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Population Densities of Pest Aphids and their Associated Natural Enemies on Faba Bean in Kafr EL-Sheikh, Egypt

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Population dynamics of insect pests are complex and are dependent on various biotic and abiotic factors. Understanding pest population dynamics and factors affecting them is important for predicting pest outbreaks and constructing the management strategy. Aphids are among the major pest groups in bean crops and aphid outbreaks can frequently occur when the management is inappropriate. In the present study, we examined the population fluctuation and abundance of aphid species and their associated predators and parasitoids in faba bean fields during 2016/17 and 2017/18 seasons in Kafr EL-Sheikh, Egypt. Among four pest aphids detected, *Aphis craccivora* was the most dominant, followed by *Acyrtosiphon pisum* while *Aphis gossypii* and *Myzus persicae* were found in low densities throughout the season. Although *A. craccivora* was detected throughout the growing season, the density is notably high in the early growth stage of faba bean. Among the predators, *Chrysoperla carnea* and true spiders (*Singa* sp. and *Dictyna* sp. were most abundant, followed by *Coccinella undecimpunctata*. The other common predators were *Scymnus* spp., *Paederous alfieri*, and *Orius* sp. *A. craccivora* was found to be parasitized by the parasitoid *Aphidius* spp., and the percentages of parasitism were high in the beginning of growth season then declined to zero before the middle of the season. The importance of pest aphids and their natural enemies in faba bean fields was discussed.

Key words: Pest management, *Vicia faba*, seasonal abundance, natural enemies, parasitism rate

INTRODUCTION

Faba bean (broad bean) *Vicia faba* L. is the third most important legume in the world. For its nutritive and growth characteristics, faba bean is a main cool season legume. The legume grains contain a great proportion of protein (28%) and carbohydrates (58%), as well as vitamins (Gupta, 1982). Also, faba bean plants have ancillary benefits of nitrogen fixation in the soil and thus require a low fertility requirement. Because of these, faba bean is one of the most important crops in Egypt and other part of the world.

Significant yield losses of faba bean occur due to attack by multiple insect pests either in the open field or during the storage process. Aphids are among the most serious and widespread insect pests attacking faba bean in many geographical regions (Radcliffe *et al.*, 1993), and, in Egypt, they infest faba bean plants all over the country causing considerable yield losses due to direct feeding by sucking plant sap or to indirect transmission of virus diseases (Hull, 1964; Hannou, 1995; El-Defrawi and Mokhtar, 2007; Khattab *et al.*, 2014). Black bean aphid *Aphis fabae* Scopoli, cowpea aphid *Aphis craccivora* Koch and pea aphid *Acyrtosiphon pisum* Harris are the most important widespread species infest-

ing faba bean in Egypt, and are the major targets of pest management programs in legume crops (Hossni, 2004; Mousa *et al.*, 2019)

In commercial plantings, farmers often use aphidicides in the form of foliar sprays to control pest aphids. This practice can often lead to unwelcome consequences such as undesirable deleterious impacts on natural enemies, development of insecticide resistance, etc., and, hence, chemical control of aphids may turn into an ineffective method (Denholm and Rowland, 1992; Radcliffe *et al.*, 1993; Ueno, 2006). Therefore, incorporation of other practices such as use of plant extracts, natural substances, intercropping and resistant varieties is on demand to reduce aphid pest incursions (Dent, 2000; Mousa *et al.*, 2013; Elsharkawy and Mousa, 2015; Tran *et al.*, 2016; 2017; Sun *et al.*, 2018; Mousa and Ueno, 2019).

Keeping pest infestation below an economically injury level is the fundamental process as preventative measures in long-term integrated pest management programs (Dent, 2000). Also, the timing of insecticide applications is based on the economic threshold level in order to maximize the efficiency of controlling methods and to preserve insect natural enemies. These practices would save the amounts of insecticides, labor, fuel and other materials. However, to do such practices, we need the fundamental knowledge of population dynamics of target pests and their natural enemies, as well as the species compositions of both pests and natural enemies.

In the present study, we focus on pest aphids in faba bean fields of Kafr EL-Sheikh areas in Egypt where aphid control is crucial to stable production of faba bean. Our current knowledge and understanding of population

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dynamics of aphids and their natural enemies have been limited. Thus, the aim of the present study is to examine the population trends, species composition and the seasonal abundance of most dominant aphid species and their associated natural enemies. For these purposes, we made a series of field studies for two years faba bean open fields in Kafr EL-Sheikh. Based on the results, we discuss on the importance of pest aphids and their natural enemies in faba bean fields.

MATERIALS AND METHODS

Study fields

The present study was carried out in the Experimental Farm of Sakha Agricultural Research Station, Kafr EL-Sheikh Governorate during faba bean planting seasons in two successive years 2016/2017 and 2017/2018. A field of one feddan (equal to 4200.8 m²) was divided into four parts of the same size and cultivated with an early mature variety of faba bean, Sakha 4, from the third week of November during the two study seasons. The variety Sakha 4 was obtained from Legumes Research Department, Sakha Agricultural Research Station. Regular conventional practices were performed and no insecticides were applied during the study period.

Survey of aphid species and associated predators

Populations of aphids and associated predators were monitored weekly from Dec. 20th 2016 till Apr. 4th 2017 in the first study season and from Dec. 16th 2017 till Mar. 31st 2018 in the second season. Field surveys were carried out in the morning time. 15 faba bean plants were randomly selected from each part using a cross diameter method and the whole plant was inspected in the field. Aphids and the associated predators that were detected were identified and counted with the aid of 8x lens.

Parasitism rate

The importance of aphid parasitoids was assessed by investigating the percentages of parasitism of the most dominant aphid, *Aphis craccivora*. Every week, bean plants infested with aphids were chosen and transferred to the laboratory. Then, 50 aphid individuals were randomly collected from the plants and were divided into five groups in petri dishes (10 insects/petri dish). The aphids in petri dishes were supplied with fresh faba bean leaves. They were daily observed for the formation of mummies. Rate of parasitism was estimated according to Farrell and Stufkens (1990) as percentage of parasitism = the number of mummified aphids/total number of aphids × 100. Mummies were reared until parasitoid emergence. The percentage of parasitoids that had successfully emerged from mummified aphids was then calculated.

Dominance percentages

Using the above mentioned data set, dominance percentages of aphid species and natural enemies were determined by the formula of Fasulati (1971); domi-

nance percentage = $(t / T) \times 100$, where t is the total number of each species, and T is the total number of all species counted.

Data analyses

The data were analyzed using COSTAT software.

RESULTS AND DISCUSSION

Pest aphids

Field surveys for two successive seasons in 2016/2017 and 2017/2018 revealed population dynamics of pest aphids in faba bean fields. We showed in Fig. 1 the seasonal prevalence of four aphid species detected, i.e., cowpea aphid *Aphis craccivora* Koch., cotton aphid *Aphis gossypii* (Glov.), green peach aphid *Myzus persicae* (Sulzer) and pea aphid *Acyrtosiphon pisum* (Harris), which belong to the family Aphididae in Homoptera.

Cowpea aphid *A. craccivora* appeared from the beginning of planting season (Dec. 20th and Dec. 16th in the 2016/2017 and 2017/2018 surveys, respectively) when the densities were not high. However, the populations of *A. craccivora* increased rapidly, forming one peak on Jan. 3rd with 307.0 ± 222.5 individuals recorded (mean \pm SD) in 2016/2017; in 2017/2018, there was also one distinct peak, which appeared on Dec. 30th with 176.0 ± 154.0 individuals (Fig. 1). The other three species of pest aphids, i.e., *A. gossypii*, *M. persicae* and *A. pisum*, appeared one week later than *A. craccivora*, and their densities mostly remained very low until harvest (Fig. 1). Pea aphid *A. pisum* was rather rare until

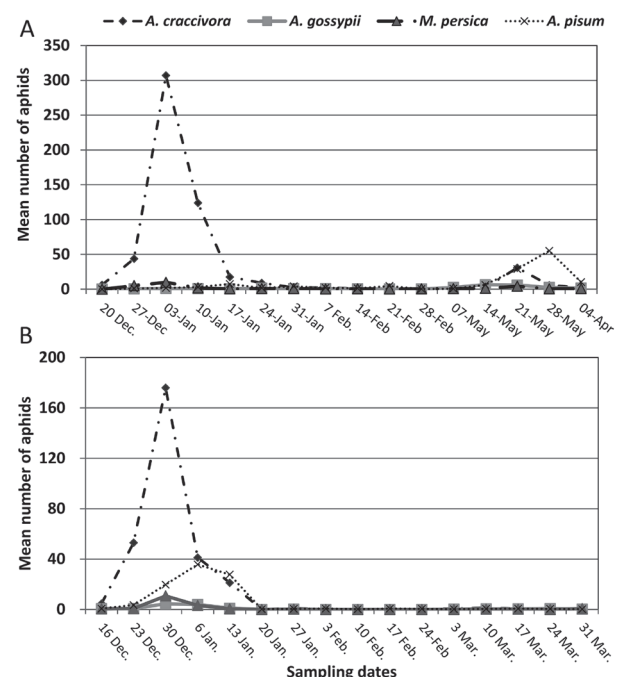


Fig. 1. Mean weekly abundance of four aphid species occurred in faba bean fields during 2016/2017 (A) and 2017/2018 (B) seasons.

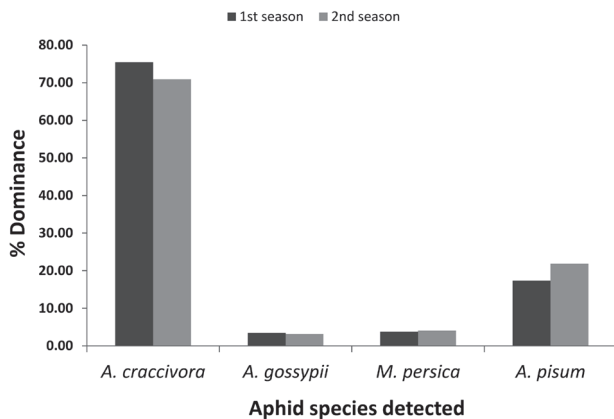


Fig. 2. Dominance percentages of the four aphid species detected in faba bean fields.

the end of the 2016/2017 season, and a density peak appeared on Mar. 28th when the mean density was 55.00 ± 15.13 individuals, but in the 2017/2018 season, *A. pisum* appeared much earlier, and the peak was found on Jan. 6th with the mean density of 35.8 ± 26.6 , then it disappeared again till the harvest time (Fig. 1).

The dominance percentage showed that cowpea aphid was the major pest aphid in our region; it achieved 75.42% and 70.91% in the 2016/2017 and 2017/2018 surveys, respectively, and the dominance percentages were followed by *A. pisum* and *M. persicae*, and *A. gossypii* (Fig. 2). It was therefore noticed that *A. craccivora* was the most dominant species, which could increase rapidly in the early stage of faba bean and one distinct population peak appeared in late December or early January (Fig. 1). Care should thus be taken to monitor this pest aphid, in particular, in the early planting season.

Awadalla *et al.* (2016) recorded two peaks for *A. craccivora*, *M. persicae* and *A. pisum* on broad bean, and the first and second peaks were at the fourth week of January and second week of March, respectively. Also, Awadalla *et al.* (2013, 2014) mentioned that *A. craccivora* and *M. persicae* had two peaks on faba bean. The difference between our study and Awadalla *et al.* may arise because of the difference in climate conditions between the study localities. In previous studies in Egypt, some authors suggest an influence of relative humidity or other climate conditions on aphid populations in bean fields (*e.g.*, Khalafalla and El-Galaly, 1998; Salman and Mohamed, 2000). However, it is unclear how abiotic factors including climate conditions could affect pest aphids like *A. craccivora* in faba bean fields. The importance of abiotic factors determining pest aphid population dynamics will thus be one of the main subjects in future studies.

Aphid predators

In our study field, a variety of arthropod predators associated with aphids were detected on faba bean plants (Fig. 3). The main predators detected were common green lacewing *Chrysoperla carnea* (Steph.) (both larval and adult stages), eleven-spot ladybird *Coccinella undecimpunctata* L. (both larval and adult stages),

minute pirate bug *Orius* sp. (both nymphal and adult stages), rove beetle *Paederus alfieri* Koch (adult stage only), lady beetle *Scymnus* spp. (both larval and adult stages) and two species of true spiders, *Singa* sp. and *Dictyna* sp. The two true spider species are combined and reported in Fig. 3 as “true spiders” because of their low numbers.

In the 2016/2017, predators began to appear from the earliest growth stage of faba bean (Fig. 3A). *Ch. carnea* was the most dominant predator with the mean dominance percentage of 28.05 %, followed by true spiders with 23.76%, while *Orius* sp. was the least abundant predator (Fig. 4). Fewer numbers of predators were occurred in 2017/2018 (Fig. 3B). However, *Ch. carnea* again was the most abundant species (25.09%) while *P. alfieri* was the least one (Fig. 4). It was noticeable that, in 2017/2018, predator densities increased in the last week of the field study period, and that population dynamics differed markedly between the two study seasons.

El-Sarand (2013) found four common insect predators associated with aphids in Kafr El-Sheikh; *Ch. Carnea*, *P. alfieri*, *C. undecimpunctata* and *Scymnus* spp., and also found the green lacewing was the most abundant while *Scymnus* was the least. Our present study therefore agrees with El-Sarand (2013) study. In other Egyptian geographical region, *e.g.*, El-Khrga Oasis at western Egypt, Abdel Khlek *et al.* (2018) showed that *C. undecimpunctata* was the most dominant predator in faba bean fields. This may be due to the geographic and environmental differences; while our studied field located in the delta of Egypt, El-Khrga Oasis was at a dry area in the middle of the western desert. Thus, composition and abundance of aphid predators can differ depending on the year and locality, presumably reflecting their biotic and abiotic preferences.

Aphid parasitoids

The present surveys on aphid parasitism revealed that the aphid *A. craccivora* suffered from high levels of parasitism by parasitoid wasps (Fig. 5). The major genus of the parasitoids was identified as *Aphidius* (Hymenoptera: Aphidiidae). No statistical difference was detected in mean parasitism rates between the two study seasons ($F = 1.199$, $P < 0.28$). The mean parasitism rates started from high values, *i.e.*, 50% and 56% for first and second seasons, respectively, and, then, reached 100% parasitism (Fig. 5). However in the 2016/2017 season, the parasitism rate became 0% in the fifth sampling date, and no parasitism was detected till the end of the season; in 2017/2018, the parasitism rates remained high until the 8th week, and became 0% thereafter (Fig. 5).

Thus, the present study has shown that aphid parasitoids can play an important role in suppressing *A. craccivora* populations; the activity of the parasitoid *Aphidius* spp. is very high during the early to middle stages of faba bean when the host aphid *A. craccivora* is abundant, and the percentages of parasitism overall are fairly high during the period. The conservation of such

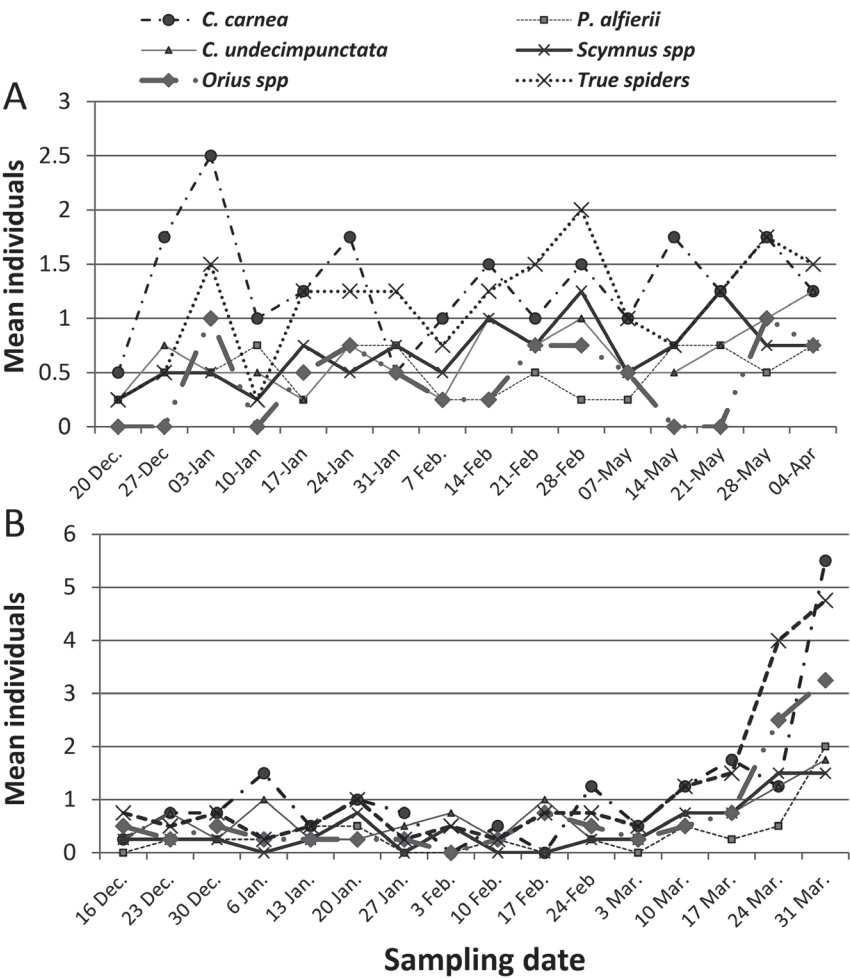


Fig. 3. Mean weekly abundance of aphid-associated predators in faba bean fields during 2016/2017 (A) and 2017/2018 (B) seasons.

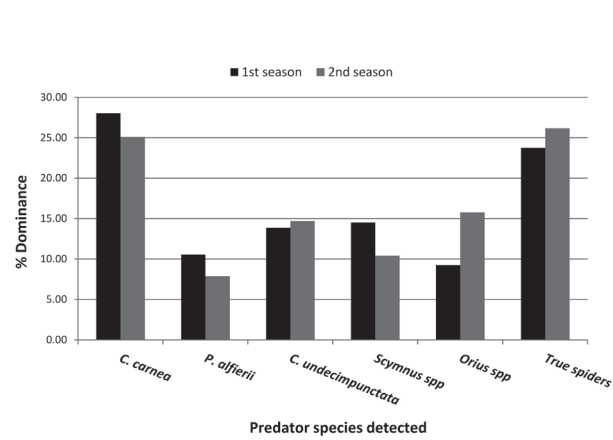


Fig. 4. Dominance percentages of the predatory species associated with aphids in faba bean fields.

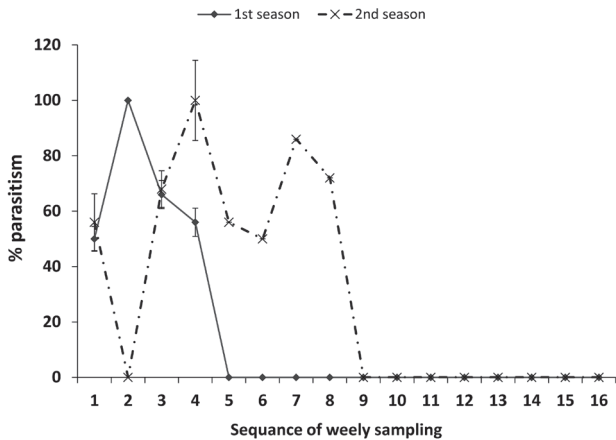


Fig. 5. The relationships between the sampling dates (from December 20th 2016 to Apr. 4th 2017 in 2016/2017 season and from Dec. 16th 2017 to Mar. 31st 2018 in 2017/2018 season) and the parasitism percentages of the aphid parasitoid *Aphidius* spp. in faba bean fields. Vertical lines indicate standard errors.

aphid parasitoids should be important in IPM of faba bean production. Also, the exact identification of the *Aphidius* species will be done and the species composition should be revealed in future.

The levels of parasitoid activity appear to differ between the 2016/2017 and 2017/2018 seasons. In the latter season, parasitism rate remained high until the middle of growing season. It is unknown what factors are involved in such a difference. It is well known that humidity and temperature considerably affect life expectancy and reproduction of small insects, including aphid parasitoids (Stary, 1970; Giga and Smith, 1983; Fink and Völkl, 1995; Aung *et al.*, 2011; Tran *et al.*, 2012). The natural enemies and climatic conditions are of the most important factors affecting the population dynamics of insect pests (Bylund, 1999; Alalouni *et al.*, 2013; Bassiony *et al.*, 2017). We suspect the difference in weather or climate conditions could be associated with it but further field surveys are required to examine how such abiotic conditions affect the activity of parasitoids and predators.

AUTHORS' CONTRIBUTIONS

In the present study, I. A. Khodeir and M. A. Khattab designed the study and prepared the first draft of the manuscript. K. M. Mousa analyzed the data, wrote the manuscript and discussed the results. A. S. Sharabash conducted the field experiments, and O. M. Rakha helped during the experiment. T. Ueno discussed the results, polished up the research concept and the manuscript.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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