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Orijinal araştırma (Original article)

Abundance patterns of predatory bugs, *Orius* spp. (Hemiptera: Anthocoridae) and their some insect preys on faba bean with different planting dates in Adana province, Turkey

Adana ilinde farklı tarihlerde ekilen bakla bitkisinde avcı *Orius* spp. (Hemiptera: Anthocoridae) ve bazı böcek avlarının popülasyon yoğunlukları

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Summary

Population densities of predatory bugs, *Orius* spp. (Hemiptera: Anthocoridae) and their insects preys on faba bean were investigated in Adana province of Turkey in two growing seasons, 2007/08 and 2008/09. Faba bean was planted on 10 October, 25 October, 10 December and 25 December. Insect species were sampled by beating the plants vigorously into a white plastic container. Leafhopper complex species [*Asymmetrasca decedens* (Paoli) and *Empoasca decipiens* Paoli] (Hemiptera: Cicadellidae)] and pea aphid, *Acrytosiphum pisum* (Haris) (Hemiptera: Aphididae) were more abundant in late plantings in December. *Orius* spp. [*Orius niger* (Wolff) and *Orius laevigatus* (Fieber)] were the main predacious insects. *Orius* spp. were significantly more abundant on the early-planted beans in January-February period. However, *Orius* adults moved to late-planted plots, especially plots planted on 10 December when plants had high numbers of flowers. Although significant and positive relationships between *Orius* spp. and aphid populations were detected in plots of the latest planting date, this relationship had no more contribution to population increase of *Orius* spp. It seems that *Orius* spp. benefited more from the faba bean plants for plant meal, shelter, mating and ovipositon sites than from insect preys. Finally, it would be better to cultivate faba bean in late October in the eastern Mediterranean region conditions, due to plants having low abundance of the main pests and high abundance of the predators, and also high numbers of fruiting parts.

Keywords: Faba bean, harmful insects, predatory insects, *Orius* spp., planting date

Özet

Orius spp. (Hemiptera: Anthocoridae) ve avlarının, farklı tarihlerde ekilen bakladaki popülasyon yoğunlukları, Adana ilinde 2007/08 ve 2008/09 yıllarında incelenmiştir. Bakla 2007 yılında 10, 25 Ekim; 2008 yılında ise 10 ve 25 Kasım tarihlerinde ekilmiştir. Böcekler, bitkilerin beyaz renkli kap içerisine silkelenmesiyle toplanmıştır. Bezelye yaprakbiti, [*Acrytosiphum pisum* (Haris) (Hemiptera: Aphididae) ve karmaşık yaprakpireleri [*Asymmetrasca decedens* (Paoli) and *Empoasca decipiens* Paoli (Hemiptera: Cicadellidae)] geç ekilen parsellerdeki bitkilerde nisan ayında yüksek yoğunlukta bulunmuşlardır. Örnekleme süresince ana predator türler olarak, *Orius* spp. [*Orius niger* (Wolff) ve *Orius laevigatus* (Fieber)] kaydedilmiştir. *Orius* spp. bireyleri ocak-şubat döneminde, erken zamanda ekilen parsellerdeki bitkilerde yüksek yoğunlukta bulunmuş, fakat daha sonraları geç ekilen parsellere özellikle, bu dönemde çiçek sayısının daha yüksek olduğu 3. tarihte ekilen (10 Kasım) parsellere geçmişlerdir. Önemli ve pozitif ilişki *Orius* spp. ve yaprakbiti popülasyonları arasında görülmüş olup, sadece, en geç tarihte ekilen parsellerde saptanmıştır. Ancak, bu ilişkinin *Orius* popülasyon artışına katkısı olmamıştır. *Orius* bireylerinin, böcek avlarından daha çok, bitkilerden besin, korunma, çiftleşme ve yumurta bırakma amacıyla daha fazla yararlandıkları kanaatine varılmıştır. Sonuç olarak, Doğu Akdeniz Bölgesi koşullarında bakla ekiminin, bitkilerin daha düşük yoğunlukta zararlı böcek ve daha yüksek sayıda avcı böcek barındırdığı ve ayrıca daha yüksek sayıda meyve organına sahip olduğu ekim ayının sonlarında yapılması önerilir.

Anahtar Sözcükler: Bakla, zararlı böcekler, avcı böcekler, *Orius*spp. ekim tarihi

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Introduction

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

In Turkey, the insect species and their pest status on faba bean are rudimentary. However, in previous studies performed in same ecological area, insect pests of faba bean and their economic importance were described by Atakan & Ulusoy (2008) and the seasonal abundance of the western flower thrips, *Frankliniella occidentalis* (Pergande) and the generalist predator *Orius niger* (Wolff) (Hemiptera: Anthocoridae) were studied by Atakan (2010). Pest status of insects of faba bean in the Mediterranean countries including Tunisia, Syria was documented by Weigand & Bishara (1991). According to this study, aphids and *Sitona* spp. were the main pest of faba beans in those countries.

Non-chemical control strategies are crucial in insect pest management in diverse crops. Cultural and biological control of pestiferous thrips species are important components of integrated pest management strategies in various crop plants. Optimizing crop sowing strategy is a well-known cultural practice employed to avoid pest infestation in various crops. Problems due to the widely use of chemical insecticides encourage the development of alternative pest management tactics including use of biological control elements such as generalist predators including *Orius* species (Riudavets, 1995). *Orius* spp. were the main predators of aphids and flower thrips in cotton fields in Adana province, Turkey (Atakan & Özgür, 1994; Atakan & Gençer, 2008).

In Turkey, influences of faba bean varieties or genotypes, sown in different planting dates, on some plant characteristics and seed yield were previously reported (Tosun et al., 1984; Bozoğlu, 1989). Effects of different planting dates of faba bean on population densities of harmful and beneficial insect species and on prey-predator interactions are not clearly understood. Faba bean plants planted in October and December may create various ecological interactions between populations of pest insects and predatory insects (mainly *Orius*). This crop system may also allow us to understand clearly predation abilities of *Orius* spp. on pest insects in faba bean and other crops in the region.

The main objectives of this study were to assess (a) the species compositions of harmful and beneficial insects on faba bean, (b) abundance patterns of two main sucking pest insects and predatory bugs, *Orius* spp. in the plots representing different planting dates and (c) to test developments of faba bean plants (i.e. numbers of flowering parts) in plots planted at different time. Obtained data may be evaluated in integrated pest management strategies of faba bean and optimizing planting date in the region.

Materials and Methods

Study Site

This work was carried out in the Research and Application Farm (RAF) of the Faculty of Agriculture, University of Çukurova in two growing seasons, 2007/08 and 2008/09. The experimental area (N: 37° 01.809´; E: 35° 21.694´) has a high plant biodiversity, i.e., it is a polyculture area which includes winter vegetables (onion, broccoli, lettuce and red cabbage) grown in the small plots. Additionally, various citrus trees (lemons, oranges, mandarins and grapefruits) and olive trees, and temperate fruits such as nectarines and apples are also grown commercially.

Experimental procedure

The experimental area of faba bean (cv. Lara) was located at nearby winter vegetable crops (plots with 4 m^2) which they were also experimentally grown. The total size of the faba bean experimental area was 1375 m^2 (55 m $\times$ 25 m). A completely randomized plot design with three replicates was used. The size of the each plot was 12 m^2 (3 m $\times$ 4 m). Experimental plots were separated with a 2 m wide strip of bare ground. 120 seeds of faba bean were planted in each plot.

There were four planting dates: (1) 10 October (first planting date), (2) 25 October (second planting date), (3) 10 December (third planting date) and (4) 25 December (fourth planting date) in both years. No insecticide was applied during the course of the experiments but all plots were treated by the fungicide captan 50% WP with its recommended dose (3000 gr ha^{-1}) on 26 February and 9 March in 2008, due to occurrence of the botrytis infections on the plants.

Sampling of insects on faba bean

Faba bean and weeds were sampled from December to April of 2007-2008. Sample size was 20 randomly selected plants per plot. Insect species were sampled by beating the plants vigorously into a white plastic container (37 $\times$ 28 $\times$ 7 cm) for about 5 sec. Collected insect species were counted by using a hand lens in the field. Most *Orius* specimens were returned to the plots and a few were taken to the laboratory for identification. Insects that could not be identified in the field were transported to the laboratory and some of them were killed by help of the killing jar. Small and soft-bodied insects were kept in 60% ethanol.

In the laboratory, the thrips samples were transferred into vials containing AGA solution (i.e. 10 parts 60% ethanol, one part glacial acetic acid, and one part glycerin) and kept for one day. Thrips species were slide-mounted and identified under a binocular microscope.

Insect identification

Thrips species were identified by the author. *Orius* species were identified by following key descriptions of Önder (1982) and Tommasini (2004). Other collected predators or pest insect species were identified by using reference material deposited at the Entomology Laboratory of the Plant Protection Department, Faculty of Agriculture, Çukurova University, Adana-Turkey. Immature thrips (thrips larvae) and nymphs of the *Orius* specimens were pooled into a single category because no comprehensive key is available for their identification.

Identified insect samples were counted separately under a stereomicroscope with 45$\times$ magnifications.

Abundance of flowering structures on faba bean

Numbers of flowers and bean pods were also evaluated. A total of five or eight plants were randomly selected in each plot and their all flowers and green pods were counted at weekly intervals in February-March period for both years.

Data analysis

By excluding leafhoppers, aphids and *Orius* species, the abundance of other insect species, including thrips and other predators, were not evaluated because their numbers on the most sampling dates were too few to analyze.

To determine effects of planting and sampling dates on the abundance of adults (pooled) and nymphs (pooled) of *Orius* spp., leafhopper complex species (*Asymmetrasca decedens* (Paoli) and *Empoasca decipiens* Paoli) and pea aphid, *Acrytosiphum pisum* (Haris), were analyzed by the General Linear Model (GLM)-repeated measure statistical analysis. Weekly comparisons of the numbers of leafhoppers, aphids and *Orius* on faba beans among the sampling dates were done by using the Tukey's honestly significant difference (HSD) test at $P<0.05$.

Numbers of sucking insect pests and predatory insects in plots of the last sampling dates (fourth planting) in December was not evaluated because plants were too small to sample.. Relationships between the numbers of *Orius* and leafhoppers or aphids in each planting dates were evaluated by quadratic regression analysis at $P<0.05$. To determine influence of planting dates on developments of flowering parts (i.e. numbers of flowers and pods), one sampling date, where numbers of flowers or pods was the highest in each represent planting date, were considered for the analysis. Numbers of flowers on plants in all plots on 13 March in 2008 and on 11 March in 2009, and numbers of pods on plants in all plots on 17 March in 2008 and on 25 March in 2009 were the highest.

All analyses were performed by using the Microsoft Statistics Program SPSS 15.0. (SPSS, 2006).

Results

Harmful and predatory insect species on faba bean

Seasonal total numbers of identified harmful and predatory insect species in faba bean plots are presented in Table 1. A total of 16 harmful insect species were identified in the plots representing different planting dates. Leafhoppers complex species, *Asymmetrasca decedens* and *Empoasca decipiens* and pea aphid, *Acrytosiphum pisum* were more abundant pest insects in the plots. Their numbers were more abundant especially in late-planted plots. Coleopteran insect species, *Meligethe*s *aeneus* (F.) and *Sitona* sp., and hemipteran seed bug, *Nysius* sp. were recorded mostly at the flowering stage of plants and their total numbers were slightly greater in early plantings (i.e. in plots of first and second planting dates). Thrips species were observed sporadically in bean flowers in all plots and their numbers (pooled) were slightly greater on the first and second planting dates than those of others. Other pest insect species were recorded occasionally and their numbers were very low through sampling dates in all plots.

Table 1. List of harmful and beneficial insect species and their abundance (total numbers of individuals) in faba bean plots planted at different four dates in Balcalı in 2007-2009

	Total no of individuals				
Harmful insects Order/Family	1st/10 Oct	2nd/25 Oct	3rd/10 Dec	4th/25 Dec	Total
Sitona sp. Coleoptera/Curculionidae	13	9	13	0	35
*Meligethe*s *aeneus* (F.) Coleoptera/Nitidulidae	6	23	15	12	56
Epicometis (*Tropinota*) *hirta* Poda Coleoptera/ Scarabaeidae	0	2	1	1	4
Oxythrea cinctella (Schaum) Coleoptera/Scarabaeidae	0	1	0	0	1
Exolygus gemmellatus (L.) Hemiptera/Miridae	1	1	1	0	3
Nysius sp. Hemiptera/Lygaeidae	63	21	1	5	90
Oxycarenus hyalinipennis (Costa) Hemiptera/Lygaeidae	0	0	1	0	1
A*symmetrasca decedens* (Paoli)*Empoasca decipiens* Paoli Hemiptera/Cicadellidae	1162	1082	1466	1406	5116
Acyrthosiphum pisum (Haris) Hemiptera/Aphididae	714	653	1371	1468	4206
Aphis craccivora Koch Hemiptera/Aphididae	0	0	12	0	12
Thrips major (Priesner) Thysanoptera/Thripidae	8	5	6	1	20
Frankliniella occidentalis (Pergande) Thysanoptera/Thripidae	7	28	17	9	61

Table 1 (continued)

Harmful insects Order/Family	Total no of individuals 1st/10 Oct	2nd/25 Oct	3rd/10 Dec	4th/25 Dec	Total
Thrips meridionalis Uzel Thysanoptera/Thripidae	16	12	6	0	34
Thrips tabaci Lind. Thysanoptera/Thripidae	10	7	5	2	24
Limothrips denticornis (Haliday) Thysanoptera/Thripidae	0	1	0	0	1
Melanthrips pallidior Priesner Thysanoptera/Aeolothripidae	19	3	3	2	27
Total	2019	1848	2917	2760	
Beneficial insects					
Coccinella semptempunctata L. Coleoptera/Coccinellidae	2	1	0	3	6
Hippodamia (Adonia) *variegeta* Goeze Coleoptera/Coccinellidae	1	2	0	0	3
Stethorus sp. Coleoptera/Coccinellidae	0	1	0	0	1
Tachyporus sp. Coleoptera/Staphylinidae	4	0	0	0	4
Paederus littoralis Gravenhorst Coleoptera/Staphylinidae	1	3	0	5	9
Orius niger (Wolff) Hemiptera/Anthocoridae	300	355	242	148	1045
Orius laevigatus (Fieber) Hemiptera/Anthocoridae	93	92	49	22	256
Orius minitus (L.) Hemiptera/Anthocoridae	0	0	2	2	4
Orius nymphs Hemiptera/Anthocoridae	43	37	55	22	157
Nabis sp. Hemiptera/Nabidae	0	1	0	0	1
Campylomma sp. Hemiptera/Miridae	1	2	1	0	4
Chrysoperla carnea (Stephens) Neuroptera/Chrysopidae	9	6	13	0	28
Aeolothrips collaris Priesner Thysanoptera/Thripidae	1	1	0	0	2
Total	455	501	361	200	

A total of 10 predacious insect species were identified (Table 1). Species numbers and total numbers of individuals representing each insect taxa were usually greater in the plots of the first and second planting dates. *Orius* species were the main predacious insects throughout the sampling periods.

Table 2. Abundance of (total numbers of individuals) harmful (pooled) and beneficial insects (pooled) in faba bean plots planted at different four dates in Balcalı in 2007-2009

		Harmful insects		Beneficial insects	
Sampling period	Plantings/dates	Total no	Per sample	Total no	Per sample
2007-2008	1st/10 Oct	1156	1.83	159	0.26
	2nd/25 Oct	1202	1.90	197	0.32
	3rd/10 Dec	2167	3.43	198	0.33
	4th/25 Dec	2188	3.83	110	0.22
2008-2009	1st/10 Oct	863	1.43	296	0.46
	2nd/25 Oct	646	1.07	304	0.48
	3rd/10 Dec	749	1.24	164	0.26
	4th/25 Dec	721	1.50	92	0.16

Overall, numbers of total harmful insects were greater in plots of the third and fourth planting dates in 2008 but similar in 2009 (Table 2). Numbers of total predatory insects were usually greater in early plantings than numbers found in other planting dates (Table 2). The lowest numbers of total predator were detected on the latest planting date in both years.

Species composition of *Orius* on faba bean

Orius niger was the main predatory bug in all plots (Figure 1). Percentages of *O. laevigatus* on the first and second planting dates were similar (Figure 1a, b) and relatively greater (39-42%) than other planting dates (Figure 1c, d) and almost was the highest with a ratio of 59% in second planted-plots in March 2009 (Figure 1b). Most of *Orius* nymphs were encountered in April 2008. Seasonal percentages of nymphs in the second and third plantings in 2008 were nearly equal with ratios of 46% and 50%, respectively (Figure 1b, c). In 2009; the first, second and third plantings had similar percentages of nymphs, with a range of 62-75% (Figure 1a, b, c).

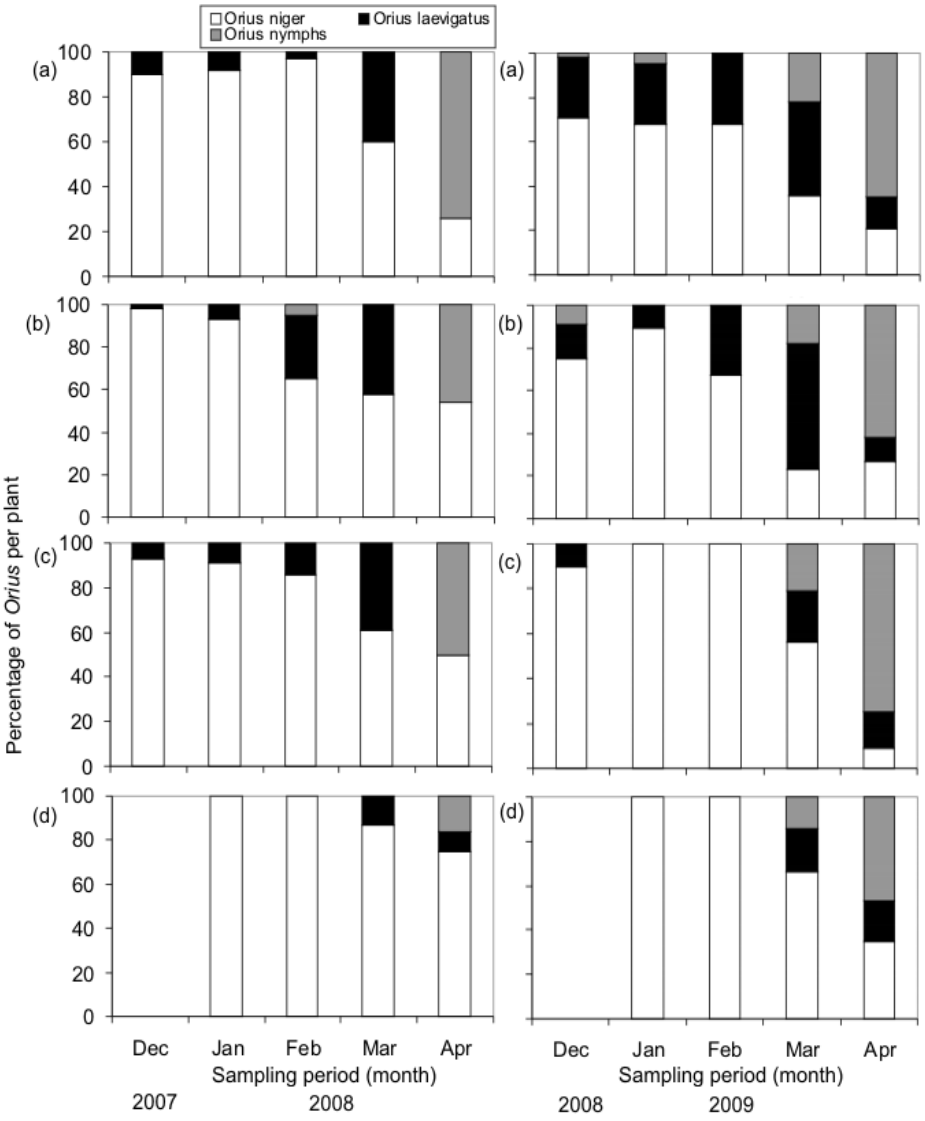

Figure 1. Monthly percentage of nymphs and adults of *Orius* in faba bean plots planted at different four dates in Balcalı in 2007-2009; (a) first (10 October), (b) second (25 October), (c) third (10 December) and (d) fourth (25 December) planting date.

Abundance of two sucking pests and *Orius* spp. on faba bean

Aphids

Planting dates (in 2008: $F_{3,116}$=33.270, P <0.001; in 2009: $F_{14,1624}$=7.231, P <0.001) and sampling dates (in 2008: $F_{16,1856}$=451.995, P <0.001; in 2009: $F_{14,1624}$=20.134, P <0.001) significantly influenced abundance of leafhoppers in both years. According to climatic conditions (Figure 2a), abundance of aphids on faba bean with different planting dates in 2008 and 2009 are given in Figure 2b. Mean numbers of aphids started to increase after 25 March and rapidly reached its peak levels in the third and fourth plantings, with mean numbers of 18.93±1.83 and of 15.9±0.86 individuals per plant on 15 April, respectively in 2008. On this date, mean temperature was also high (25.46 ^{o}C) (Figure 2a). Mean densities of aphids in the third and fourth planting dates were similar but significantly greater on 1, 8 April and on 15 April ($F_{3,116}$=27.798, P <0.001; $F_{3,116}$=25.835, P <0.001; $F_{3,116}$=26.028, P <0.001, respectively) than those numbers found in early plantings. In 2009, abundance of aphids in all plots was lower compared to data of previous experimental year. Aphid infestations on plants started in an earlier period in all plots. Mean numbers of aphids on 1 and 8 April were significantly higher with mean numbers of 4.05±0.58 and of 2.86±0.17 individuals per plant in the third planting date ($F_{3,116}$=8.619, P <0.001; $F_{3,116}$=12.697, P <0.001, respectively; Figure 2b).

Leafhopper complex

Planting dates (in 2008: $F_{3,116}$=66.333, P <0.001; in 2009: $F_{14,1624}$=45.387, P <0.001) and sampling dates (in 2008: $F_{16,1856}$=559.496, P <0.001; in 2009: $F_{14,1624}$=216.787, P <0.001) significantly influenced abundance of leafhoppers in both years. According to climatic conditions (Figure 2a), abundance of leafhoppers on faba bean in 2008 and 2009 are given in Figure 2c. Leafhoppers individuals showed the main population developments after February, when mean temperatures started to increase (Figure 2a). In 2008, mean numbers of leafhoppers in all plots varied 0.40-9.00 individuals in January-March period and thereafter rapidly peaked in mid-April in all plots. On 15 April, significant peak density of leafhoppers was observed in plots of third planting date ($F_{3,116}$ 116=74.156, P <0.001). In 2009, numbers of leafhoppers in abundance in all plots were low (Figure 2c). Leafhoppers were significantly more abundant in plots of third planting date on the most sampling dates in February–March period (P <0.001). Mean numbers of leafhoppers significantly peaked in plots of third and fourth planting dates on 15 April ($F_{3,116}$=20.330, P <0.001).

***Orius* spp.**

Planting dates (in 2008: $F_{3,116}$=3.913, P <0.01; in 2009: $F_{14,1624}$=10.768, P <0.001) and sampling dates (in 2008: $F_{16,1856}$=4.822, P <0.001; in 2009: $F_{14,1624}$=10.475, P <0.001) significantly influenced abundance of *Orius* spp. in both years. According to climatic conditions (Figure 2a), abundance of predators on faba bean with different planting dates in 2008 and 2009 are given in Figure 2d. *Orius* individuals (mainly adults) were present on plants throughout the sampling course. In 2008, mean numbers of *Orius* spp. (adults + nymphs) in first and second sampling dates were similar but significantly greater on 2, 8 January and on 15 January ($F_{3,116}$=3.884, P <0.05; $F_{3,116}$=7.824, P <0.001; $F_{3,116}$=7.338, P <0.001, respectively; Figure 2d) than those of others. In February-April, population densities of *Orius* spp. were slightly greater on plants of third planting date. In 2009, numbers of *Orius* in abundance in first and second plantings were similar but significantly greater than those of other two plantings on 7, 14 January and on 21 January ($F_{3,116}$=5.628, P <0.001; $F_{3,116}$=16.998, P <0.001; $F_{3,116}$=3.518, P <0.05, respectively) (Figure 2d). *Orius* numbers in first and second plantings on 4 and 11 February were significantly greater than those of others ($F_{3,116}$=4.259, P <0.01;$F_{3,116}$=4.010, P <0.01, respectively). After February, relatively

high numbers of *Orius* spp. were detected mostly in third planting date and numbers were significantly more on 1 and 8 April ($F_{3,116}$=3.008, P <0.05; $F_{3,116}$=6.337, P <0.01, respectively).

There was no significant difference for numbers *Orius* nymphs among the plots in 2008 but significantly greater in second and third plantings on 1 and 8 April in 2009, ($F_{3,116}$=5.289, P <0.01; $F_{3,116}$=4.374, P <0.01, respectively) (data not shown).

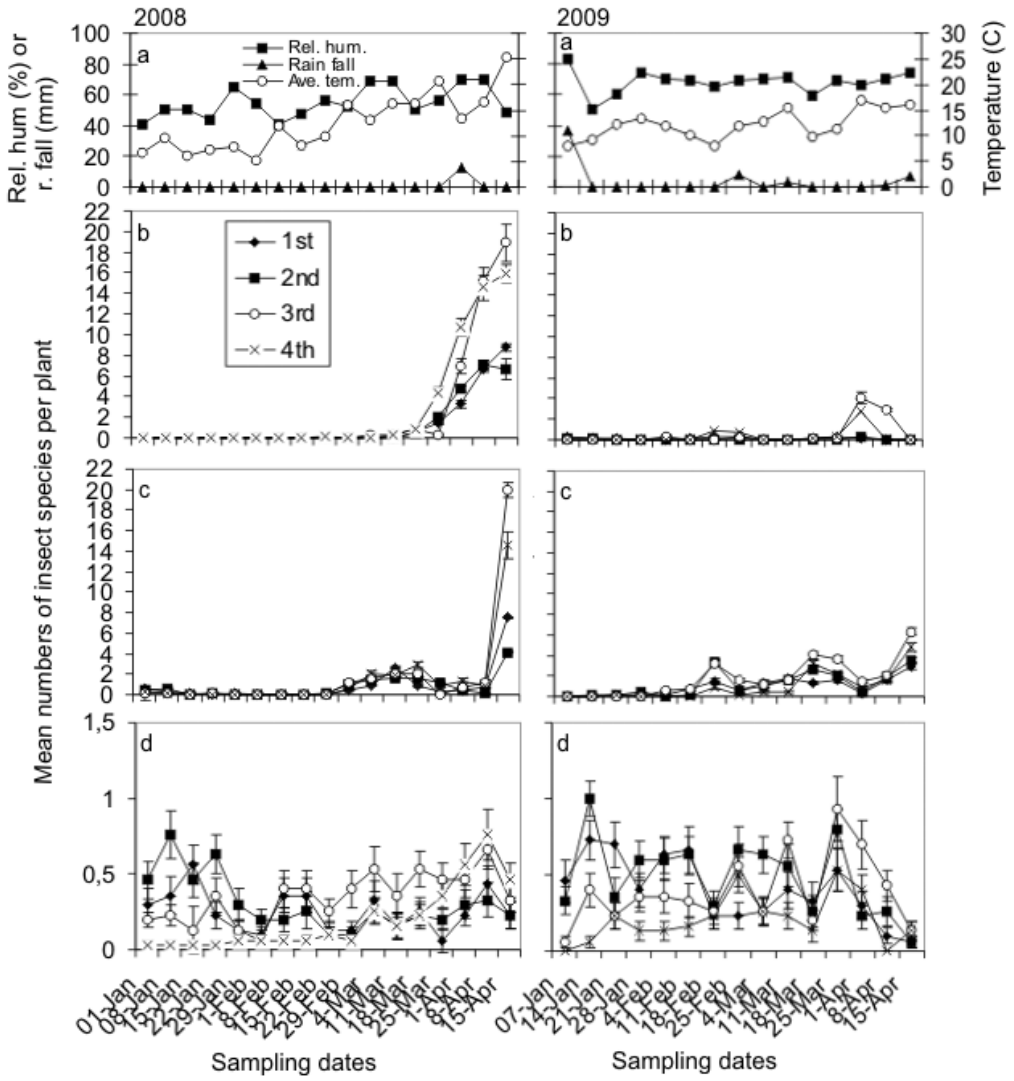

Figure 2. According to climatic conditions (a), mean numbers (±SE) of pea aphids (b), leafhoppers complex (c) and predatory bugs, *Orius* spp. (nymphs+adults) (d) in faba bean plots planted at different four dates in Balcalı in 2008-2009. Faba bean plants were planted on 10 October (first planting date), (2) 25 October (second planting date), (3) 10 December (third planting date) and (4) 25 December (fourth planting date) in 2008 and 2009.

Relationships between *Orius* and leafhoppers or aphids on faba bean

Relationships between *Orius* and leafhoppers or aphids populations are presented in Table 3 and in Figure 3. There was no relationship between populations of *Orius* and leafhoppers complex in all planting dates in both years (Figure 3a, b, c). Numbers of *Orius* were low when leafhoppers and aphid numbers rose to peak levels in both years. There was a significant and positive relationship between populations of *Orius* and aphids only on fourth planting date in both years (Table 3; and Figure 3d; P <0.01).

Table 3. Relationships between populations of *Orius* spp. and aphids or leafhoppers in faba bean plots planted at different four dates in Balcalı in 2008-2009

Years	Plantings /dates	Associations	df	R^2	F	P	Equations
2008	1st /10 Oct	*Orius*-aphids	2,14	0.02	0.109	0.898	$Y=-17.271x^2 +11.905x-0.3979$
		Orius-leafhoppers	2,14	0.06	0.057	0.945	$Y=-20.904x^2 +10.975x-0.1979$
	2nd/25 Oct	*Orius*-aphids	2,14	0.10	0.856	0.446	$Y=--220.93x^2 +17.096x-1.2515$
		Orius-leafhoppers	2,14	0.05	0.410	0.671	$Y=1.787x^2 -2.811x+1.411$
	3rd/10 Dec	*Orius*-aphids	2,14	0.18	1.608	0.235	$Y=44.999x^2 -17.804x+2.166$
		Orius-leafhoppers	2,14	0.04	0.322	0.730	$Y=-32.232x^2 -24.063x-1.952$
	4th/25 Dec	*Orius*-aphids	2,14	0.81	30.920	0.000	$Y=8.279x^2 -16.700x-1.183$
		Orius-leafhoppers	2,14	0.35	3.796	0.048	$Y=-33.573x^2 +29.301x-1.412$
2009	1st /10 Oct	*Orius*-aphids	2,12	0.08	0.549	0.592	$Y=-0.6378x^2 +0.632x-0.006$
		Orius-leafhoppers	2,12	0.51	6.471	0.012	$Y= 5.005x^2 -6.804x+2.643$
	2nd/25 Oct	*Orius*-aphids	2,12	0.23	1.808	0.206	$Y= 0.317x^2 -0.375x+0.127$
		Orius-leafhoppers	2,12	0.30	2.615	0.114	$Y= 2.691x^2 -5.426x+3.014$
	3rd/10 Dec	*Orius*-aphids	2,12	0.17	1.239	0.324	$Y= -4.726x^2 +6.303x-0.961$
		Orius-leafhoppers	2,12	0.16	1.208	0.333	$Y= 12.208x^2 -11.777x+3.848$
	4th/25 Dec	*Orius*-aphids	2,12	0.66	11.629	0.002	$Y= 10.702x^2 -2.420x+0.094$
		Orius-leafhoppers	2,12	0.10	0.700	0.516	$Y= 12.822x^2 -8.149x+1.756$

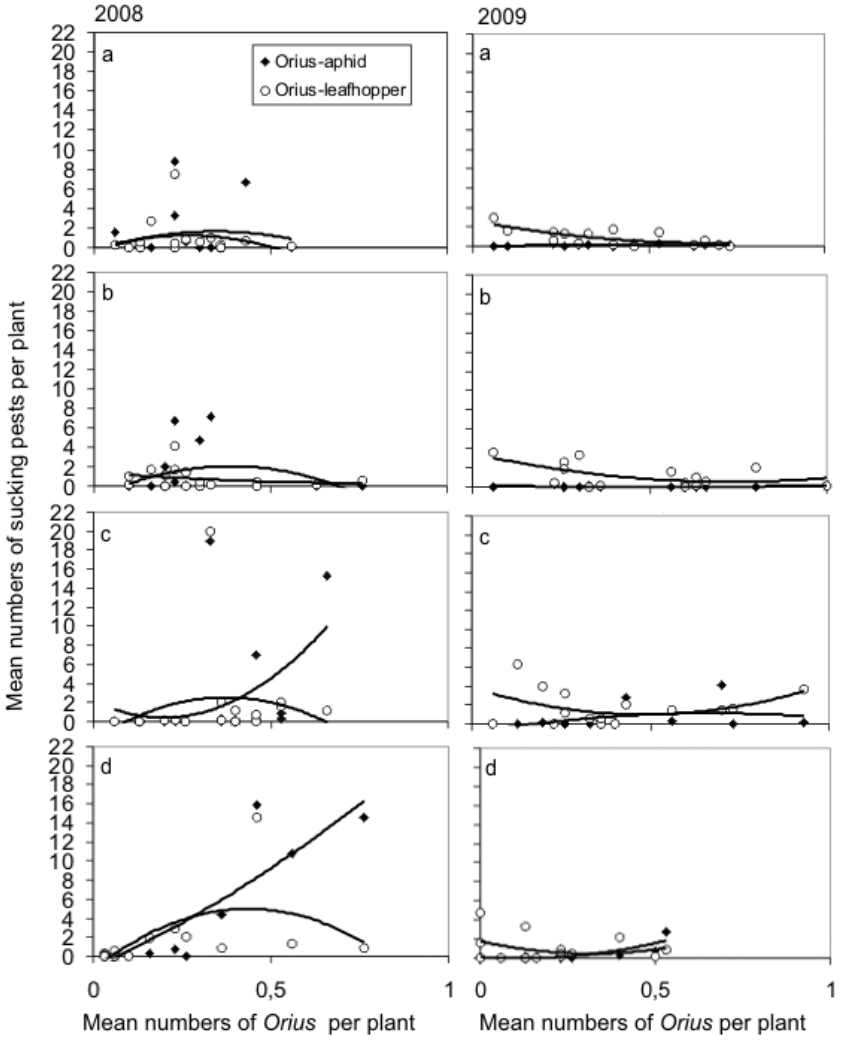

Figure 3. Relationships between *Orius* spp. (nymphs+adults) and pea aphids or leafhoppers complex in faba bean plots planted at different four dates in Balcalı in 2008 and 2009; (a) first (10 October), (b) second (25 October), (c) third (10 December) and (d) fourth (25 December) planting date.

Influence of planting dates on plant developments

Planting dates affected significantly numbers of flowers (in 2008: $F_{3,56}$=70.692, P <0.001; in 2009: $F_{3,92}$=2121.140, P <0.001) and green pods (in 2008: $F_{3,56}$=1998.14, P <0.001; in 2009: $F_{3,92}$=82.707, P <0.001) in both years. Mean number of flowers was similar on first and second planting dates but significantly higher than numbers found on other two planting dates in 2008 ($F_{3,56}$=18.486, P <0.001; Figure 4a). Mean number of flowers was similar on the first, second and third planting dates but significantly higher than the fourth planting date in 2009 ($F_{3,92}$=41.484, P <0.001; Figure 4a). Mean number of green pods was similar on the first and second planting dates (Figure 4b) but significantly higher than numbers found on other two planting dates in both years (in 2008: $F_{3,56}$=29.844, P <0.001; in 2009: $F_{3,92}$=47.465, P <0.001). The lowest number of green pods was recorded in plots of the fourth planting date in both years.

Similar to developments of flowering structures of plants, yields of green pods were similar on the first and second plantings but greater than those of others in both years (N. Sarı, unpublished data).

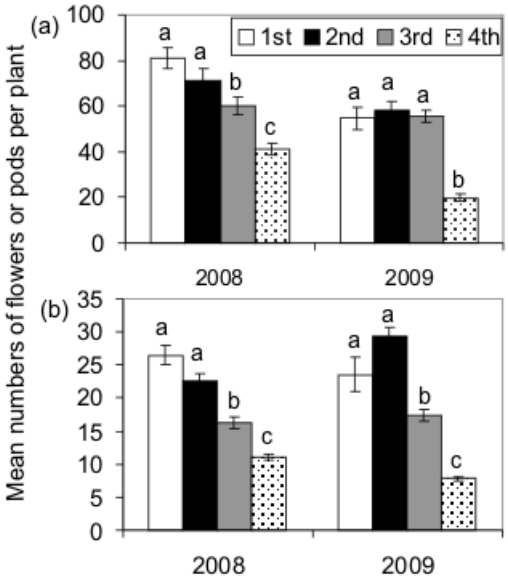

Figure 4. Seasonal mean numbers (±SE) of flowers (a) and green pods (d) on faba bean plots planted at different four dates in Balcalı in 2008 and 2009. Means of bars labeled with the same letter do not differ significantly, Tukey's HSD test, P <0.05. Faba bean plants were planted on (1) 10 October (first planting date), (2) 25 October (second planting date), (3) 10 December (third planting date) and (4) 25 December (fourth planting date) in 2008 and 2009.

Discussion

The results show that *O. niger* was the main anthocorid species dwelling on faba bean plants in all plots characterized by different planting dates. *O. niger* appeared to be more active predator in the hard winter conditions. While *O. niger* was the most common anthocorid species in all parts of Turkey, *O. laevigatus* was recorded mostly in the southeastern part of Turkey (Önder, 1982). *O. niger*, *O. laevigatus* and *Orius majusculus* (Reuter) are the commonly found anthocorid species in the Mediterranean basin. However, the predominance of any of these species may depend on the location. For instance, in Italy, *O. niger* predominated in the northwest, whereas *O. laevigatus* predominated in the warmest locations of the country (Tommasini, 2004; Bosco et al., 2008; Bosco & Tavella, 2008). *O. laevigatus* relatively more abundant in March in all faba bean plots may indicate that this predator prefers living in warmer climatic conditions.

Planting dates significantly influenced abundance of the main sucking insect pests. Aphids appeared to be more common in late-planted faba bean plots. Fresh leaves and young shoots of plants may be more

attractive to both aphids and leafhoppers individuals in late plantings. Although pea aphids were more abundant in late-planted plots especially in 2008, no considerable damage was noted on plants. Weigand & Bishara (1991) reported that aphid species, *Acyrthosiphum pisum* and *Mysuz persicae* Sulzer were only occasional pests on faba bean in the Mediterranean countries such as Syria, Egypt, Tunisia and Morocco but other aphid species, *Aphis fabae* Scopoli and *Aphis craccivora* Koch were the most important and their populations were relatively more abundant in early-planted bean crops than late-planted ones in Egypt but no significant difference was observed (El-Heneidy et al., 1998). Similar to the aphid case, leafhoppers were significantly more abundant on late-planted bean plants. Mahmoud et al. (2011) concluded that broad bean was the most preferred host plants to *Empoasca decipiens* Paoli in Egypt. In current study, leafhoppers caused the damage of light yellow colored-leaflets on plants in only late-planted plots. However, it is not clearly known pest status of the leafhoppers dwelling on faba bean plants in our region and other parts of Turkey. Based upon the findings, faba bean appears to be an important winter host for the leafhoppers complex species in our region, as well as citrus trees (Başpınar, 1994).

Orius spp. significantly more abundant on the early-planted faba beans in January-February, but later, individuals of adult *Orius* moved to late-planted plots, especially to plots of the third planting date. Relatively greater abundance of the main insect pests occurred in a late period in the plots of the third and fourth planting dates, but this did not provide a conspicuous contribution to the development and abundance of *Orius* spp. In contrast, lower numbers of *Orius* nymphs were detected in plots of the latest planting date where there was a good relationship between *Orius* and aphid populations. Like to other identified and sampled predators, *Orius* individuals may feed upon their insect preys colonizing the plants especially in plots of the late plantings. However, it is assumed that *Orius* spp. benefited more from the faba bean plants for plant meal, shelter, mating and ovipositon sites rather than from the insect prey species including aphids and leafhoppers. Similarly, there was no relationship between numbers of *Orius* spp. and its prey the western flower thrips, *Frankliniella occidentalis* (Pergande) in flowers of faba bean plants grown in the plots with weedy or with bare strips in same ecological area (Atakan, 2010). Abundance of flowers on plants might influence the presence and abundance patterns of *Orius* spp. rather than their insect preys. Colonization of the faba bean flowers by the great numbers of *Orius* adults throughout growing season (Atakan, 2010) may be an evidence for this issue. As well-known, *Orius* species also benefit from the plant nectars and pollens (Dick & Jarvis, 1962; Salas-Aquilar & Ehler, 1977; Riudavets, 1995).

Planting date influenced also developments of fruiting parts of plants. Numbers of flowers and green pods in plots planted in October (i.e. early plantings) were similar but greater than those of plots planted in December (i.e. late plantings) (Figure 4a, b). Similarly, Pandey (1981) achieved the highest seed yield on faba bean (cv. Bihoral) in plots planted on 30 October; plots planted after 30 December had lower yield, due to lower numbers of pods and weights of seeds. The best planting date of the faba bean in Samsun province, Turkey was 6 October and early-planted plots produced greater yields than the yields of late-planted plots (Bozoğlu, 1989).

In conclusion, although faba bean plants hosted many pest insect species, only leafhoppers complex species and pea aphids appeared to be main pest insects and they were relatively more abundant in the plots planted in December. Pest statuses of both insects on faba bean crop plants are not well-understood. However, avoidance of late planting of faba bean (i.e. planting in December) may be a good cultural practice in controlling of both insects in the region. *Orius* species are main predaceous insects in all plots of faba bean. Flower loads on plants may be a more influencing factor for presence and abundance of *Orius* spp. than their insect preys. Based upon the findings, planting of faba bean in late October seems to be good cultural practice, due to (i) plants hosting relatively high numbers of predators (mainly *Orius* spp.) and relatively low numbers of main insect pests and (ii) plants producing higher numbers of green pods. Cultivation of faba bean in winter-spring period in agricultural landscapes, especially in agricultural areas with less plant diversity in the Mediterranean region could be useful for conservation and augmentation of beneficial insects.

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