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ABUNDANCE PATTERNS OF THE WESTERN FLOWER THRIPS, *Frankliniella occidentalis* (PERGANDE)(THYSANOPTERA: THRIPIDAE), AND ITS PREDATORY BUGS, *Orius* spp. (HEMIPTERA: ANTHOCORIDAE), ON FABA BEAN IN ÇUKUROVA REGION OF TURKEY

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ABSTRACT

Thrips species on faba bean cultivated in Adana Province, Turkey, were investigated to determine their natural insect enemies in the 2010-2011,2014-2015, and 2016-2017 growing seasons. Ten thrips species (one species belonging to Aeolothripidae and nine to family Thripidae) were found. The western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), was the dominant thrips species, comprising about 44.4% of the total samples. Among the natural enemies, *Orius niger* (Wolff), *Campylomma nicolasi* Puton and Reuter, and *Orius laevigatus* (Fieber) were the most notable species. The population densities of thrips and their natural enemies were highest in March. Mean densities of *F. occidentalis* were less than 5 individuals on most sampling dates in experimental fields in which no pesticides were used, but were more than 15 individuals per plant in some sampling months in commercial fields where *Orius* numbers were relatively lower. Densities of *Orius* spp. were closely associated with the densities of *F. occidentalis*. Thrips to *Orius* spp. ratios were less than 5:1, indicating that pestiferous thrips might have been suppressed by *Orius*.

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1 Introduction

Faba bean (*Vicia faba* L., family Fabaceae) is a nutritious human food crop containing high protein (Anonymous, 2001). It is widely grown in the eastern Mediterranean region of Turkey where it enriches soil fertility by keeping nitrogen in the soil. Faba bean production is fourth among the leguminous crops grown in Turkey. Atakan (2012) studied the common insect species on faba bean and suggested that leafhoppers (*Empoasca* spp.) and aphids (*Aphis fabae* Koch) were the most common species in Turkey. The seasonal densities of the western flower thrips, *Frankliniella occidentalis* (Pergande), and its generalist predator *Orius niger* (Wolff) (Hemiptera: Anthocoridae) on faba bean have been studied by Atakan (2010). *Frankliniella occidentalis* and *O. niger* were the most abundant insect species of faba bean and of weedy plant species (Atakan, 2010). Nuessly et al. (2004) reported 61 herbivorous insect pest species and 32 predator and parasitoid species on faba bean in Florida (USA); and *Aphis craccivora* Koch (Hemiptera: Aphididae) was the most damaging pest of faba bean in their study.

Cultural and biological control of pest thrips are important elements of integrated pest management strategies in diverse crop plants (Razavi & Ahmadi, 2016). The use of chemical insecticides against pest insects can cause significant problems to health and environment. Therefore, alternative pest management tactics, such as biological control of pest thrips by generalist predators (e.g., *Orius* species), are needed (Riudavets, 1995).

Orius spp. were found on various vegetable crops in different parts of Turkey (Bulut & Göçmen, 2000). They are important biological control agents for suppressing populations of pest thrips, especially the western flower thrips (van de Veire & Degheele, 1992; Tavella et al., 2000). *Orius niger* can reduce population pressure of *Frankliniella* flower thrips in untreated cotton fields in the Çukurova region of Turkey (Atakan, 2006; Atakan & Gençer, 2008). However the role of *Orius* spp. as predators of thrips on winter crops, such as faba bean, has not been studied in Turkey.

In Turkey, Faba bean typically is cultivated as a winter crop, with flowering during early winter and spring having various ecological impacts on the population dynamics of *F. occidentalis* and *Orius* spp. The interaction between *F. occidentalis* and *Orius* spp. might help in understanding the predation potential of *Orius* species on pestiferous insects on arable crops in the region.

Although some associations between pest thrips and generalist predators on faba bean flowers have been studied in restricted areas, the fauna of thrips and beneficial insects and the pest status of thrips, such as *F. occidentalis* in commercial fields of faba beans are not well understood. Additionally, an understanding of plant part preferences of thrips and *Orius* spp. throughout the season is rudimentary. This information is needed to estimate the densities of both insects. The main objectives of this study were to (i) determine the thrips species and their natural enemies in the Mediterranean region of Turkey, (ii) determine the abundance patterns of *F. occidentalis* and *Orius* spp. on faba bean and (iii) determine the choice of faba bean plant parts by *F. occidentalis* and *Orius* spp.

2 Materials and Methods

2.1 Samplings in experimental plots

Seasonal abundance of the western flower thrips and its predatory bugs was studied in untreated faba bean plots (500 m^2, 20 m×25 m) at weekly intervals in the Research and Implementation Area of Department of Plant Protection, Faculty of Agriculture, University of Çukurova, Balcalı, Adana, Turkey. Sampling was carried out during 10 January-27 March 2010 (12 sampling dates) and 12 January-8 March 2011 (9 sampling dates). The main plot was divided into four sub-plots (each 125 m^2, 5 m×25 m). Five plants from each sub-plot were randomly selected. Beating of plants to sample thrips species and their predatory insects are commonly used sampling methods (Atakan, 2010, Atakan, 2012). Thus, selected plants were bent down and vigorously shaken in a white plastic container for 5 seconds. Thrips and predators were collected with a fine brush and stored in 2 ml plastic vials containing 60% ethanol.

When plants were at the flowering stage, five plants from each sub-plot were selected randomly, and 6 leaflets and flowers from each selected plant were sampled for *F. occidentalis* and *Orius* spp. Leaflet and flower samples from each plant were transferred to the laboratory. To estimate the populations of thrips and beneficial insects including *Orius* spp., flowers and leaf samples were kept for one or two hours in a deep-freezer and then tapped onto a white plastic sheet. Thrips and predators were collected with a fine brush and kept in 2ml plastic tubes containing 60% ethanol for subsequent identification. The same procedure was repeated the next year.

2.2. Samplings in commercial fields

Abundances of *F. occidentalis* and *Orius* spp. were investigated in commercial faba bean fields during the 2014-2015, and 2016-2017 growing seasons in Adana Province, Turkey. Surveys were carried out once per month during the growing season. During surveys, the same fields were regularly sampled. In each survey, 4-8 fields were visited to determine the numbers of thrips and predatory insects. The size of commercial fields sampled varied from 0.5 to 1.0 ha. Sampling was carried out when plants were flowering. Each field was divided into four quarters (1.250-2.500

m^2 sub-plots) as replicates. Five plants in each sub-plot were randomly selected. Under laboratory conditions, the thrips samples were placed in vials containing AGA solution (10 parts 60% ethanol, 1 part glacial acetic acid, and 1 part glycerine) and kept for subsequent identification.

2.3 Identification of insects

Slide-mounted thrips (adults) were identified by using the keys given by zur Strassen (2003) and Balou et al. (2012). *Orius* spp. were identified with the keys given by Önder (1982) and Tommasini (2004). Other isolated predators and pestiferous insect species were identified by reference to material in the Entomology Laboratory of the Plant Protection Department, Faculty of Agriculture, University of Çukurova, Adana, Turkey. No identification keys are available for nymphs of *Orius*. Therefore, these were treated as a single entity.

2.4. Data analysis

Surveys of thrips and predatory insects were performed only in commercial fields in the 2014-2015, and 2016-2017 growing seasons (Tables 1, 2). The populations of other pest insects including aphids and leaf hoppers and some predators were not quantified because their numbers were small throughout the sampling period. Larval thrips were not evaluated due to their low numbers on faba bean plants sampled in all locations. Effects of plant parts and sampling dates on the abundance of *Orius* spp. adults (pooled) and nymphs (pooled) and *F. occidentalis* adults were evaluated by using General Linear Model (GLM) repeated measures statistical analysis (Groves et al., 2003). Weekly comparisons of the numbers of thrips and *Orius* on leaflets and flowers were made throughout the sampling period by using Student's t-test at $P<0.05$. Numbers of *F. occidentalis* and *Orius* spp. per plant part (leaflets and flowers) were pooled over sampling dates and sampling years. Their mean numbers were grouped by Student's t-test at $P<0.05$.

The relationship of mean numbers of thrips and *Orius* in the flowers was evaluated by using quadratic regression analysis at $P<0.05$ significance level. The relationship between climatic factors (mainly average temperature and relative humidity) and thrips or *Orius* populations in all fields was analysed using SPSS 15.0. (SPSS, 2006).

3 Results and Discussion

3.1. Surveyed thrips and predatory insect species in 2014-15 and 2016-17

Ten species of thrips were identified during the 2014-2015, and 2016-2017 growing seasons (Table 1). All major species belonged to the family Thripidae, where as representatives of Aeolothripidae were found in fewer numbers. *F. occidentalis* (Pergande), *Thrips tabaci* Lindeman, and *Thrips hawaiiensis* (Morgan) were the most common species. *F. occidentalis* was the dominant species in the thrips fauna. It was represented in 44.0% of the total samples and accounted for 89.5% of all specimens.

Table 1 Composition, distribution, and abundance of thrips species on faba beans grown commercially in Adana Province, Turkey, 2014-2015, and 2016-2017

Family and species	Frequency per year		Abundance per year		Overall frequency		Overall abundance	
	2014-15	2016-17	2014-15	2016-17	Number	%	Number	%
Aeolothripidae								
Aeolothrips collaris	0	1	0	1	1	0.21	1	0.16
Melanthrips fuscus	1	1	1	1	2	0.42	2	0.33
Melanthrips pallidor	1	1	1	1	2	0.42	2	0.33
Thripidae								
Frankliniella occidentalis	77	130	193	350	207	44.04	543	89.46
Isoneuro thrips avustralis	1	0	1	0	1	0.21	1	0.16
Kakothrips priesneri	1	0	1	0	1	0.21	1	0.16
Thrips hawaiiensis	0	14	0	24	14	2.9	24	3.96
Thrips meridonalis	0	3	0	3	3	0.63	3	0.50
Thrips major	0	1	0	1	1	0.21	1	0.16
Thrips tabaci	15	2	27	2	17	3.61	29	4.78

Table 2 Composition, distribution, and abundance of bene ficial insects on faba beans grown commercially in Adana Province, Turkey, 2014-2015, and 2016-2017

Family and species	Frequency per year		Abundance per year		Overall frequency		Overall abundance	
	2014-15	2016-17	2014-15	2016-17	Number	%	Number	%
Cole./Cocciellidae								
Adonia variegata	0	2	0	2	2	0.42	2	0.62
Coccinella septempunctata	2	2	2	2	4	0.85	4	1.25
Cole./Staphylinidae								
Paederus sp.	0	1	0	1	1	0.21	1	0.31
Tachyporus	3	1	3	1	4	0.85	4	1.25
Hem./ Anthocoridae								
Orius laevigatus	7	11	7	11	18	3.82	18	5.60
Orius majusculus	3	3	3	3	6	1.27	6	1.86
Orius niger	103	52	172	76	155	32.97	248	77.27
Orius vicinus	0	1	0	1	1	0.21	1	0.31
Hem. /Lygaeidae								
Piocoris erythrocephalus	0	1	0	1	1	0.21	1	0.31
Hem./Miridae								
Campylomma nicolasi	15	13	15	17	28	5.95	32	9.97
Neu./Chrysopidae								
Chrysoperla carnea	0	4	0	4	4	0.85	4	1.25

Thrips tabaci ranked second with representation in 36.0% of the total samples and accounting for 4.8% of adult specimens collected. The other species was found in 0.2-2.9% of the total sample and represented 0.2-0.3% of the total specimens (Table 1). *F. occidentalis* was the most active thrips species, and appeared on several crops and weeds throughout the winter season. These results agree with those of Atakan & Uygur (2005), who reported high populations of *F. occidentalis* in the winter. The dominance of *F. occidentalis* on winter crops might be due to its higher reproductive rate, large numbers of its host plants, and its better adaptation to hard winter conditions worldwide (Kirk & Terry 2003).

Other pest insects, such as *Empoasca decipiens* Paoli (Hemiptera: Cicadellidae), *Aphis fabaea* Scop. and *Acyrthosiphon pisum* (Harris) (Hemiptera: Aphididae), and *Nezara viridula* L. (Hemiptera: Pentatomidae), were also collected during the study period but their numbers were small and were not evaluated. However, in previous work by Atakan (2012), Atakan (2016) in the same area, the presence of other pest insects was also reported on faba bean.

Eleven predatory insect species in the orders Coleoptera (two coccinellids and two staphylinids), Hemiptera (four anthocorids, one mirid, and one lygaeid), and Neuroptera (one chrysopid) were identified (Table 2). *Orius niger* (Wolff), *Campylomma nicolasi* Puton and Reuter, and *Orius laevigatus* (Fieber) were the most notable predators. *O. niger* was dominant, being present in 32.9% of samples and accounting for 77.2% of adult specimens. The results agree with those of Tommasini (2004), who reported that *O. niger, O. laevigatus*, and *O. majusculus* (Reuter) were common anthocorid species in the Mediterranean basin. *O. niger* was dominant in north western Italy, whereas *O. laevigatus* was more common in the warmest locations of the country (Bosco et al., 2008). Thus, the predominance of insect species may depend on location. *C. nicolasi* was the second most common predator, being represented in 5.9% of the samples and accounting for about 9.9% of the specimens (Table 2). Overall frequency and abundance of the other predatory insect species varied from 0.2 to 3.8% and 0.3 to 5.6%, respectively (Table 2). A few coccinellid beetles (Coleoptera) were also detected. Low numbers of coccinellids paralleled the low numbers of their prey, such as aphids, in all fields surveyed. *C. undecimpunctata* and *C. septempunctata* were more abundant in Egyptian broad bean fields and had a consistent relationship with their prey, *Aphis craccivora* Koch (Gameel, 2014). Similarly, *A. craccivorais* a serious pest of faba beans in Egypt (Aly, 2014).

Total numbers of thrips and predatory insect species on faba beans in commercial fields were low compared with numbers in the experimental field (Tables 1, 2). This result might be because of excessive application of pesticides against common pests and diseases of faba bean. In previous work (Atakan, 2012; Atakan, 2016), the populations of leafhoppers, aphids, and predatory anthocorids on faba bean were higher in the experimental plots in which no pesticide was used.

3.2. Distribution of *F. occidentalis* and *O.niger* on various plant parts in 2010 and 2011

Distribution of *F. occidentalis* and *O. niger* on various plant parts was studied only in experimental plots in years 2010 and 2011. Sampling date and sampling date × plant part interaction have significant effects on abundance of thrips and *Orius* spp. (Table 3). The majority of thrips and adults and nymphs of *Orius* spp. were found on the flowers of faba bean (Figure 1). Cumulative mean numbers of thrips and *Orius* were significantly higher on flowers than on leaves in 2015 (*F. occidentalis*: t = 4.799, $F_{1,\ 38}$= 23.027, P <0.0001; adult *Orius* spp.: t = 4.551, $F_{1,\ 38}$= 29.710, P<0.0001; nymphs of *Orius* spp.: t=3.672, $F_{1,\ 38}$= 13.486.400, P< 0.0001) and in 2016 (*F. occidentalis*: t = 3.426, $F_{1,\ 38}$= 11.740, P<0.001; adult *Orius* spp.: t = 7.085, $F_{1,\ 38}$= 50.203, P<0.0001; nymphs of *Orius* spp: t=2.530, $F_{1,38}$= 6.400, P=0.016) (Figure 2).

When prey for *Orius* species is not available, they can feed on nectar and pollen; consequently, their populations are higher on

Table 3 Results of repeated measures statistical analysis (RM-ANOVA)

Source	Df	MS	F	Significance
Thrips (Within subject effects)				
Date	8	1.019	7.427	P<0.0001
Date × plantpart	8	0.519	3.782	P<0.0001
Error	304			
Between subject effects				
Intercept	1	12.100	65.686	P<0.0001
Plantpart	1	4.900	26.600	P<0.0001
Error				
***Orius* spp. (Within subject effects)**				
Date	11	0.425	3.214	P<0.0001
Date × plantpart	11	0.469	3.546	P<0.0001
Error	418			
Between subject effects				
Intercept	1	6.302	44.382	P<0.0001
Plantingdate	1	4.219	29.710	P<0.0001
Error	38			

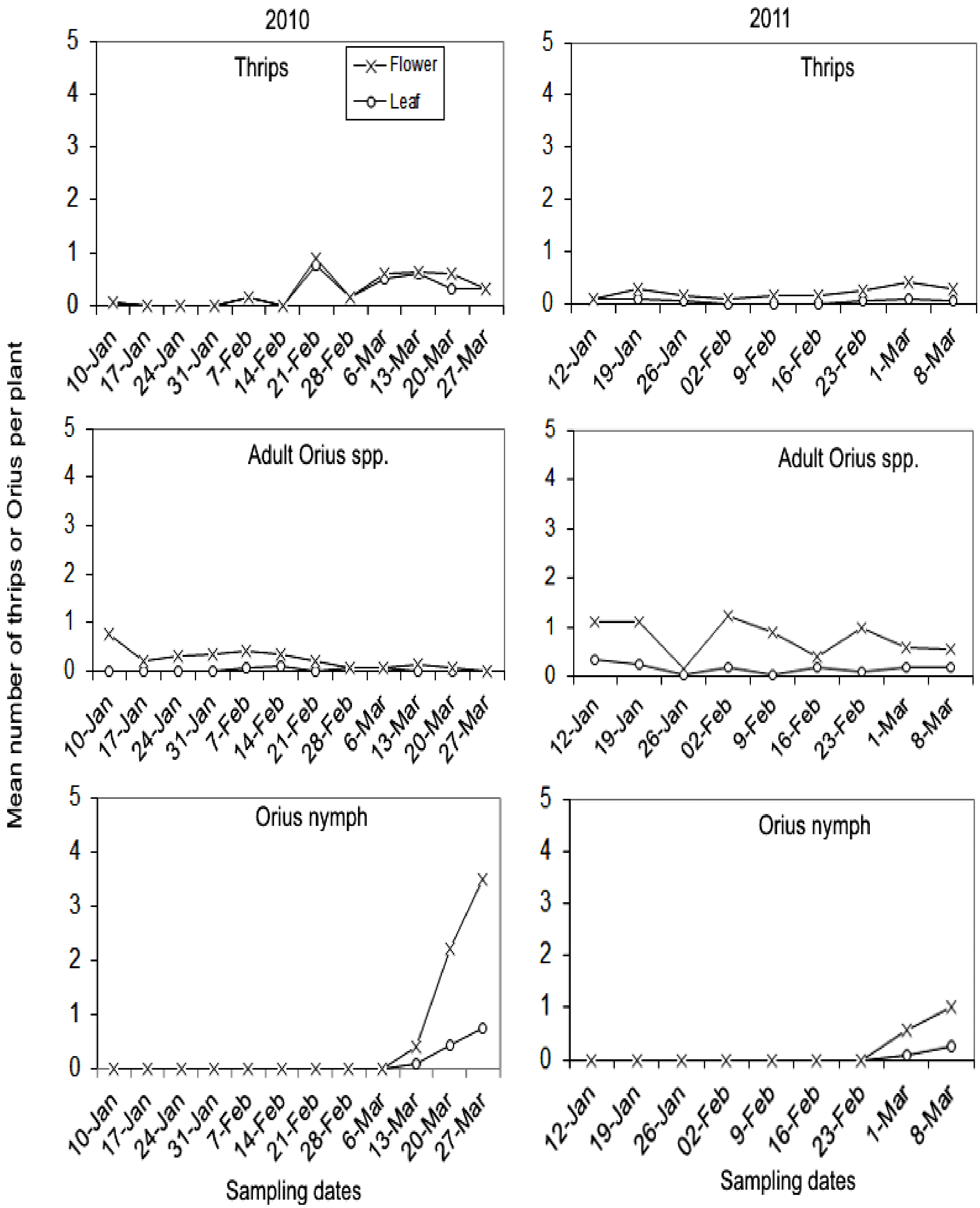

Figure 1 Mean numbers of *F. occidentalis* and *Orius* spp. on two plant parts of faba beans in experimental plots in Adana province, Turkey, 2010 and 2011

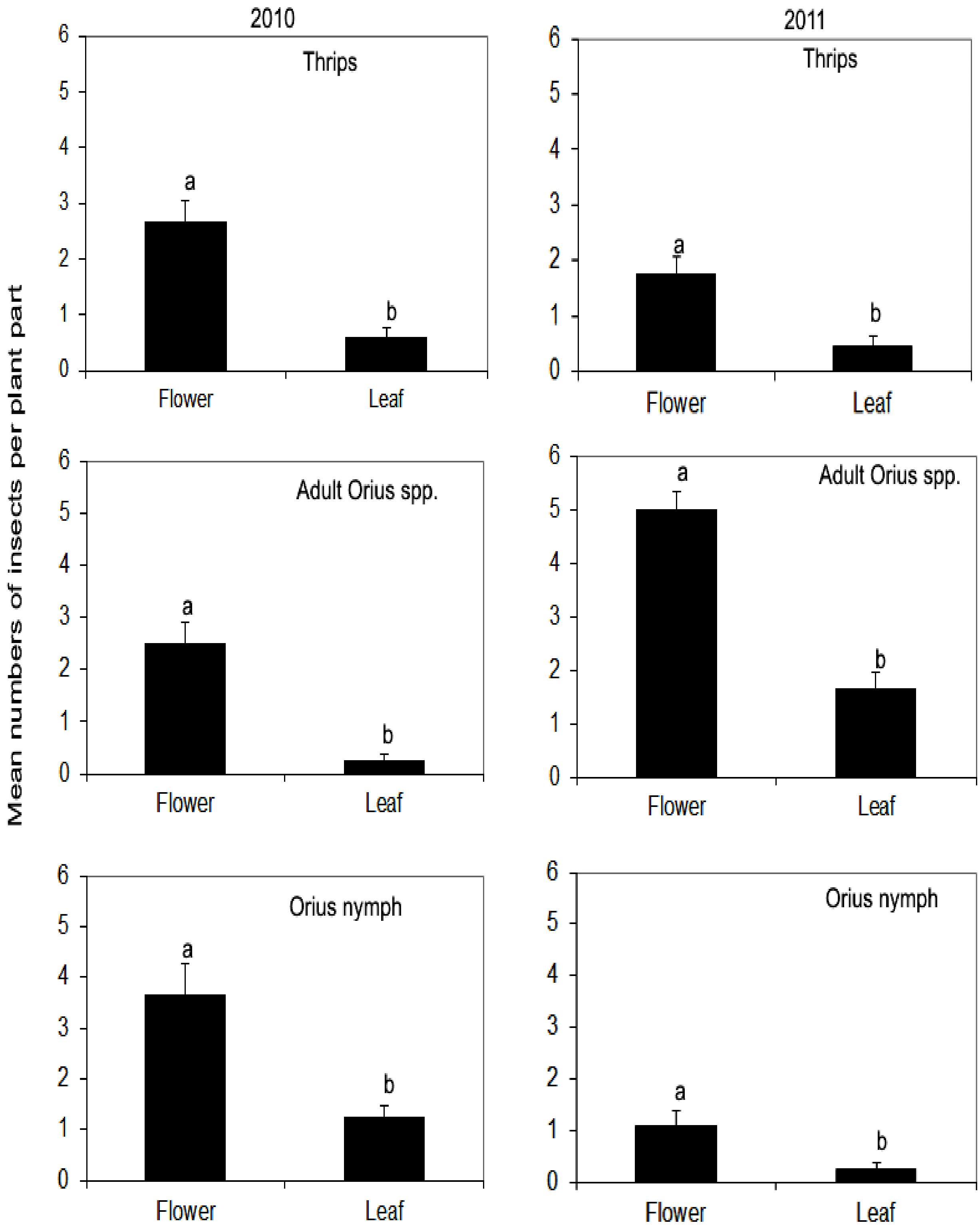

Figure 2 Cumulative mean numbers of *F. occidentalis* and *Orius* spp. On two plant parts of faba beans in experimental plots in Adana province, Turkey, 2010 and 2011

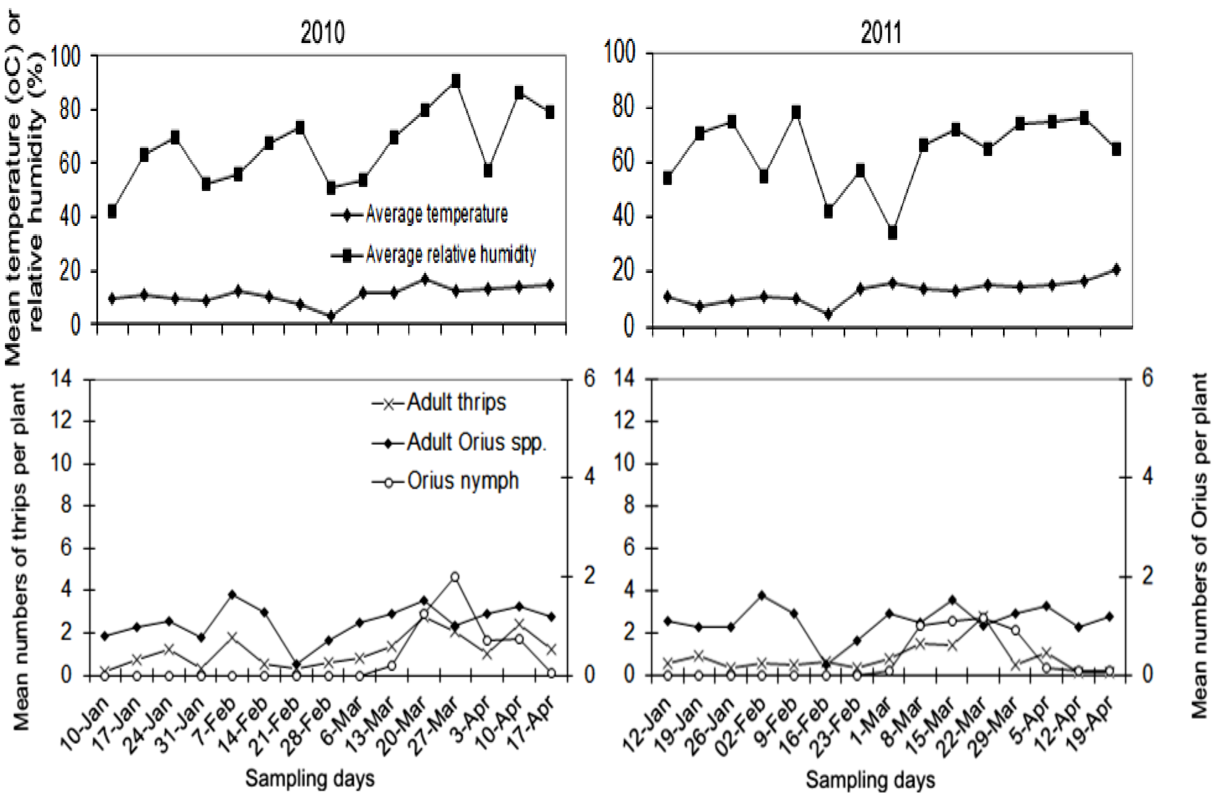

Figure 3 Mean numbers of *F. occidentalis* and *Orius* spp. on faba beans of experimental plot in Adana province, Turkey, 2010 and 2011.

flower parts (Kiman & Yeargan, 1985; Riudavets, 1995). Faba bean might be a source of extra-floral nectar, which supports *Orius* spp. regardless of the presence of *F. occidentalis* or other prey. Many beneficial insects were detected in faba beans cultivated in southern Florida (USA) (Nuessly et al., 2004). The densities of the bean's flowers might have affected the densities of *Orius* spp. more than their prey (thrips). An abundance of *Orius* adults in the experimental areas might support this suggestion (Atakan, 2010).

3.3. Abundances of thrips and *Orius* on flowers

3.3.1. Years 2010 and 2011

Mean numbers of thrips were highest in flowers. The numbers began increasing after 21 February 2010 (0.55 thrips per plant) and reached a maximum on 13 March 2010; thereafter, numbers started decreasing (Figure 3). When thrips populations were highest on plants, the mean temperature was relatively low (7.3 ^{o}C) and relative humidity was 73.7%. No thrips were found in April when few flowers were detected on the plants. Numbers of *Orius* were higher, with means of 2.0-3.5 individuals per plant in January to mid-April when thrips numbers were high, but there was no correlation between thrips and *Orius* spp. numbers. The population of *Orius* spp. was highest in flowers on 27 March, as was thrips density. The first nymphs of *Orius* spp. appeared on 13 March (mean of 0.2 *Orius* individuals per plant). Two weeks later, the mean density of *Orius* nymphs was the highest (mean of 1.2 individuals per plant).

The results for 2011 are similar to those of 2010; the mean number of thrips ranged from 0.3 to 0.9 in January-February (Figure 3). Thereafter, the density of thrips started to increase and peaked in flowers, with a mean density of 2.8 thrips per plant on 22 March 2011; the thrips population then declined. When the thrips population was greatest, the mean temperature was relatively high (14.4^{o}C), and there was no apparent increase in relative humidity on this date. The mean numbers of adult *Orius* spp. were similar throughout the sampling period and varied between 2 and 3 individuals per plant. The first nymphs of *Orius* spp. were detected on 1 March. During March, mean densities of *Orius* nymphs remained constant, with an average of one individual per plant. In April, variation in mean numbers of *Orius* nymph was recorded and the pattern of nymphal occurrence showed similarities with the adult population of thrips and *Orius*.

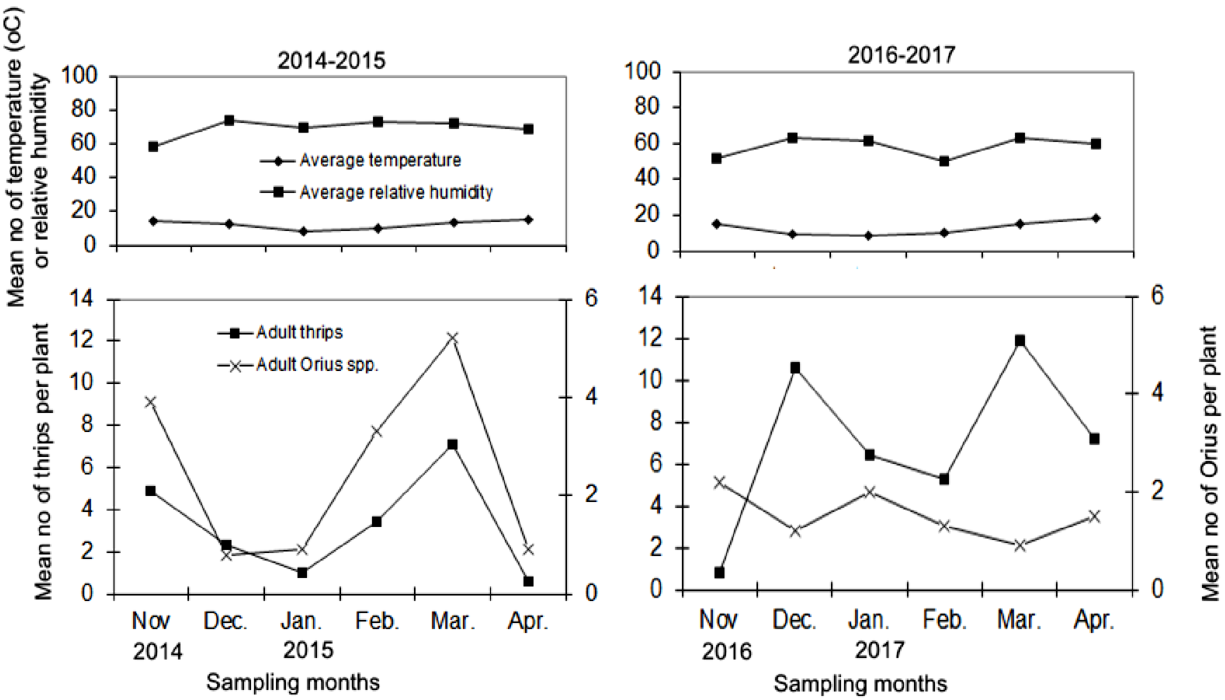

Figure 4 Monthly mean numbers of *F.occidentalis* and *Orius* spp. on faba beans grown commercially in Adana province, Turkey, 2014-2015, and 2016-2017

3.3.2. Season 2014-15

In the 2014-2015 growing season, the monthly mean densities of thrips and *Orius* spp. in flowers are shown in Figure 4. The mean density of *F. occidentalis* was 4.9 individuals per plant in November 2014; thereafter, the thrips population declined until February 2015 and then peaked in March (7.1 individuals per plant). The mean density of thrips decreased to its lowest level in April (0.6 individuals per plant). Low temperature in March (13.3 ^{o}C) favoured the development of thrips populations. Increases in temperature negatively affected the multiplication of thrips in flowers, possibly explaining the reduced thrips population in April. The *Orius* population followed the thrips population in flowers in the 2014-2015 growing season. The number of *Orius* (5.2 individuals per plant) cope with the thrips population in 2014-2015.

3.3.3. Season 2016-17

Monthly mean densities of thrips were greater in the 2016-2017 growing season (Figure 4) than in the previous study year. Thrips densities were high from December (10.6 individuals per plant) to March (11.9 individuals per plant) and the effect of temperature was more pronounced. The density of thrips was lowest in October (mean number of 0.8 individuals per plant). Mean densities of *Orius* spp. were lower than those of thrips throughout the sampling period, ranging from 0.9 to 2.2 individuals per plant.

Increasing temperature in March favoured the development of thrips densities but further increases in temperature (in April) negatively influenced thrips abundance, which began decreasing in the first week of April. Like temperature, low flower density of faba bean also affects thrips abundance; it was higher until March but began decreasing in April. There was no correlation between mean densities of thrips or *Orius* spp. and mean temperature or relative humidity in any year. However, increasing temperature might have positively influenced egg-hatching of *Orius*. Hence, the first nymphs of *Orius* spp. were detected in early March. *Orius* numbers were also less during non-flowering periods.

Orius might be a regulating factor of thrips dynamics on faba bean plants. A previous study in the same ecological area, suggested a positive relationship between the densities of *F. occidentalis* and *O. niger* in faba bean flowers (Atakan, 2010). Faba bean plants might be a good trap crop for thrips and a banker plant for beneficial insects, such as predatory bugs (*Orius* spp.). The findings of Smith et al. (2013) are contradictory to those of the present study. These researchers suggested that faba bean is not a good trap crop for thrips in the Snow Peas region of Guatemala. The differences might be attributable to ecological

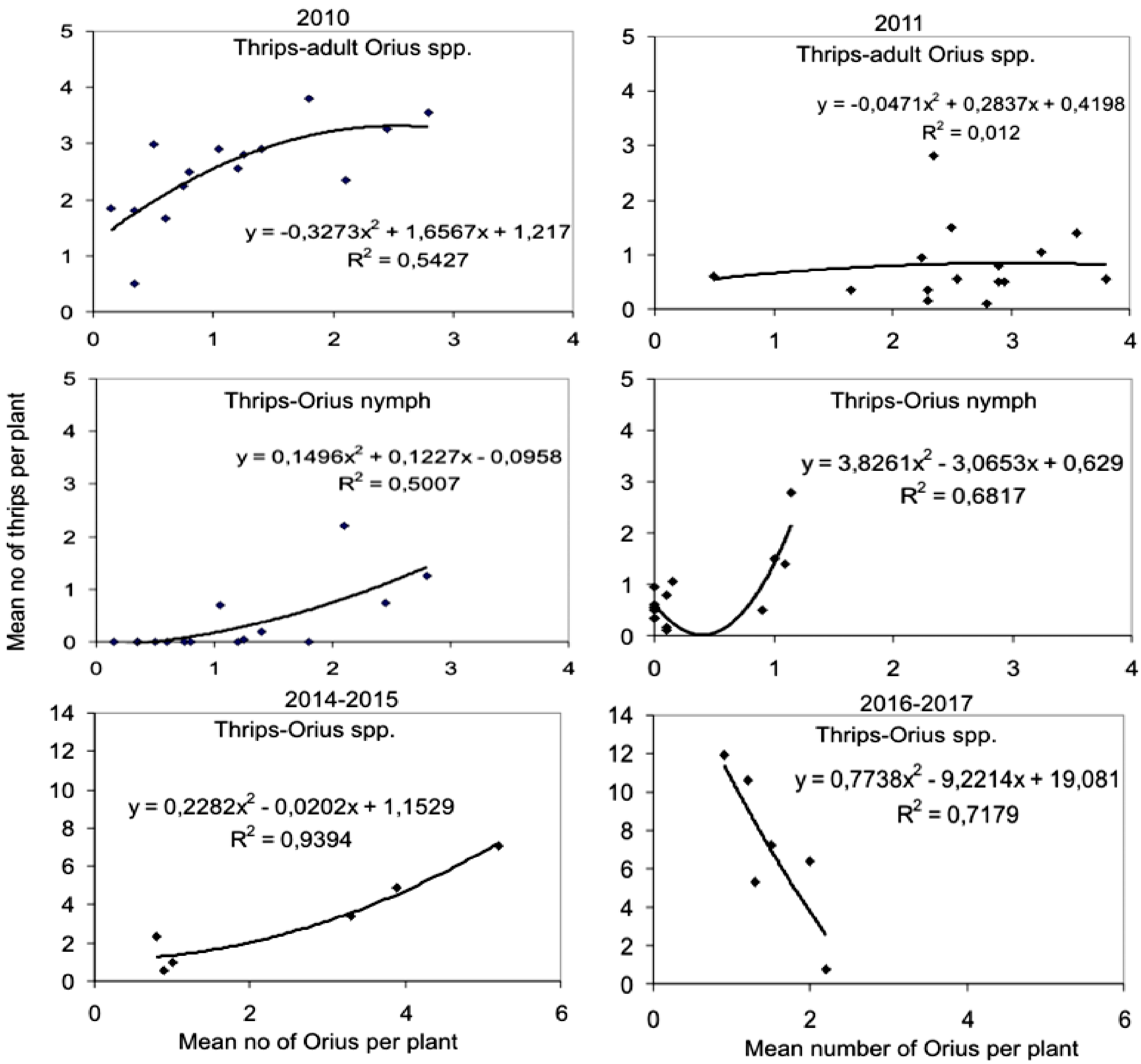

Figure 5 Relationships between adult thrips and adult *Orius*, and adult thrips and *Orius* nymphs on faba beans in Adana province, Turkey, 2010 and 2011, 2014-2015 and 2016-2017

differences between the geographical regions. *F. occidentalis* numbers were relatively higher in commercial fields (Figure 4) when compared with those of the previous growing season (Figure 3). This difference might be due to pesticide applications in commercial fields. However, the *Orius* population on faba beans in commercial fields followed the population of thrips.

3.4. Thrips-predator relationships

In experimental plots, the mean abundance of *O. niger* in faba bean flowers was significantly higher compared with that of thrips in 2010 and 2011. In 2010, there was a significant and positive relationship between thrips and adults of *Orius* spp. ($F_{1,13}$= 6.081, P = 0.015) and thrips and *Orius* nymphs ($F_{1,13}$ = 7.7201, P = 0.009) (Figure 5). In 2011, the thrips population did not follow the pattern of the adult *Orius* population. A significant and positive relationship between numbers of thrips and nymphs of *Orius* was detected ($F_{1,13}$ =12.851, P =0.001) (Figure 5). There was a consistent relationship between numbers of thrips and *Orius* spp. in the 2014-2015 ($F_{1,4}$= 14.389 P= 0.02) and 2016-2017 growing seasons ($F_{1,4}$= 6.837, P = 0.036) (Figure 5). The low abundance of *F. occidentalis* throughout the autumn-spring period on faba bean

Table 4 Total numbers of thrips and *Orius* and prey:predator ratios on faba beans in Adana Province, Turkey, 2010-2011, 2014-2015, and 2016-2017

Sampling year or period	Months	No. of Thrips	No. of *Orius*	Prey (thrips):predator (*Orius*) ratios
2010	January	8	140	0.05
	February	54	221	0.44
	March	90	233	0.38
	April	7	70	0.10
	Total	159	664	
2011	January	40	179	0.23
	February	40	178	0.22
	March	140	284	0.49
	April	26	167	0.15
	Total	246	808	
2014-2015	November	49	70	0.70
	December	23	8	2.87
	January	10	12	0.83
	February	34	33	1.03
	March	71	52	1.36
	April	6	9	0.66
2016-2017	November	8	22	0.66
	December	106	12	4.81
	January	64	20	3.20
	February	53	13	4.07
	March	119	9	13.2
	April	72	15	4.8
	Total	615	275	

Table 5 Prey:predator ratios on two plant parts of faba beans in Adana Province, Turkey, 2010-2011

Months	Leaves			Flowers		
	No. of thrips	No. of *Orius*	Prey (thrips) : predator (*Orius*) ratios	No. of thrips	No. of *Orius*	Prey (thrips): predator (*Orius*) ratios
Year 2010						
January	0	0	-	0	25	-
February	3	3	3	18	22	0.81
March	9	1	9	36	73	0.49
April	0	0	-	7	30	0.23
Total	12	4		61	150	
Year 2011						
January	6	13	0.46	6	34	0.17
February	1	11	0.09	12	56	0,21
March	3	8	0.37	11	15	0.73
Total	10	32		29	105	

might have resulted from thrips population suppression by predatory bugs. The results also revealed that larval thrips had a higher risk of predation than did the adults.

3.5. Prey (thrips)-predator (*Orius*) ratio on flowers

The prey-predator ratio was less than 0.5 thrips per *Orius* in the experimental plots in 2010 and 2011 (Table 4). In commercial fields during the 2014-2015 growing season, the lowest prey-predator ratio (0.7 thrips per *Orius*) was in April, while the highest prey-predator ratio (2.9 thrips per *Orius*) was in December (Table 4). In 2016-2017, prey-predator ratios were higher compared with 2014-2015. During this growing season, the thrips: *Orius* ratio ranged between 0.7 and 13.2. Thrips suffered more due to *Orius* spp. attacks in November (0.7 thrips per *Orius* spp.) and less in March (13.2 thrips per *Orius* spp.).

3.6. Prey (thrips)-predator (*Orius*) ratio on various plant parts

Prey (thrips)-predator (*Orius*) ratios on various plant parts i.e. leaflets and flowers of faba bean were also studied in only experimental plots in years 2010 and 2011 (Table 5). In 2010, the lowest numbers of thrips and *Orius* were recorded on faba bean leaves (Table 5). In January and April, no thrips were found on leaves of faba bean. For flowers also, a reduction in the prey:predator ratios was reported after January 2010 and 2011. In both years, prey-predator ratios in flowers were less than one thrips per *Orius*, indicating that thrips might have a higher predation risk in flowers rather than on leaves (Table 5). Delayed suppression of thrips populations was assumed for anthocorid-thrips ratios greater than 1:217, where as immediate suppression of populations was observed within 6.5 days at predator-prey ratios greater than 1:50 (van den Meiracker & Ramakers, 1991).

In the present study, the ratio of prey to predator in flowers ranged from 0.05 to 13.2 and was below five adult thrips per *Orius* on most sampling months. Funderburk et al. (2000) concluded that numbers of *F. occidentalis* colonizing field peppers were near zero within days after predator : prey ratios reached 1:40. The present results suggest that thrips on faba bean plants might have suffered most from predation by *Orius* spp. because prey-predator ratios were often lower than the ratios in previous studies.

Conclusion

Although faba bean hosted many pest species, their numbers were low and their damage to plants was not observed. *Orius* species were the most common predaceous insects in the faba bean fields. Flower densities on plants might be a primary factor for the presence and abundance of *Orius* spp., rather than their insect prey, such as thrips. Cultivation of faba bean in October seems to be a good cultural practice because (i) plants have relatively high densities of predators (mainly *Orius* spp.) and relatively low numbers of pest thrips and other pest insects, and (ii) plants generate more green pods. Growing of faba bean in the winter-spring period, especially in agricultural areas having poor plant diversity in the Mediterranean region, could be useful for conservation and augmentation of beneficial insects.

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Conflict of Interest

The author declares that there were no conflicts of interest.

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