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Impact of hymenopterous parasitoids (Hymenoptera: aphidiidae) attacking the cowpea aphid, *Aphis craccivora* Koch (Homoptera: aphididae) infesting broad bean plants at Assiut governorate

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Abstract

The present study was carried out in Refa village at Assiut governorate during 2017-2018 and 2018-2019 seasons. The role of primary parasitoids attacking the cowpea aphid was evaluated under field conditions. The obtained data revealed that, the population density of the cowpea aphid began to appear on the faba bean plants after one month of sowing and developed progressively up to the end of March. The start of warming weather seems to be the favorable condition for development and multiplication of the cowpea aphid, Aphis Craccivora Koch. In addition, the rapid increase of the pest during the vegetative growth of the plants might be related to suitability of the host plants in these stages. Four species of primary parasitoids; Aphidius colemani Viereck, Aphidus matricaria (Haliday), Diaretella rapae (M'Intosh) and Paraon necans (Mackauer) were recorded and identified belonging to family Aphidiidae. Furthermore, two hyperparasitoid species belonging to two families, Cynipidae; Alloxysta sp. and Pteromalidae, Oachyneuron sp. Mummified aphid densities tended to rise and fall in synchrony and there was a marked increase in number of mummified aphids at start of the aphid population decline.

Keywords

Faba bean, *A. craccivora*, Hymenopterous parasitoids.

INTRODUCTION

Faba bean is an essential food crop that provides a major source of protein for humans and domestic animals. Cowpea aphid, *Aphis craccivora* Koch is considered one of the most injurious pests infesting faba bean plants in Egypt (Selim *et al.*, 1987, El - Defrawi *et al*., 2000, Ragab *et al*., 2002a and Saleh, 2004 and 2009). It sucks the plant sap causing a decrease in plant vitality, and consequently reduces the crop yield. In addition, aphids are considered the most serious vectors of plant viruses which may induce destruction of the infested crop. Biological control is a main factor of integrated control programs including parasitoids, predators and pathogens (Sarhan, 1976 and Maghraby, 2012). In Egypt, recorded the parasitoid *Diaeretiella rapae* (M'Intosh), for the first time, association with the field population of *A. craccivora*, infesting broad bean in Mansoura district (Ragab *et al.*, 2002). It also parasitized many aphid species, *Myzus persicae*, *Pentalonia nigronervosa*, *Acyrthosiphon pisum*, *Sitobion avenae*, *Shizaphis graminum* and *Aulacorthum solani* (Stary and Stechmann, 1990). Therefore, an overall evaluation of the role of parasitoids in natural control of the cowpea aphid, *A. craccivora* in Upper Egypt is unavailable. Therefore, the present study was undertaken to determine the species of primary parasitoids attacking the cowpea aphids, their relative impact and seasonal occurrence.

MATERIALS AND METHODS

The present study was undertaken at Refa village (27.0976° N, 31.2070° E), Assiut District (10 Kilometers south of Assiut City). It has long been planted to patches of alfalfa, faba bean, Egyptian clover, wheat, maize and vegetables. This study was oriented in the farmer fields during two successive growing seasons of 2017-2018 and 2018-2019. Field and laboratory studies were conducted.

In the field, an area of about half feddan (about 2100 m^2) was cultivated with faba bean variety Giza 843and it was obtained from the Ministry of Agriculture. Normal agricultural practices were performed and no insecticidal treatments were used during the study period. Regular samples consisted of 50 faba bean plants weekly was randomly collected and brought back in transparent paper bags to the laboratory for counting aphids (nymphs and adult). Samples were taken weekly after one month from planting and continued till the end of the season. At the same time number of parasitized aphid (mummies) was also counted and recorded. The mummies were collected from faba bean fields during 2017-2018 and 2018-2019 seasons. Mummies were placed in small vials and then kept in the laboratory conditions. The mummies were inspected regularly and the emerging parasitoids were identified and counted. Growth stages of the plants were recorded according to National faba bean Association (GRDC, 2014). Dominance degrees (D) of the identified predators and parasitoids were calculated according to (Facylate, 1971).

In the laboratory, in each inspection date, samples of live *A. craccivora* were collected from faba bean plants. The specimens were kept in paper bags and transferred to laboratory. The aphids were caged on faba bean seedlings in plastic pots, 50 aphid individuals / each cage were placed. Aphids were reared under laboratory conditions and observed daily for more than 10 days to record mummies. Mummies were removed and placed individually in small vials and observed until the adult emergence. Emerging parasitoids were examined for identification according to (Pike *et al*., 1997).

Statistical analysis

Percentage of parasitism in the field each sampling date was estimated as: Parasitism (%) = No. of mummified aphid (mummies) / sum aphids + mummies) x 100 (Feng *et al.*, 1992).

Parasitisation rate (%) of each sampling date was estimated as:

A/ (B) x 100, were

A = Number of developed mummies.

B = Number of aphids.

Dominance degrees (%) of the collected predator species were estimated according to the formula of (Facylate, 1971) as follow:

$$D = \frac{t}{T} \times 100, \text{ Where}$$

t = Total number of each species during the collecting period.

T = Total number of all species collected during the collecting period.

Identification was made at Plant Protection Research Institute. Species of parasitoids were sent to Dr. Peter Stary, Institute of Entomology, Academy of Science, Czech Republic for identification.

Temperature (ºC) and relative humidity (%) (Maximum, minimum) within inspection dates, were the selected weather factors and obtained from a metrological station located in Assiut governorate.

RESULTS AND DISCUSSION

1- Aphid populations

Data presented in Tables (1 and 2) show the population change of the cowpea aphid during 2018 and 2019 seasons. The population fluctuation of the cowpea aphid (nymphs and adults) was investigated during two successive growing seasons of 2017-2018 and 2018-2019. Data of the population expressed in weekly.

2017-2018 Season

Data in Table (1) summarize the changes in the population densities of the *A. craccivora* (nymphs and adults) infesting faba bean plants during 2017-2018 season. Data show that the *A. craccivors* began to appear in the field in relatively low numbers (0.10 individuals / plant) third week of November when the plants were in the seedling stage. This period coincided with a maximum temperature of 27.86^{o}C, a minimum temperature of 13.71^{o}C, a maximum RH of 72.57% and a minimum RH of 13.25%. Thereafter, the population density of the pest fluctuated in scarcely numbers to attain the peak (46.34 individuals / plant) during the second week of February 10, when the plants were during the vegetative growth stage (end of flowering and beginning of ripening stages). The recorded weather factors in this period were 30.07 and 8.64^{o}C for max. and min., temperature and 70.71 and 9.43% for max. and min. RH, respectively. Then the number of aphids decreased gradually till the end of March, when the faba bean plants were in the ripening stages. The recorded weather factors were 30.57^{o}C and 11.43^{o}C for max. and min. temperature and 60.57% and 12.86% for max. and min. RH, respectively (Figure 1).

2018-2019 season

Data in Table (2), show the population trend was nearly similar as in 2017-2018 season. *A. craccivora* were first appeared in relatively high numbers during the third week of November after one month of sowing when the plants were in the seedling stage. Then, the number increased gradually forming the peak of 82.56 individuals / plant during the first week of February (the end of flowering and the beginning of ripening stages). The recorded max., min. temperatures were 23.50 and 4.71^{o}C and the max., min. RH were 80.57 and 25.43%, respectively. The population then decreased to its lowest level (2.23 individuals / plant). The recorded max., min. temperature were 27.71^{o}C, 7.14^{o}C and the max., min. RH were 77.14%, 15.14%, respectively (Figure 2).

The obtained data revealed that, the population density of the cowpea aphid comparatively higher in 2018-2019 season than in 2017-2018 season. The number of nymphs and/or adults during 2019 season was nearly one and half as much as of 2017-2018 season. It is clear also that the population of the pest began to appear on the faba bean plants after one month of sowing and developed progressively up to the end of March. The start of warming weather seems to be the favorable condition for development and multiplication of the *A. craccivora*. In addition, the rapid increase of the pest during the vegetative growth of the plants might be related to suitability of the host plants in these stages.

2- Aphid parasitoids recorded associated with broad bean plants in Assiut

Four species of primary parasitoids; *Aphidius colemani* Viereck**,** *Aphidus matricaria***,** *Diaretella rapae* (M'Intosh) and *Paraon necans* (Mackauer) were recorded and identified belonging to family Aphidiidae; in addition to two hyperparasitoid species belonging to two families, Cynipidae; *Alloxysta* sp. and Pteromalidae, *Oachyneuron* sp. Table (3).

Aphid primary parasitoids were previously recorded in different parts of the worlds by several investigators (Abdel-Rahman *et al*., 2000, Abdel-Samad and Gomaa, 2004, El-Fatih, 2006, Salmen, 2007 and Shehata, 2019). In addition, (Abou-Attia *et al.*, 2003, El-Hussieni *et al.*, 2003 and Shehata, 2019) reported that *D. rapae* was the most

dominant aphid parasitoid species followed by *P. necans*. The present results agree with those of (Ragab *et al.,* 2002b, Saleh, 2009 and Maghraby, 2012), who found that *D. rapae*, L. fabarum and *Ephedrus sp.* as parasitoids on *A. craccivora* in Egypt. (Abdel-Samad and Ahmed, 2006), recorded *L. fabarum*, *A. matricariae* and *Trioxys* sp. were found attacking *A. craccivora* on faba bean cultivars.

The present results agree with those of (Stary and Erdelen, 1987), in Yemen, who mentioned that *A. colemani* was the parasite reared from *A. craccivora* on *Vigna* sp., (Cruz *et al.,* 1992), in Portugal, mentioned that *Diaeretiella* sp. and *Trioxys* sp. were a primary parasitoid of *A. craccivora* in cowpea fields. In Egypt, Youssif (2009) found that, the most dominant primary parasitoids were *D. rapae*, *A. colemani*, *Aphidius* sp. and *Trioxys sp*. and unidentified species of hyperparasitoids be longed to the two families, Pteromalidae and Cynipidae on *A. craccivora* infested cowpea plants.

2.1- Dominance degrees of parasitoids attacking the cowpea aphids infesting broad bean plants

Data in Table (4) show the dominance degrees (%) of hymenopterous parasitoid species emerged from mummies of *A. craccivora* collected from broad bean plants during 2017-2018 and 2018-2019 growing seasons in Assiut. *A. matricaira* and *D. rapae* had the most dominant degrees percentage (31.68 and 23.76% during 2017-2018) and (25.35 and 16.90% during 2018-2019) followed by *P. necans*, meanwhile, *A. colemani* had low values of dominance. For the secondary parasitoids, *Alloxysta* and *Oachyneuron* had the lowest dominance degrees (9.90, 7.93%, and 22.54, 8.45%) during 2017-2018 and 2018-2019, respectively.

3- Impact of hymenopterous parasitoids in regulating cowpea aphid in Assiut

Field and laboratory studies were conducted to determine the effect of hymenopterous parasitoids in relation to cowpea aphid population during 2017-2018 and 2018-2019 growing season.

3.1- Field observations (Mummification rate)

2017-2018 season

Data in Table (1) revealed that the mummified aphids appeared on faba bean plants during the period extended from the third week of November up to the end of March. The percentage of parasitism was relatively low generally <3% until the middle of January. Then the level of parasitism dramatically increased as the aphid population increased. Maximum parasitism (6.38%) was achieved during the end of February and the beginning of March.

2018-2019 season

Data in Table (2) showed that the mummified aphids appeared on plants at the third week of November up to the end of March. The percentage of parasitism was relatively low (0.15%) at the third week of November and increased with small number of forming a peak (7.44%) at the middle of March. Generally, the mummification rate in the first season more than those in the second season.

3.2- Laboratory observations (Parasitization rate)

The present study was oriented under laboratory condition to estimate the rate of parasitism by hemeopterous parasitoids attacking cowpea aphid, *A. craccivora*. Live aphids (apterous forms) were collected weekly from faba bean field. In each date specimens were transferred to the laboratory and aphids were reared until formation of mummies.

2017-2018 and 2018-2019 seasons

Data presented in Table (1 and 2) showed that, during 2017-2018 season, 48 mummies were developed from 900 alive individuals of aphids with parasitization rate 5.33%, while in 2018-2019 season, 55 mummies were developed from 900 live individuals of *A. craccivora* with parasitization rate (6.11%). Generally, based on the total number of developed mummies throughout the whole season, it shows that the parasitization rate ranged from (2.12%) during last week of January to a maximum level (12%) during last week of February and beginning of March.

The present study indicated that the hymenopterous parasitoids are considered to be potentially important regulates of cowpea aphid in faba bean ecosystem. They appear to be synchronized with the start of aphid population and they may be able

to affect the growth of the aphid population. Later in the season, parasitization rate were capable of affecting aphid numbers at their highest population level. These results are similar to (Shehata, 2019) she observed that the parasitoids play an important role in natural regulation of aphid population in wheat fields. (Kring and Glistrap, 1983) stated that the rapid decline in aphid densities by late summer is primarily due to the high rates of predators and parasitoids. The present results are in agreement with those of Abdel-Samad and Gomma, (2004) and Levie *et al.*, (2005) who concluded that the natural enemies affect aphid numbers particularly at the time of their higher population level. (Abdel-Rahman *et al.*, 2000) stated that, as a general rule, an aphid infestation usually decline rapidly after 20% of the aphids are mummified because at this point of living aphid have been parasitized but not yet turned into mummies.

Table (1) Population densities of cowpea aphids on broad bean plants and the rate of parasitism (%) in the field and in the laboratory, Assiut 2017-2018 season.

Date	Field observations / 100 plants			Laboratory observations			Ratio**
	Mean No.		(%)	No. obs.*	Mummies		
	Aphids	Mummies			No.	(%)	
Nov., 18, 2017	1.10	0.00	0.00	50	0.00	0.00	0.00
25	2.44	0.00	0.00	50	0.00	0.00	0.00
Dec., 2	4.88	0.01	0.20	50	0.00	0.00	0.00
9	16.23	0.02	0.12	50	0.00	0.00	0.00
16	18.99	0.02	0.10	50	0.00	0.00	0.00
25	22.83	0.25	1.08	50	1.00	2.00	1.85
30	24.78	0.31	1.23	50	1.00	2.00	1.62
Jan. 6, 2018	25.31	0.41	1.59	50	2.00	4.00	2.51
13	26.34	0.55	2.04	50	2.00	4.00	1.96
20	30.23	1.01	3.23	50	2.00	4.00	1.23
27	31.90	1.03	3.13	50	3.00	6.00	1.91
Feb., 3	36.42	1.35	3.57	50	3.00	6.00	1.68
10	46.34	1.42	2.97	50	4.00	8.00	2.69
17	23.18	1.45	5.89	50	5.00	10.00	1.69
24	16.29	1.11	6.38	50	6.00	12.00	1.88
March, 3	6.91	0.42	5.73	50	6.00	12.00	2.09
10	2.49	0.10	3.86	50	7.00	14.00	3.62
17	1.12	0.03	2.61	50	6.00	12.00	4.59

* No collected alive aphids; ** Parasitism in the lab. / parasitism in the field.

Table (2) Population densities of cowpea aphids on broad bean plants and the rate of parasitism (%) in the field and in the laboratory, Assiut 2018-2019 season.

Date	Field observations / 100 plants			Laboratory observations			Ratio**
	Mean No.		(%)	No. obs.*	Mummies		
	Aphids	Mummies			No.	(%)	
Nov., 18, 2018	3.78	0.00	0.00	50	0.00	0.00	0.00
25	6.27	0.01	0.15	50	0.00	0.00	0.00
Dec., 2	17.89	0.04	0.22	50	0.00	0.00	0.00
9	18.74	0.08	0.42	50	1.00	2.00	4.76
16	19.34	0.11	0.56	50	1.00	2.00	3.57
25	21.11	0.23	1.078	50	1.00	2.00	1.85
30	30.23	0.46	1.49	50	2.00	4.00	2.68
Jan. 6, 2018	31.95	0.75	2.29	50	2.00	4.00	1.74
13	35.16	1.01	2.79	50	3.00	6.00	2.15
20	49.38	1.12	2.21	50	3.00	6.00	2.71
27	69.69	1.32	1.85	50	4.00	8.00	4.32
Feb., 3	70.61	1.41	1.95	50	4.00	8.00	4.10
10	82.56	1.75	2.07	50	5.00	10.00	4.83
17	66.26	1.96	2.87	50	5.00	10.00	3.48
24	34.33	2.01	5.53	50	6.00	12.00	2.16
March, 3	28.66	2.05	6.67	50	6.00	12.00	1.79
10	15.17	1.22	7.44	50	7.00	14.00	1.88
17	2.23	0.01	0.44	50	6.00	12.00	27.27

* No collected alive aphids; ** Parasitism in the lab. / parasitism in the field.

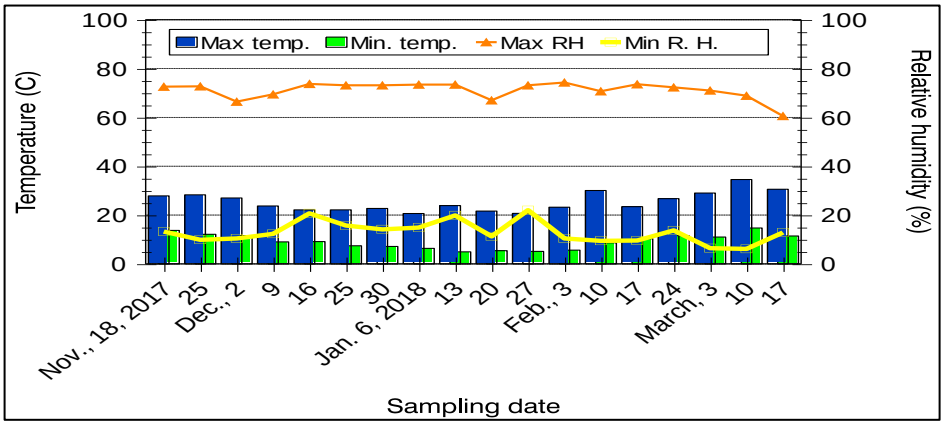

Figure (1) Meteorological data recorded during 2017-2018 season.

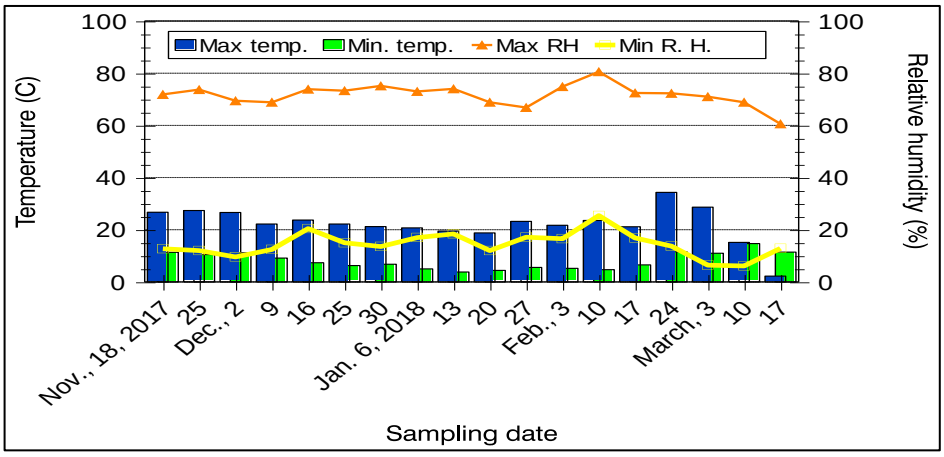

Figure (2) Meteorological data recorded during 2018-2019 season.

Table (3) A partial list of certain hymenopterous parasitoids collected attacking the cowpea aphid during two successive seasons of 2017-2018 and 2018-2019.

Order	Family	Parasitoid Species
Hymenoptera	Aphidiidae	*Aphidius colemani* Viereck
		Aphidus matricaria
		Diaretella rapae (M'Intosh)
		Paraon necans (Mackauer)
	Cynipidae	*Alloxysta* sp.
	Pteromalidae	*Oachyneuron* sp.

Table (4): Dominance degrees (%) of some parasitoids reared on *A. craccivora* inhabiting broad bean plants, during two successive seasons of 2017-2018 and 2018-2019.

Species	Dominance degrees (%)					
	2017-2018	2017-2018	2018-2019	2018-2019	Total	
	No.	(%)	No.	(%)	No.	(%)
A. colemani	15	14.85	8	11.27	23	13.37
A. matricaria	32	31.68	18	25.35	50	29.07
D. rapae	24	23.76	12	16.90	36	20.93
P. necans	12	11.88	11	15.49	23	13.37
***Alloxysta* sp.**	10	9.90	16	22.54	26	15.11
***Oachyneuron* sp.**	8	7.93	6	8.45	14	8.14
Total	101	100.00	71	100.00	172	100

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الملخص العربي

تاثير طفيليات غشائية الاجنحة التي تهاجم من البقوليات الذي يصيب نباتات الفول البلدي بمحافظة اسيوط

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تم اجراء الدراسة في قرية ريفا محافظة اسيوط خلال موسمين متتاليين 2017-2018 و 2018-2019. تم تقييم دور الطفيل الاولي الذي يهاجم من البقوليات تحت الظروف الحقلية. اشارت البيانات الي ان الكثافة العددية لمن البقوليات تبدا في الظهور علي نباتات الفول بعد شهر من الزراعة واستمرت حتي نهاية شهر مارس. وكانت الظروف الجوية الدافئة ملائمة لتطور وتضاعف من الفول. بالاضافة الي ان الزيادة السريعة للافة اثناء النمو الخضري للنبات ربما تكون مرتبطة بالعوائل النباتية المناسبة في هذه المراحل. تم تسجيل اربعة انواع من الطفيليات الاولية المتطفلة علي من الفول التابعة لعائلة Aphidiidae وهي *Aphiddius colemani, Aphidus martticaria, Diaretella rapae, Paraon necans* بالاضافة الي نوعين من الطفيليات الثانوية *Alloxysta* sp. التابع لعائلة Cynipidae والطفيل *Oachyneuron* sp. التابع لعائلة Pteromalidae . وكثافة المومياوات زادت وانخفضت بالتزامن وكانت هناك زيادة ملحوظة في عدد مومياوات المن مع بداية انخفاض تعداد المن.