it is considered a citrus pest, but despite its low abundance the presence of *P. kellyanus* itself in Adana deserves attention as the experience in other countries suggests. However further investigations are needed to ascertain the effects of thrips on citrus yield and the role of *Orius* spp. and phytoseiids in biological control of citrus thrips.

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