

Effect of flowering plants surrounding faba bean fields on the phenology and community composition of the cowpea aphid *Aphis craccivora* predators

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ABSTRACT

The current work was carried out in faba bean fields at Sidi-Salem district, Kafr El-Sheikh governorate during two growing seasons (2012/13 and 2013/14) to study the effect of flowering plants on phenology and community composition of the cowpea aphid, *Aphis craccivora* (Koch.) predators. In the first field, replicates were marginally surrounded with a belt of flowering plants (Coriander, *Corindrum saivum* L.), whereas in the second one did not. Population of each predator species differed from season to season and from field to other. Although, the attracted percentage of each predator species differed from season to season, *Chrysoperla carnea* (Steph.) was the only species exhibited strong attractiveness in the field with flowering plant margins and contributed with the highest fate of occurrence in flowering plots of faba bean during both plantation seasons. It contributed with 29.10 and 22.60 % of the total attracted numbers. Whereas, *Orius laevigatus* (Fiber) contributed with the lowest fate of attractiveness (13.05 and 16.36%) to flowering plants during the first and second seasons. On the other hand, *Paderus alferii* Koch and *Coccinella undecimpunctata* L. contributed with the highest fate of attracted predators to non-flowering plant fields.

Keywords: Coriander, floral plants, population density, predator species

INTRODUCTION

The faba bean (*Vicia faba* L.) is considered an important crop in Egypt. It plays an essential role in improving the soil as it fixes nitrogen by amount of 45-552 Kg/h, which influences the following crop in a rotation. It is considered also a main source of food for the mankind and its domestic animals, where it contains a great proportion of proteins (28%) and carbohydrates (58%) in addition to many vitamins and other nutrients (Mahmoud et al., 1996).

Faba bean plants are attacked by several serious insect pests attacking faba bean crop involving the aphids. In the recent years, the yield of faba bean affected widely by aphid infestations which play a critical way in transmitting virus diseases, that cause considerable losses to the crop yield (Jackai, 1995; Mohamed and Slman, 2001; Ward et al., 2002). The cowpea aphid, *Aphis craccivora* (Koch.) (Homoptera: Aphididae) is considered as one of the most injurious insect pests attacking faba bean plants (Soliman, 2004).

The beneficial impacts of flowering plants on natural enemies have been received much attention (e.g., Zhao et al., 1992; Cowgill et al., 1995; Idris and Grafius, 1995). Conserving and stabilizing natural enemies are major prerequisites to subtend the ecological needs of these beneficials within or close to the crop (Landis et al., 2000). Flowering borders surround crop field margins could supply necessary sources and shelter for natural enemies through suffering periods of flowers absent, thus conserving high populations of these beneficials (Bugg and Waddington, 1994; Landis et al., 2000; Ahern and Brewer, 2002; Büchi, 2002; Sanchez et al., 2003; Wanner et al., 2006a, b; Isaacs et al., 2009; Hogg et al., 2011). For example, floral nectar and pollen are essential nutrients, beside the main prey, that require by predators such as; ladybeetles (Freeman Long et al., 1998; Nalepa et al., 1992; Pemberton and Vandenberg, 1993), lacewings (McEwen and Kidd, 1995; Freeman

Long et al., 1998), and syrphids (Carreck and Williams, 1997; Hickman and Wratten, 1996; White et al., 1995), to improving their fecundities and longevities. Some studies demonstrated that the spider's population increased and aphid's population decreased in case of the wheat field surrounded with flowering plants (Jmhasly and Nentwig, 1995). Additionally, there are some evidences that flowering plant strips increase the alternative prey densities, and thus enhancing the bio-control impacts (Frank, 2003; El-Nabawy et al., 2015). The presence of flowering plant strips within field crop increases the killing for beneficials in crop fields. Accordingly, floral resources close to crop fields can reduce exposure of natural enemies to chemicals and improve the re-invade by these beneficials more rapidly after disappearing of chemical applications (Walton and Isaacs, 2011). Most previous studies have been focused on effect of extra- and intra-floral nectars on survival, fecundity, and flight ability of insect parasitoids (e.g., Leius, 1963; Foster and Ruesink, 1984; Jervis et al., 1993; Idris and Grafius, 1997; Carreck and Williams, 1997; Baggen and Gurr, 1998; Tooker and Hanks, 2000; Begum et al., 2004; Lee et al., 2004; Steppuhn and Wäckers, 2004; Wäckers, 2004), whereas predators received little attention. Therefore, the current work was conducted to give highlights on the effect of flowering plants, surrounded the faba bean plants, on the phenology and community composition of the cowpea aphid *A. craccivora* predators.

MATERIALS AND METHODS

The present work was applied in faba bean fields at Sidi-Salem district, Kafr El-Sheikh governorate during 2012/2013 and 2013/2014. An area of approximately 600 m² was divided into two plot strips, each was 300 m². Each plot was divided to four replicates, each was 75 m². In the first plot, replicates were marginally surrounded with a belt of flowering plants (Coriander, *Corindrum saivum* L.), whereas in the second one did not. All procedures regarding timing

of plantation, varieties and sampling technique was followed as recommended. Samples were taken 15 days after cultivation and continued weekly till the end of the harvesting time. Five plants from each replicate were selected randomly, monitored, and numbers of the predator species were visually recorded in the field.

Populations of predatory insects associated with cowpea aphid in faba bean fields were statistically compared between both flowering and free-flowering fields in each growing season using *t*-test. Further, populations of all observed predators were analyzed in each field type, i.e. flowering or free-flowering, in each growing season using one-way ANOVA. Prior to ANOVA, data were checked for assumptions of normality and equality of variance (Shapiro–Wilks and Levene’s tests, respectively). Mean values were differentiated by the Bonferroni test ($\alpha = 0.05$).

RESULTS

1. Effect of flowering plant margins on phenology of aphid predators.

Chrysoperla carnea (Steph.)

Data presented in Figure (1A) indicated that, the population of green lacewing, *C. carnea* was higher in faba bean surrounded with flowering plants than in free-flowering plants in both seasons of study. In the field of faba bean with flowering plant margins, *C. carnea* had two peaks of abundance during the first season (2012/13). The first peak (3.5 individuals / 5 plants) was recorded on 24th of January 2013 and the second peak (1.75 individuals) was on 27th of February 2013. In free flowering field, two peaks of abundance were also observed for *C. carnea*. The first peak (1 individual) was recorded on 27th of December, 2012 and the second one (1.25 individuals / 5 plants) was on 24th of January 2013.

Data represented in Figure (1B) showed that in the second year of plantation (2013/14), the population of *C. carnea* showed three peaks of abundance, in fields surrounded with flowering plants, with the highest one (3.5 individuals) on 24th of January 2014. Whereas, two periods of limited abundance were observed for *C. carnea* in the field with free-flowering plant margins with the highest abundance (1.25 individuals) recorded on 6th of February 2014.

Statistical analysis confirmed that there was a highly significant difference in the average number of *C. carnea* between faba bean fields margined with flowering plants and that free of flowers in the first and second seasons of plantation ($t = 3.39$; $P = 0.002$ and $t = 3.73$; $P = 0.001$; Table 1).

Coccinella undecimpunctata (L.)

Data illustrated in Figure (2A) indicated that the population of ladybeetle, *C. undecimpunctata* was higher in the field of faba bean surrounded with flowering plant than that free of flowering plant margins in both seasons of investigation. In the field of faba bean margined with flowering plants, *C. undecimpunctata* showed three peaks of abundance during the first year (2012/13). The first peak (1.75 individuals) was recorded on 17th of January, 2013, the

second peak (2.25 individuals) on 6th of February, 2013, and the third one (2.5 individuals) was on 27th of February, 2013. In faba bean field with free-flowering plant margins, two peaks of abundance were observed. The first peak (2 individuals) was recorded on 6th of February, 2013 and the second one (1.75 individuals) was recorded on 20th of February, 2013.

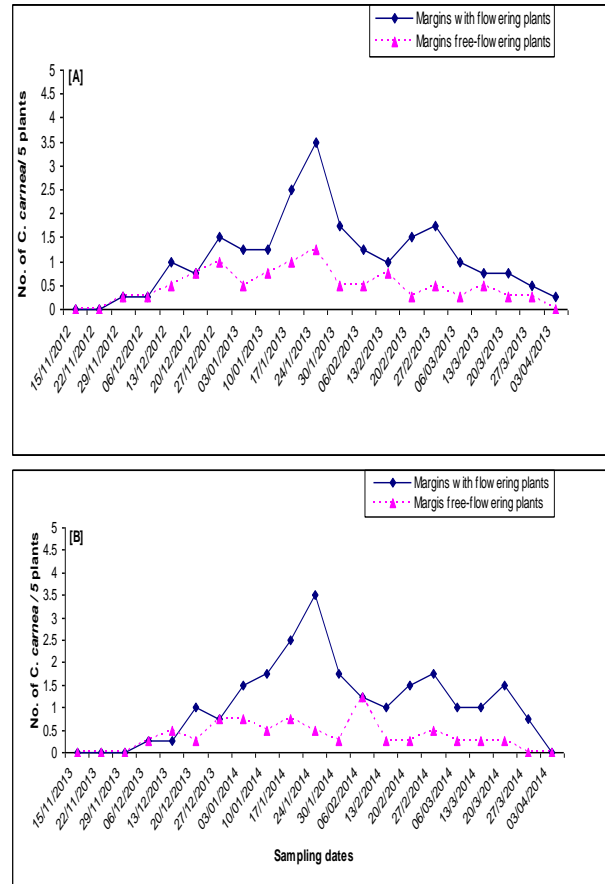


Fig. (1): Mean number of green lacewing, *C. carnea* in faba bean fields surrounded with flowering and without-flowering plants during 2012/13 (A) and 2013/14 (B) plantation seasons at Sidi-Salem district, Kafr El-Sheikh Governorate.

In the second year of plantation (2013/14), the population of *C. undecimpunctata* showed two peaks of abundance in the flowering field with the highest one (5 individuals) on the 10th of January, 2014. Whereas, two periods of limited abundance were observed for *C. undecimpunctata* in free-flowering fields with the highest abundance (2.5 individuals) on 6th March (Fig. 2B).

The average number of *C. undecimpunctata* did not significantly differ between flowering and free-flowering faba bean fields in the first and second seasons of plantation ($t = 1.14$; $P = 0.25$ and $t = 1.10$; $P = 0.27$, respectively; Table 1).

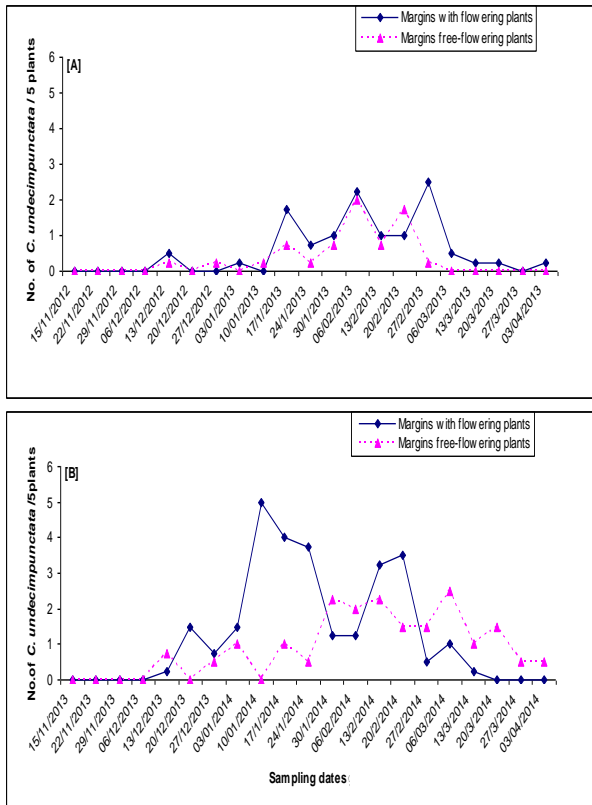


Fig. (2): Mean number of ladybeetle, *C. undecimpunctata* in faba bean fields surrounded with flowering and without-flowering plants during 2012/13 (A) and 2013/14 (B) plantation seasons at Sidi-Salem district, Kafr El-Sheikh Governorate.

Paederus alferii Koch.

Data illustrated in Figure (3 A) showed that the population of *P. alferii* was higher in the field of faba bean with flowering plant margins than that without flowering plants margins in both seasons of study. In the field with flowering plant margins, *P. alferii* showed one peak (2.25 individuals / 5 plants) of abundance during the first season on the 6th of February, 2013. In the field of faba bean without flowering plant margins, two peaks of abundance were observed for *P. alferii*. The first peak was recorded (1.25 individuals) on 10th of January, 2013 and the second one (1 individuals) on 13th of February, 2013.

In the second season of plantation, the population of *P. alferii* showed two peaks of abundance in the field surrounded with flowering plants with the highest abundance (3 individuals) on 24th of January, 2014. In free-flowering fields, two slight periods of limited abundance were observed for *P. alferii* with the highest one (0.75 individual) on 6th of March, 2014 (Fig. 3B).

The average numbers of *P. alferii* differed significantly between flowering and free-flowering fields in the second season of plantation ($t = 4.19$; $P = 0.001$), but did not in the first year ($t = 1.67$ 1.72; $P = 0.12$) (Table 1).

A significant effect of flowering plants on the average numbers of *S. syriacus* had been obtained in the first and second seasons of plantation ($t = 2.47$; $P = 0.01$), ($t = 2.09$; $P = 0.04$; Table 1).

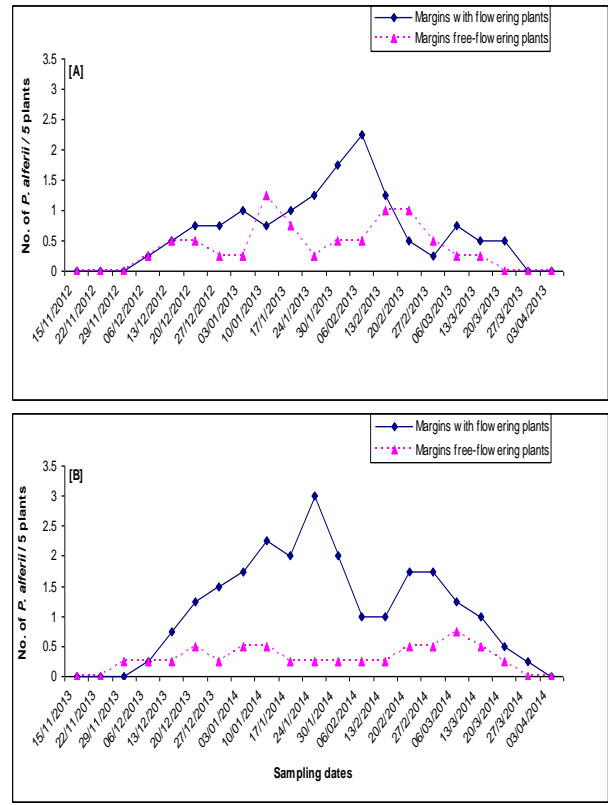


Fig. (3): Mean number of Egyptian Rove beetle, *P. alferii* in faba bean fields surrounded with flowering and without-flowering plants during 2012/13 (A) and 2013/14 (B) plantation seasons at Sidi-Salem district, Kafr El-Sheikh Governorate.

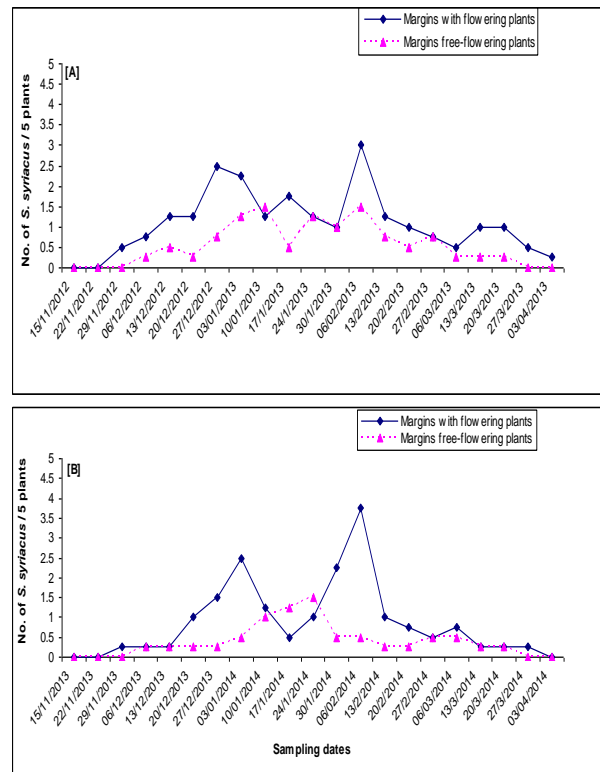


Fig. (4): Mean number of ladybeetle, *S. syriacus* in faba bean fields surrounded with flowering and without-flowering plants during 2012/13 (A) and 2013/14 (B) plantation seasons at Sidi-Salem district, Kafr El-Sheikh Governorate.

Scymnus syriacus Muslant

The population of *S. syriacus* was higher on faba bean field margined with flowering plant than that without flowering plant margins of both seasons of study (Fig. 4). In the field of faba bean with flowering plant margins, *S. syriacus* had two peaks of seasonal abundance during the first season (Fig. 4A). The first peak (2.5 individuals / 5 plants) was recorded on 27th of December, 2012 and the second one (3 individuals) on 6th of February, 2013. In the field without flowering plant margins, two peaks of abundance were observed for *S. syriacus* in the first year (Fig. 4A). The first peak was recorded on 10th of January, 2013 (1.5 individuals) and the second one (1.5 individuals) on 6th of February, 2013.

The population of *S. syriacus* in the field of faba bean with flowering plant margins showed two peaks of abundance with the highest one (3.75 individuals) on 6th February 2014 of the second year (Fig. 4B). Whereas, one period of slight abundance (1.5 individuals) was observed for *S. syriacus* on 24th of January, 2014 in the field of faba bean without flowering plant margins.

Orius laevigatus (Fiber)

Data illustrated in Figure (5) showed that *O. laevigatus* had the highest population in faba bean field surrounded with flowering plants compared to faba bean field without flowering plants in both seasons of study. In the field of faba bean with flowering plant margins, *O. laevigatus* had two peaks of abundance during the first year (Fig. 5A). The first (1.75 individuals / 5 plants) was recorded on 17th of January, 2013 and the second one (1 individuals) was on 27th of February, 2013. In the field of faba bean without flowering plant margins, two peaks of abundance were observed for *O. laevigatus*. The first peak (0.75 individuals) was recorded on 10th of January, 2013 and the second one (1.25 individuals) was recorded on 6th of February, 2013.

In the second season of plantation (Fig 5B), the population of *O. laevigatus* showed three peaks of abundance with the highest one (1.25 individuals) was recorded on 13th of February, 2014 in faba bean field with flowering plant margins. Whereas, three period of limited abundance were observed for *O. laevigatus* in faba bean field without flowering plant margins with the highest abundance (0.75 individuals) on 3rd of January, 2014.

Statistical analysis revealed that there were no significant and significant differences in the average numbers of *O. laevigatus* between faba bean field with and without flowering plant margins in the first and

second season of plantation ($t = 1.41$; $P = 0.16$ and $t = 2.17$; $P = 0.03$, respectively; Table 1).

One-way ANOVA confirmed that there was a significant effect of flowering plant in faba bean field on mean number of adult predators visually monitored per five plants ($F_{4,104} = 3.48$; $P = 0.02$), but did not in the field of faba bean without flowering plant margins ($F_{4,104} = 0.89$; $P = 0.47$) in the first season of plantation (Table 3). Whereas, there was a significant effect of faba bean field without flowering plant margins on mean number of adult predators visually monitored per each replicate $F_{4,104} = 7.46$; $P = 0.001$, but did not in the field of faba bean with flowering plant margins ($F_{4,104} = 2.41$; $P = 0.05$) in the second season of plantation (Table 1).

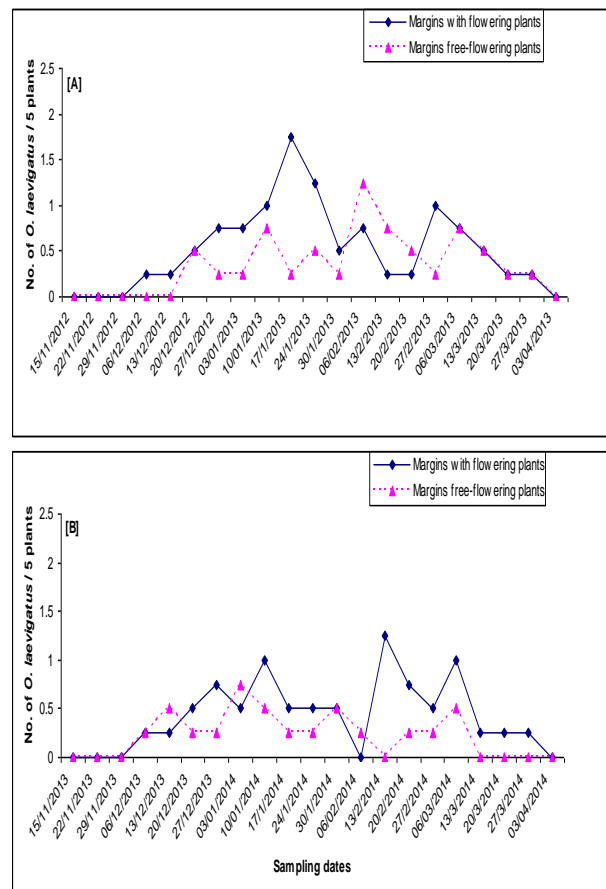


Fig. (5): Mean number of the minute pirate bug, *O. laevigatus* in faba bean fields surrounded with flowering and without-flowering plants during 2012/13 (A) and 2013/14 (B) plantation seasons at Sidi-Salem district, Kafr El-Sheikh Governorate.

Table (1): Mean number (\pm SE) of adult predators in both flowering and free-flowering faba bean fields infested with the cowpea aphid, *A. craccivora* at Sidi-Salem district, Kafr El-Sheikh Governorate during 2012/13 (A) and 2013/14 (B) plantation seasons.

Species	Flowering plants		Free-flowering plants		t- test		P	
	A	B	A	B	A	B	A	B
<i>C. carnea</i>	4.66 \pm 0.75 a	4.52 \pm 0.79 a	1.91 \pm 0.30 a	1.38 \pm 0.28 b	3.39	3.73	0.002	0.001
<i>C. undecimpunctata</i>	2.83 \pm 0.66 bc	5.47 \pm 1.46 a	1.38 \pm 0.50 a	3.66 \pm 0.73 a	1.14	1.10	0.25	0.27
<i>P. alferii</i>	2.57 \pm 0.53 bc	4.42 \pm 0.75 a	1.52 \pm 0.32 a	1.19 \pm 0.17 b	1.67	4.19	0.12	0.001
<i>S. syriacus</i>	4.38 \pm 0.74 ab	3.47 \pm 0.83 a	2.23 \pm 0.43 a	1.57 \pm 0.35 b	2.47	2.09	0.01	0.04
<i>O. laevigatus</i>	2.09 \pm 0.41 c	1.71 \pm 0.31 a	1.38 \pm 0.28 a	0.91 \pm 0.19 b	1.41	2.17	0.16	0.03

Means (\pm SE) bearing the different letters in each column are significantly different at the 5% probability level

2. Effect of flowering plant margins on community composition of aphid predators.

Data in Figure (6) shows the community composition of the main insect predators visually monitored in faba bean fields infested with cowpea aphid, *A. craccivora* during the first and second plantation seasons in the field of faba bean with flowering plant margins and that without flowering plant margins. Although, the visited percentage of each predator species differed from season to season and from field to field, *C. carnea* was the only species exhibited strong attractiveness in the field with flowering plant margins and represented

by 22.6 and 29.10 % during the two successive seasons, 2012/13 and 2013/14, respectively. While, *O. laevigatus* ranked the last category and represented by 13.05 and 8.73% during the two successive years, respectively.

In the field without flowering plant margins, the predator *P. alferii* and *C. undecimpunctata* ranked the first category and contributed with 22.57 and 42.8% during 2012/13 and 2013/14, while, *O. laevigatus*, contributed with the lowest fate during the two successive years, respectively (Fig. 6).

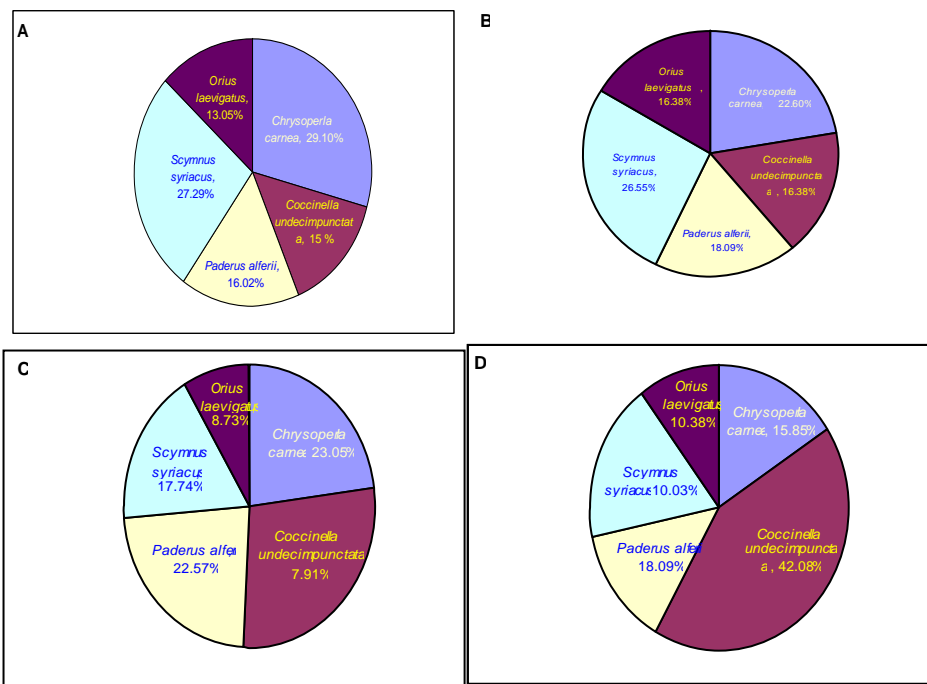


Fig. (6): Community composition of main insect predators associated with cowpea aphid, *A. craccivora* in faba bean field surrounded with flowering plant stripes during 2012/13 (A) and 2013/14 (B) and in that without flowering plant margins during 2012/13 (C) and 2013/14 (D) plantation seasons at Sidi-Salem district, Kafr El-Sheikh Governorate.

DISCUSSION

The current work was designed to test the effect of flowering plants on *A. craccivora* predator populations, inhabiting faba bean fields, by monitoring the occurrence of insect visitation over time. There are many reasons that may be responsible for boosted predator densities in the flowering plant plots; 1) flowering plants indirectly affect the predator population by increasing the various food resources (Hatley and Macmahon, 1980; Landis et al., 2000; Jonsson et al., 2008). For example, it can provide predators with alternative food resources (pollen) and some previous studies have indicated the value of pollen in the good ecosystem as an alternative food resource for raising the fecundity of linyphiid spider (Peterson et al., 2010) and longevity (Vogelei and Greissl, 1989). 2) The flowering plants may provide suitable refuges for natural enemies. Sunderland and Samu (2000) found the density of spiders can maximize by increasing suitable

refuges. Malumbres-Olarte et al. (2012) reported a positive relationship between density of lycosid spiders and plant species diversity. 3) Flowering plants change the habitat composition or may optimize the density of alternative prey and this point was confirmed by Frank (2003) who found that the flowering plants strips are very important to increase the numbers of alternative prey and also, Landis et al. (2000) indicated that changing the habitat composition can increase the alternative prey of spiders.

Almost, flowering plants attracted significantly higher numbers of most *A. craccivora* predators in faba bean fields compared to control plots. Variations in numbers between fields with and without flowering strips may be a result of dramatic variations in climatic conditions between winter and summer, variations in plant materials, or provisional differences in sampling. In faba bean field, there was a significant variation between predator species in the number of adults attracted to flowering plots in both seasons of plantation

with the higher attractiveness was for green lacewing. This is a normal because the higher requirements of carbohydrates to gain energy for supporting adult reproductive success and longevity (e.g., McEwen and Kidd, 1995; Limburg and Rosenheim, 2001; Romeis et al., 2004).

Community composition percentage also revealed that *C. carnea* contributed with the highest fate of occurrence in flowering plots of faba bean during both plantation seasons. Whereas, *C. undecimpunctata* occurred highly in non-flowering plots. The impact of flower strips in fields of cabbage did not discover any differences in numbers of Coccinellidae (Kienegger and Kromp, 2001; Kienegger et al., 2003). Hurej et al., (1998) in his study on the attractiveness of blossoming flower strips in attracting predators of *Aphis fabae* observed little presence of ladybeetles on both, flowered and control fields. The lowest occurrence of coccinellids in flowered fields may be because 1) incorporating floral resource plants into agroecosystems can increase population of natural enemies (Hickman and Wratten, 1996; Patt et al., 1997a; White et al., 1995), but may defeat to give an effective management of the main insect, if flowering plants does not synchronize with periods of natural enemy activity (Bowie et al., 1995), if floral structure impedes natural enemies from feeding (Patt et al., 1997b), and/or if natural enemy slowly moves between the main crop and floral resources (Bigger and Chaney, 1998; Freeman Long et al., 1998) and 2) In urban landscapes, conservation of natural enemies is alternative method for managing insects. These landscapes are poor in the qualities of resources for their natural enemies due to their floristically impoverished. It implies these habitats are freed from main requirements that are needed by beneficials (Dreistadt et al., 1990; Hanks and Denno, 1993; Sperry et al., 2001).

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تأثير النباتات المزهرة المحيطة بالفول البلدى على التعداد والتكوين المجتمعي للمفترسات الحشرية المصاحبة لحشرة من البقوليات

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اجريت الدراسة الحالية فى حقول الفول البلدى فى منطقة سيدى سالم محافظة كفر الشيخ خلال موسمى الدراسة ٢٠١٣/٢٠١٢ و ٢٠١٣/٢٠١٤ لدراسة تأثير النباتات الكسيرة المزهرة على التعداد والتركيب المجتمعي لمفترسات حشرة من البقوليات . احيطت حواف المكررات فى الحقل الأول بشريحة من النباتات الزهرية بينما لم يحدث ذلك فى حقل الفول الثانى. لوحظ أن تعداد كل مفترس من المفترسات محل الدراسة اختلف من موسم لموسم ومن حقل لآخر. بالرغم من أن نسبة الانجذاب لكل مفترس اختلفت من موسم إلى آخر إلا أن مفترس أسد المن الاخضر هو الوحيد الذي أظهر انجذاب قوى للحقول المحاطة حوافها بنباتات زهرية وأسهمت النباتات المزهرة فى حقول الفول فى زيادة نسب تواجد مفترسات اسد المن الاخضر حيث انجذب المفترس بنسبة ٢٩.١٠ و ٢٢.٦٠ % من المجموع الكلى للأعداد المنجذبة على التوالي، فى حين اسهمت بقعة الأوريس بالنصيب الأقل من المفترسات التي انجذبت للنباتات الزهرية (١٣,٠٥ و ١٦,٣٨ %) خلال السنة الأولى والثانية على التوالي ، على الجانب الآخر أسهم مفترس الرواغة وأبو العيد ١١ نقطة بالنصيب الأعلى من المفترسات المنجذبة لحقول الفول غير المزهرة.