PREDATOR-PREY INTERACTIONS BETWEEN PREDATORY BUG *ORIUS* SPP. (HEMIPTERA: ANTHOCORIDAE) AND WESTERN FLOWER THRIPS, *FRANKLINIELLA OCCIDENTALIS* (PERGANDE) (THYSANOPTERA: THRIPIDAE) ON FABA BEAN IN TWO DIVERSE HABITATS

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ABSTRACT: Field experiments were established in two ecologically diverse areas (polyculture and triculture) in the same agricultural landscape in the Research and Application Farm of the Faculty of Agriculture, University of Çukurova, Balcalı in seasons; 2005 and 2006 in which prey-predator interactions between predatory bugs, *Orius* spp. and their prey, western flower thrips, *Frankliniella occidentalis* (Pergande) on faba bean was evaluated. *Orius niger* (Wollf) was found to be the most prevalent predatory insect species in both habitats. *F.occidentalis* and *Orius* species were mainly collected from the flowers of faba bean in both location and years. Densities of both insect species were relatively greater in polyculture area than those numbers found in triculture. Numbers of *F. occidentalis* and *Orius* spp. were greater in polyculture in both years. Population trends of *Orius* spp in abundance were significantly related to the population patterns of *F. occidentalis* in both habitats in both years ($P<0.05$). Ratios of prey: predator (thrips: *Orius*) were found to be lower as less than 0.25 thrips per *Orius* on faba bean in both habitats, indicating that *Orius* was an effective predator of pest thrips species. Furthermore, faba bean were found to be more useful in conservation and augmentation of *Orius* spp. in winter time.

KEY WORDS: Prey-predator interactions, *Orius* spp., *Frankliniella occidentalis*, abundance, faba bean

Faba bean (*Vicia faba* L.) is an important nutritious food crop containing high protein levels as human food. This crop is cultivated widely together with other winter vegetable crops in the eastern Mediterranean region of Turkey. Faba bean is also a good rotational crop fixing nitrogen and thus enhancing soil fertility. This crop is rank fourth among the other leguminous crops in Turkey in term of production. Faba bean is consumed as green vegetable or dried pods in the Aegean and Mediterranean Regions of Turkey (Anonymous, 2001).

Polyphagous anthocorid *Orius* spp. (Hemiptera: Anthocoridae) are often considered as important predators of thrips (Riudavets 1995). In Turkey, *O. niger* suppress effectively population increase of *Frankliniella* flower thrips in the non-insecticide treated cotton fields in Çukurova region (Atakan, 2006; Atakan & Gençer, 2008) also *Orius* spp. are recorded on various vegetable crops grown in different parts of Turkey (Yaşarakıncı & Hıncal, 2000; Bulut & Göçmen, 2000). *Orius* spp. are an important biological control agent regulating the populations of the serious pestiferous thrips, the western flower thrips (WFT), *Franklinella occidentalis* (Pergande) especially in the greenhouse crops (Tommasini, 2004; van de Veire & Degheele, 1992; Tavella et al., 2000). *O. niger* has been well

established to manage *F. occidentalis* in glasshouse cultivation of sweet pepper (van de Veire & Degheele, 1992).

Habitats represented by different plant biodiversity can affect differently richness of harmful and beneficial arthropod species insect species and their densities on host plant crops (Root, 1973; Sheehan, 1986; Russell, 1989; Andow, 1991). There are numerous studies dealing with effects of the crop diversification on abundance of the pestiferous and of beneficial insects (Letourneau & Altieri, 1983; Letourneau, 1990; Helenius, 1991; Coll & Bottrell, 1994, 1995; Nampala et al., 1999). However, in the additive intercropping experimental design, there is inter-specific plant competition that hampers crop development that may indirectly affect abundance of herbivore species (Bukovinszky et al., 2004). Greater availability of alternative foods in a mixed experimental design in the same experimental area may reduce predation risk of a target pest insect due to habitat complexity interfering with the movement and host searching behaviors of the natural enemies of pest insects (Ables et al., 1978; Andow & Prokryn, 1990).

Though, *Orius* species are common predators of thrips species on vairous crops, their winter activity and predatory ability particularly on *F. occidentalis* on winter crops such as faba bean or wild plants in the vegetationally different agricultural areas is not well understood in the Mediterranean region.

Considering the possible mixed effects of intercropping (i.e., different plant architecture, plant volatiles and cues) on accumulations of the thrips and the predatory insect, two field experiments were established in two ecologically diverse areas in the same agricultural landscape. Faba bean, cultivated as winter crop in a large scale, flowering through early-winter and-spring in the eastern Mediterranean region of Turkey, may have various ecological impacts on the *F. occidentalis-Orius* population dynamics. This may allow well-understanding of the predation abilities of *Orius* species on pestiferous insects on subsequent arable crops in the region.

In this work, we aimed to assess (a) abundance patterns of *F. occidentalis* and *Orius* spp. on faba bean in diversified two habitats (b) species compositon of *Orius* spp. on faba bean and (c) preference of faba bean parts by *F. occidentalis* and *O. niger*.

MATERIAL AND METHODS

Study Sites

This work was carried out in the Research and Application Farm (RAF) of Faculty of Agriculture, University of Çukurova in seasons; 2005 and 2006. The area of the RAF is 12 ha and has different topographical features of landscapes. For instance, winter wheat is the predominant crop in the non-irrigated area, while in the irrigated lands various agricultural crops including alfalfa, temperate fruit crops, vegetables and field crops such as cotton, maize, sesame and soybean are grown either experimentally or commercially.

The first experimental area (N: 37° 01.809´; E: 35° 21.694´) is represented by high plant biodiversity, i.e., polyculture area which included winter vegetables (onion, broccoli, lettuce and red cabbage), wheat and annual summer crops (cotton and maize) grown in small acreage. Additionally, various citrus species (lemon, orange, mandarin and grapefruit) olive trees are also grown commercially. Winter or annual summer crops were grown in an area of 1,5 ha, while citrus and olive are grown in an area of 2.2 ha and 1.5 ha, respectively. Another experiment of an area of 8.0 ha established in Cotton Research and Application Centre (CRAC) (N: 37° 00.795´; E: 35° 21.119´). In this area, wheat

(6.5 ha) and lettuce (1.0 ha) had been grown commercially. This experimental area is described as triculture. Two habitats were isolated from each other by nearly 2 km, and they have the same ecological features excluding plant biodiversity.

Experimental procedure

The experimental area of faba bean (cv. Lara) was established nearby the citrus (mandarin and orange) and olive trees, while wheat and lettuce plots (50 or 100 m²) in polyculture area. This area included various winter vegetable crops which established in separate plots of 200 m² and they were nearly 200 m away from the experimental area.

Faba bean was planted on 5 October, 2004 and 15 October, 2005. The size of the experimental area was 500 m² (25 m-length and 20 m-width). Experimental area was divided into five replications. No pesticides were applied during the course of the experiment.

Sampling of insects on faba bean

A beating method was performed to extract thrips or *Orius* populations from the plants. For this aim in each sub-plots, five plants were randomly selected, bent down and vigorously shaken into a white plastic container for about 5 sec. The extracted thrips and predators were collected by a fine brush and stored in plastic vials (2 ml) contained 60% ethyl alcohol. In the laboratory, the thrips samples were transferred to vials containing AGA solution (i.e., 10 parts of 60% ethyl alcohol, one part glacial acetic acid and one part glycerine) and kept for one day. Thrips species were slide-mounted and identified under a binocular microscope. Larval thrips were grouped into one category due to difficulty of their identification. The same sampling method was also applied to identify other beneficial and harmful insect species inhabiting faba bean plants.

Sampling of thrips and *Orius* on various plant parts of faba bean

Five plants were randomly selected from each sub-plots of faba bean and a total of 6 leaflet and flowers (two leaflets or flowers from each three sections, upper, middle and lower) sampled for numbers of *F. occidentalis* and *Orius* in both years. Leaflets and flower samples of each plant were separately kept in plastic bags and the samples were stored in an insulated cooler and transmitted to the laboratory. In order to extract the populations of thrips or beneficial insects, flowers and leaf samples were kept for one or two hour in a deep-freezer and then, tapped onto white plastic sheet. The extracted thrips and predators were collected by fine brush and kept in plastic tubes (2 ml) containing 60% ethyl alcohol for further identification processes. Flowers were dissected carefully to expose any remained thrips or predators in flower parts and rinsed in a dettergened solution 2% for 25 sec then sieved. Thrips extracted from the solution were transferred to plastic tubes contained 60% ethyl alcohol. *Orius* species were identified by guidance of Önder method (1992) and Tommasini (2004). Thrips species were identified by the first author. Identified insect samples were counted separately under steromicroscope with x45 magnification.

Data analyzes

Other thrips species: *Thrips tabaci* Lind, *Thrips major* Uzel, *Thrips meridionalis* (Priesner), *Thrips angusticeps* Uzel and predatory thrips *Aeolothrips collaris* Priesner, were collected mainly in polyculture area and their abundance was not evaluated because their numbers were few in most sampling dates. Numbers of larval thrips were not subjected to analysis due to their very low numbers. Numbers of the most common predators, *Orius* spp. (pooled) adults and *Orius* spp nymphs (pooled). Numbers of *F. occidentalis and Orius* spp. on two plant parts (i.e., leaves and flowers) were pooled for each sampling location

and for sampling years. seasonal comparisons of the numbers of thrips and *Orius* on plant parts i.e., leaves and flowers in the two habitats, were quantified by using the simple t- test at $P < 0.05$. Relationships between numbers of thrips and *Orius* on faba bean plants were done by using Quadratic regression analysis at $P< 0.05$. All analyzes were performed by SPSS 13.0. Microsoft statistics programs (SPSS, 2000).

RESULTS

Species composition of *Orius* on faba bean

Orius niger was the most prevalent predatory insect species on both habitats, except those in March which were dominated by *O. laevigatus*. Overall, proportions of *O. niger* on faba bean in polyculture were 71 and 74% in 2005 and 2006; and in triculture, 73 and 55% in 2005 and 2006, respectively (Fig. 1).

Abundance of thrips and *Orius* on two plant parts of faba bean

Frankliniella occidentalis (adult) and adults of *O. niger* were mainly collected from the flowers of faba bean on most sampling dates in both location and years (Table 1). Overall, seasonal mean numbers of both insects were significantly higher in flowers than in leaves in both locations in both years ($P < 0.05$) (Table 1). *Orius* nymphs were always found in flowers' samples, but their numbers were very few on most sampling dates in both locations.

Abundance of thrips and *Orius* populations on faba bean

Early colonization of *F. occidentalis* in faba bean was detected in polyculture area. Population densities of thrips in both habitats were lower in 2005 than numbers in 2006 (Fig. 2). Numbers of thrips peaked in 28 March 2005 and 16 March 2006 in polyculture area. Mean numbers of thrips in polyculture were highly greater on most sampling dates as compared to mean numbers of thrips in triculture in both years (Figure. 2). Colonization's time of both *Orius* species to faba bean plants was similar in polyculture, but was two weeks earlier than those of triculture in both years (Fig. 2). Populations of total *Orius* adults fluctuated with some increases and decreases throughout the samplings in both habitats in 2005 (Fig. 2). In 2005, mean numbers of adult *Orius* spp. increased to peak on 21 February and 28 March in polyculture and 28 March in triculture. Mean numbers of *Orius* adults were greater on most sampling dates in the period between January and February than numbers found in triculture area in 2005. In 2006, mean numbers of adult *Orius* spp. increased to peak on 2 February, 16 March and 6 April in polyculture and 23 February and 30 March in triculture. Similarly, previous year, in 2006, by excluding 16 February and 30 March the mean numbers of *Orius* spp. in polyculture area were more abundant on most sampling dates than numbers found in triculture (Fig. 2).

Population trends of *Orius* spp. in abundance followed the population patterns of *F. occidentalis* in both habitats in both years. There were significantly positive relationships between numbers of thrips and *Orius* spp. in both habitats in both years (Table 2). Populations of *Orius* were greater than those of thrips in all sampling dates in both years and numbers of thrips were very low or negligible at the presence of high numbers of *Orius* populations in both habitats.

Most of the nymphs probably belonged to *O. niger* because this predator was widely-spread on faba bean on most sampling periods in both area and years. First nymphs of *Orius* were detected on faba bean in the first or second week of March in both habitats (unpublished data).

Overall, relatively greater numbers of *F. occidentalis* and *Orius* spp. were detected in polyculture in both years (Fig. 3).

Prey: predator ratio

Ratios of prey: predator (thrips: *Orius*) were found to be relatively greater in polyculture than triculture in both years (2005-polyculture = 0,15; 2005-triculture = 0,06; 2006-polyculture = 0,21; 2006-triculture = 0,13 (Fig. 4).

Other insect species

A total of 14 pest insect species were identified on faba bean during the samplings in both habitat (Table 3). Among these insect species, leafhoppers were more abundant during the sampling period. Other insect species, excluding aphid *Acyrthosiphon pisum* (Haris), were rarely found and their cumulative numbers were low in both years. *A. pisum* numbers were relatively greater in 2006 than that found in previous study-year. However no damage on plants due to aphid or leafhopper feedings was recorded in both years. In general, identified pestiferous insect numbers were greater in polyculture habitat than those found in triculture habitat.

A total of 11 predatory insect species were identified on faba bean during the sampling (Table 4). Among these insect species, *Orius niger* were more abundant during the sampling periods. Other beneficial arthropods were rarely found and their cumulative numbers were low in both years. In general, identified predacious insect numbers were greater in polyculture habitat than those found in triculture habitat. Predators *Satphylinus* and *Campylomma nicolosi* were detected only in polyculture habitat in both years.

DISCUSSION

The results show that *Orius niger* was the main *Orius* species on both faba bean. Here, *O. niger* appeared to be the more active predator in the hard winter months in the region (Fig. 1). This may be a result of both year round availability of its thrips prey (Atakan & Uygur, 2004). *O. niger* is commonly found anthocorid species in Italy, while *O. laevigatus* is the most abundant species in the warmest locations of Italy (Tommmasini, 2004).

The flowers of faba bean mainly colonized by *F. occidentalis* and *Orius* species during winter and early spring time (Table 1). It is well-known that *Orius* species benefit from the plant nectars and pollens (Dick & Jarvis 1962, Salas-Aguilar & Ehler 1977, Kiman & Yeargan 1985). Though, the flowers of faba bean might be important as pollen and nectar sources for the survival of *Orius* species beside other predators and parasitoids during unavailability or scarcity of arthropod preys. This case is more likely due to the greater availability of extra floral nectars found in faba bean plants (Anonymous, 2008). Nuessly et al. (2004) indicated that numerous beneficial insect species visited the faba bean plants grown in southern Florida (USA). Additionally, large and closed structure of those flowers might be a good hibernation and shelter site for protection of *Orius* species from unfavorable climatic conditions.

In both habitats, population densities of the thrips on plants were lower than those of *Orius* spp. (Fig. 2). Faba bean flowers were found to be good host especially for *Orius* spp. in winter time. Low densities of thrips throughout the winter-spring season may indicate that thrips have high predation risks due to *Orius* attacks. This suppression of thrips effectively by a predator depends upon several factors comprising the initial population densities of the prey and predator, their fecundity, and morphological structure of host plant (Osekre et al., 2008). Previous studies done in the region reported capability of *O. niger* to effectively suppress *Frankliniella* flower thrips on untreated crop plant such as cotton (Atakan & Özgür, 2001) and wild plants (Atakan & Tunç, 2010). There

were consistent suppressions of *F. occidentalis* populations overtime in faba bean. Prey - predator ratios in most of sampling weeks were very lower (less than 0.25 thrips per predator) than 217 thrips per *Orius*, which this ratio is critical capability ratio for *O. insidiosus* to effectively control populations of *F. occidentalis* (Sabelis & van Rijn, 1997). In current study, significant correlations obtained between numbers of thrips and *Orius* in both habitats may be an evident of *Orius* species mainly *O. niger* becoming an important natural enemy of pest thrips.

In this work, *F. occidentalis* and both *Orius* species were more abundant on faba bean grown in polyculture than their abundance found in triculture. Additionally some pest insect species such as leafhoppers were more abundant in polyculture area. This issue is probably due to great availability of different crop plant species in polyculture area. Additionally, in the polyculture, multi-flowering weed species might enhance the reproductive capacity of *Orius* species, providing nectars, pollens and also alternative preys (Atakan, 2010). Generalist natural enemies such as anthocorids are particularly assumed to benefit of plant diversification because of the great availability of food sources (Root, 1973; Sheehan, 1986; Russell, 1989). Numbers of *Orius* were lower on the intercropped cowpea + sorghum than numbers in cowpea as sole crop and cowpea + greengram mixture (Nampala et al., 1999). Population densities of *Orius* sp. were not significantly different when cowpea had grown alone or intercropped in Kenya (Kyamanyawa et al., 1993). The above findings obtained from other studies differ, probably, due to variation in microclimatic conditions, while different suitability of preferred niches and insect meals recorded within the mixed cropping system (Altieri et al., 1978; Andow, 1983; Letourneau & Altieri, 1983; Ogenga-Latigo, 1988).

The quick colonization of adult *Orius* species to faba bean in polyculture ecosystem may have resulted in the nearly two weeks earlier appearance of *Orius* nymphs than happened in triculture. The first *Orius* nymphs on faba bean were recorded in the first or second week of March in both years. We recorded both male and female of *O. niger* during the study. However, O. *niger* produced nymphs on *S. arvensis* in the mild winter period (December and January) in the same experimental area (Atakan, 2010). Tommasini & Nicoli (1996) revealed that North Italy strains of *O. laevigatus* inclined to go into diapause while the strain from the southern Italy could give offspring in the autumn and winter time. Bahşi & Tunç (2008) commented that *O. niger* would have an ability to survive and produce nymphs under unheated greenhouses conditions in Mediterranean region of Turkey, based upon the laboratory results. A reason of no nymphs dwelling the faba bean throughout the winter time (January and February) in our study was attributed to unfavorable climatic conditions for nymphal survival, resulting in death of the nymphs.

In conclusion, faba bean is a more attractive plant species hosting considerable numbers of the *Orius* species and other beneficial insects in winter time. Cultivation of faba bean, especially in monoculture area could be useful for conservation and augmentation of the beneficial insects including *Orius* spp. Overwintering biology of *O. niger* is not clearly understood. Therefore, further study should be planned for this issue.

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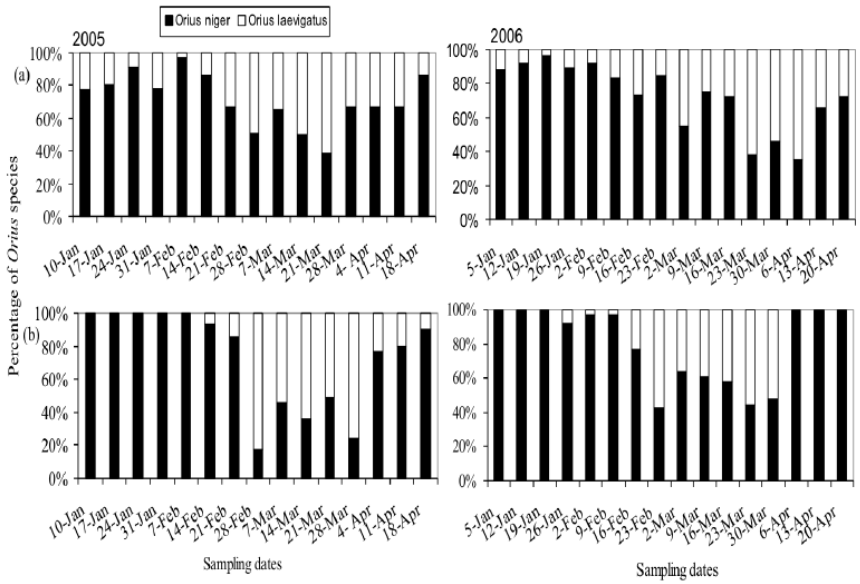

Figure 1. Proportions of adults of two *Orius* species in faba bean with polyculture (a) and (b) triculture areas in 2005-2006.

Table 1. Seasonal abundance of *Frankliniella occidentalis* and *Orius* spp. adults on leaves and flowers of faba bean in Adana province, Turkey in 2005-2006.

Years	Habitat types	Insect species	Plant parts	Mean numbers (±SE)/ plant parts	ANOVA results		
					df	t value	P value
2005	Polyculture	*Orius* spp.	Leaves	0.25±0.12	1,38	5.451	0.005
			Flowers	2.50±0,39			
	Triculture	*Orius* spp.	Leaves	0.20±0.29	1,38	5.448	0.001
			Flowers	1.90±0.09			
2006	Polyculture	*Orius* spp.	Leaves	1.65±0.32	1,38	7.085	0.0001
			Flowers	5.01±0.35			
	Triculture	*Orius* spp.	Leaves	0.15±0.08	1,38	2.429	0.021
			Flowers	1.00±0.34			
2005	Polyculture	*Frankliniella occidentalis*	Leaves	0.60±0.16	1,38	4.799	0.0001
			Flowers	2.65±0.39			
	Triculture	*Frankliniella occidentalis*	Leaves	0.0±0.0	1,38	4.723	0.0001
			Flowers	0.90±0.19			
2006	Polyculture	*Frankliniella occidentalis*	Leaves	0.45±0.18	1,38	2.859	0.005
			Flowers	1.45±0.50			
	Triculture	*Frankliniella occidentalis*	Leaves	0.90±0.20	1,38	2.983	0.026
			Flowers	2.05±0.34			

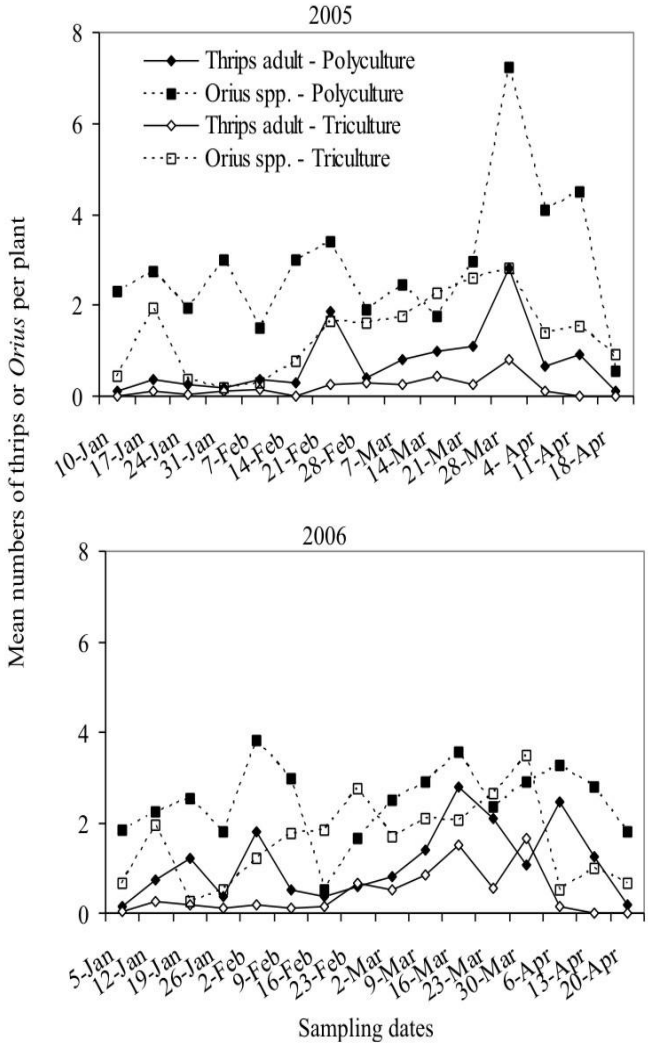

Figure 2. Mean numbers of *Frankliniella occidentalis* and *Orius* populations on faba bean in two diverse habitats in 2005-2006.

Table 2. Relationships between numbers of *Orius* spp. and *Frankliniella* thrips on faba bean plants in two diverse habitats in 2005-2006, Adana province, Turkey.

Years	Habitat type	Associations	df	R^2	F	P	Equations
2005	Polyculture	*Orius*-thrips	2,12	0.65	10.174	0,0003	$Y= 0.0496x^2 - 0.229x + 0.2815$
	Triculture	*Orius*-thrips	2,12	0.69	6.722	0.011	$Y= 0.144x^2 - 0.2248x + 0.1276$
2006	Polyculture	*Orius*-thrips	2,13	0.57	8.289	0.005	$Y= 0.217x^2 - 0.2694x + 0.3141$
	Triculture	*Orius*-thrips	2,13	0.61	10.564	0.002	$Y= 0.137x^2 - 0.0632x + 0.0857$

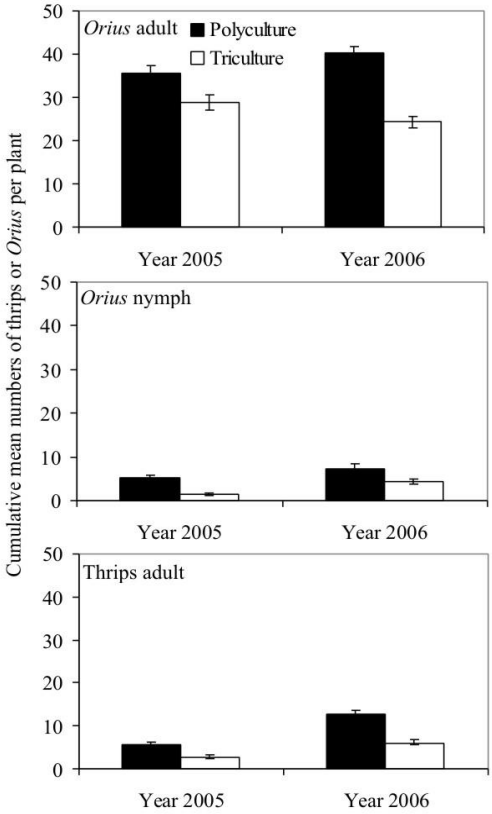

Figure 3. Seaosonal mean numbers of *Frankliniella occidentalis* and *Orius* populations on faba bean in two diverse habitats in 2005-2006.

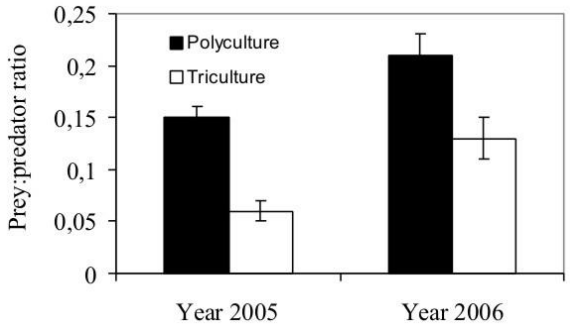

Figure 4. Seasonal prey:predator (Thrips: *Orius*) ratios in two diverse habitats in 2005-2006.

Table 3. List and cumulative numbers of harmful insect species detected on faba bean in Adana province, Turkey during 2005-2006.

Insect species	Order	2005		2006	
		PC	TC	PC	TC
Hypera variabilis Herbst.	Coleoptera/ Curculionidae	21	0	213	0
Meligethes sp.	Coleoptera/ Nitidulidae	15	0	14	4
Epicometis (*Tropinota*) *hirta* Poda	Coleoptera/ Scarabaeidae	8	0	3	0
Oxythrea cinctella (Schaum)	Coleoptera/ Scarabaeidae	5	0	0	0
Eurydema ornatum L.	Hemiptera/ Pentatomidae	0	0	5	0
Lygus sp.	Hemiptera/ Lygaeidae	0	0	6	0
Asymmetrasca decedens (Paoli)+*Empoasca decipiens* Paoli	Hemiptera/ Cicadellidae	321	240	968	340
Acyrthosiphon pisum (Haris)	Hemiptera/ Aphididae	10	5	197	13
Thrips major (Priesner)	Thysanoptera/ Thripidae	18	1	17	16
Frankliniella occidentalis (Pergande)	Thysanoptera/ Thripidae	26	16	8	2
Thrips meridionalis Uzel	Thysanoptera/ Thripidae	13	3	10	2
Thrips tabaci Lin.	Thysanoptera/ Thripidae	6	2	2	3
Thrips angusticeps Uzel	Thysanoptera/ Thripidae	5	0	1	0
Melanthrips pallidior Priesner	Thysanoptera/ Aeolothripidae	12	10	7	4

PC:Polyculture;TC:Triculture

Table 4. List and cumulative numbers of beneficial insect species detected on faba bean in Adana province, Turkey during 2005-2006.

Böcek türleri	Order/Family	2005		2006	
		PC	TC	PC	TC
Coccinella semptempunctata L.	Coleopter/ Coccinellidae	5	0	3	0
Hipodomia variegeta Goeze	Coleoptera/ Coccinellidae	4	0	2	0
Scymnus levaillanti Mulsant	Coleoptera/ Coccinellidae	6	0	1	0
Scymnus pallidipediformis Günther	Coleoptera/ Coccinellidae	8	0	5	0
Staphylinus sp.	Coleoptera/ Staphylinidae	16	0	45	0
Orius niger (Wolff)	Hemiptera/ Anthocoridae	58	49	162	90
Orius laevigatus (Fieber)	Hemiptera/ Anthocoridae	16	10	37	5
Orius majusculus (Reuter)	Hemiptera/ Anthocoridae	0	0	2	0
Campylomma nicolasi (Reuter)	Hemiptera/ Miridae	15	0	14	0
Chrysoperla carnea (Stephens)	Neuroptera/ Chrysopidae	14	3	10	2
Aeolothrips collaris Priesner	Thysanoptera/ Aeolothripidae	17	14	19	11

PC:Polyculture;TC:Triculture