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Studies on some Parasitoids of the Cowpea Aphid *Aphis craccivora* Koch (Homoptera: Aphididae) in Egypt

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ABSTRACT

Survey and population density of the aphid species *Aphis craccivora* (Koch) infesting broad bean plants and its parasitoids were studied at Zagazig district during the two successive seasons 2006-07 and 2007-08. Two primary parasitoids, *Diaeretiella rapae* (M'Intosh), *Ephedrus* sp. (Aphidiidae), and a hyperparasitoid, *Aphidencyrtus* sp. (Encyrtidae) were recorded. Highest rates of parasitism 12.73% were recorded in the 4th week of January 2006-07 and 11.09% in the 2nd week of February 2007-08. Seasonal means of parasitism rates of the primary parasitoids *D. rapae* and *Ephedrus* sp. were 8.17 and 6.45% during the two seasons, respectively. Total developmental period of the two parasitoids was investigated at three temperatures (10, 15 and 28 °C). The duration of the two parasitoids was longest at 10 °C. Generally, developmental periods of different stages of the parasitoids shortened as the temperature increased from 10 to 28 °C. Total developmental periods of the two parasitoids ranged between 11.17-27.16 and 12.38-30.48 days for *D. rapae* and *Ephedrus* sp., respectively. Sex ratios were 1:1.1 and 1:1.07 (m:f) for *D. rapae* and *Ephedrus* sp., respectively. Temperature and relative humidity played an important role in the population changes of *A. craccivora*, *D. rapae* and *Ephedrus* sp. Temperature showed a highly significant effect on the population density of *Ephedrus* sp. in both seasons. The maximum temperature and the minimum relative humidity had a positive significant effects on the population density of *D. rapae* at both seasons.

Key words: *Diaeretiella rapae*, *Ephedrus* sp., *Aphis craccivora*, Ecology, biology.

INTRODUCTION

Faba bean, *Vicia faba* L. is an essential food crop that provides a major source of protein for humans and domestic animals. Aphids are considered a group of insect pests of which the economic importance increases with the development of agriculture (Stary 1976). Faba bean is attacked by several insect pests including the cowpea aphid, *Aphis craccivora* Koch which is considered a key pest of faba bean cultivation in Egypt (Selim *et al.*, 1987, El-Defrawi *et al.* 2000, Ragab *et al.* 2002b and Saleh 2004). This species is the most common on broad bean, lentil and cowpea plants. It attacks the lower surface of leaves and the flower buds of its host plants (Attia and El-Hamaky 1991). 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 vector of plant virus which may induce destruction of the infested crop.

Biological control is a main tool of integrated control programs, since it is concerned with biotic agents including parasitoids, predators and/or pathogens (Stary, 1970). In Egypt, Saleh (2000) recorded the parasitoid; *Diaeretiella rapae* (M'Intosh) for the first time in association with the field population of *A. craccivora* infesting broad bean in Mansoura district. Also, Ragab *et al.* (2002b), recorded three parasitoids *D. rapae*, *Lysiphlebus fabarum* (Marshall) and *Ephedrus* sp. on the pest.

The present study aims to throw some light on the biology and role of parasitoid species associated with *A. craccivora* infesting broad bean. The effects of some climatic factors on population densities of the aphid and its parasitoids were also studied.

MATERIALS AND METHODS

1. Survey and estimated parasitism in the field:

Field studies were carried out during 2006 /07 and 2007/08 broad bean seasons at Kafr Sakr district, Sharkia Governorate, Egypt. *A. craccivora* population was estimated on broad bean plants, *Vicia faba*, through weekly random samples of twenty aphids infested leaves and calculated monthly. Samples were transferred to the laboratory in tight closed plastic bags. All aphid individuals found on leaves/sample were counted. Aphids were supplied by fresh host leaves and kept in Petri dishes (50 aphids/Petri dish) until formation of mummies. Emerged parasitoids were mounted and identified by Department of Biological Control, ARC, Egypt. Rates of parasitism and hyperparasitism were estimated according to Farrell and Stufkens (1990) and El-Maghraby (1993) as:

$$\text{Percentage of parasitism} = \frac{A + B}{A + B + C} \times 100$$

Where:

A = Number of mummified aphids counted at the date of inspection

B = Number of mummified host appeared during the laboratory rearing

C = No. of unparasitized aphids.

Daily records of both minimum and maximum temperatures along with relative humidity were obtained, throughout the two seasons, from the Agro-meteorological Station at Zagazig region. These records have been calculated as monthly means. The relationship between averages of the weekly numbers of aphids and the corresponding weekly means of temperature and relative humidity were recorded.

2. Biological Studies

2.1. Life cycle of *D. rapae* and *Ephedrus* sp. on *A. craccivora*.

A laboratory culture of *A. craccivora* was maintained under laboratory conditions. Nymphs of *A. craccivora* were reared on caged young seedlings of *V. fabae* grown after sowing in wet sawdust. A laboratory culture of the parasitoids *D. rapae* and *Ephedrus* sp. stared with mummies obtained form the field. Mummified aphids were placed singly in small glass tubes until emergence of adult parasitoids which were fed on 30 % sugar solution. To determine the durations of different immature stages of the two parasitoids *D. rapae* and *Ephedrus* sp. on the nymphs of *A. craccivora* at three temperatures (10, 15 and 28 °C), nymphs were confined with the parasitoids in a chimney glass for 2-6 hours. Twenty five nymphs of parasitized host aphids were daily dissected to determine the development of different immature stages of the parasitoids.

2.2 Sex ratio

Sex ratio of *D. rapae* and *Ephedrus* sp. recovered from *A. craccivora* was determined.

Obtained data were statistically analyzed using, Costat (1990) computer program.

RESULTS AND DISCUSSION

1. Survey and estimation of parasitism rate in the field

Weekly counts of *A. craccivora* on broad bean leaves during 2006-07 and 2007-08 seasons are given in (Tables 1&2). During the first season, the infestation started during the 4th week of October (20.0 °C and 63.0 % RH), while it appeared during the 3rd of October (29.20 °C and 59.29 % RH) in 2007-08 season.

The following are the hymenopterous primary and secondary parasitoid species emerged from *A. craccivora* during the period of study:

Primary parasitoids:

Aphidiidae: *Diaeretiella rapae* (M`Intosh) and *Ephedrus* sp.

Secondary parasitoids:

Encyrtidae: *Aphidencyrtus* sp.

However, Selim *et al.* (1987) and Abdel-Samad (1996) recorded *Lysiphlebus fabarum* as a parasitoid on *A. craccivora* in Egypt. Ragab (1996) and Abdel-Samad (1996) recorded also *Trioxys angelicae* (Hal.) as a parasitoid of *A. craccivora.* These latter parasitoids (*L. fabarum* and *T. angelicae*) were not recorded during the present study. The present results agree with those of Saleh (2000) and Ragab *et al.* (2002b) who recorded *D. rapae*, *L. fabarum* and *Ephedrus* sp. as parasitoids on *A. craccivora* in Egypt.

The primary parasitoid *D. rapae* was the most dominant species with mean relative densities (73.34 and 71.69 %) during the two seasons, respectively. Meanwhile, the mean relative densities of the primary parasitoid *Ephedrus* sp. were 23.33 and 25.30%, respectively. The percentage of parasitism ranged from 2.58 to 12.73 %, (at the ranges of 20.5 & 15.43 °C and 69.0 & 61.71% RH, respectively) in the first season 2006-2007. In the second season, percentage of parasitism ranged between 1.03 on October, 25th (at 27.84 °C and 62.0 % R.H.) and 11.09 on February, 14th (at 17.9 °C and 65.14% R.H.). Highest percentage of parasitism reached 12.73 % on January, 25th in 2006/07 season and 11.09 % on February, 14th in 2007/08 season. Total means of parasitism rates of *D. rapae* and *Ephedrus* sp. together were 8.17 and 6.45 % during 2006-07 and 2007-08 seasons, respectively (Tables 1&2).

One hyperparasitiod (*Aphidencyrtus* sp.) was recorded in few numbers from 7 December to 22 February in the first season and from 27 December to 28 February in the second season. Total means of hyper parasitism rates were 3.57 and 3.01% during the two seasons, respectively (Tables 1&2). However, Abdel-Samad (1996) in Egypt, reported that the rate of parasitism varied between 15.4 and 22.0 in March on the same aphid species. Also, Ragab *et al.* (2002b), stated that the highest total percentage of parasitism was 15.14 % in February in the first season and 17.40 % in January in the second season. The same authors showed also that the relative densities of *L. fabarum*, *D. rapae* and *Ephedrus* sp. were 50.05, 38.11 and 11.84 % in the first season 1998 and 46.22, 37.79 and 15.99 % in the second season 1999, respectively.

Table (3) shows the simple correlation coefficient values between temperature & relative humidity and the population density of *A. craccivora* during the two seasons of study. Temperature showed non significant positive correlation in the two seasons of

Table (1): Monthly mean percentages of parasitism of *A. craccivora* by *D. rapae* and *Ephedrus* sp. on broad bean plants in Zagazig region during 2006-07 season.

Sampling date	No. of examined aphid	No. of parasitized aphids (mummies A	B	Total)	Total Parasitism %	Emerged parasitoids: Primary parasitoids *D. rapae* N	RD %	*Ephedrus sp.* N	RD %	Hyperparasitoid *Aphidencyrtus sp.* N	RD %	Total	Mean Temp.	Mean RH %
Oct.-06	764	0	0	0	0	0	0	0	0	0	0	0	20	63
Nov.-06	712	4	40	44	6.18	28	80.00	7	20.0	0	0	35	17.45	68.75
Dec-06	632	23	45	68	10.76	31	67.39	12	26.09	3	6.52	46	16.28	71.75
Jan-07	550	15	52	67	12.18	33	67.35	14	28.57	2	4.08	49	14.08	67.41
Feb-07	403	13	30	43	10.67	25	69.44	10	27.78	1	2.78	36	15.39	63.88
Mar-07	411	14	24	38	9.25	22	73.34	7	23.33	1	3.33	30	18.44	62.55
Mean	578.7±61.64				8.17±0.92	23.17±4.91	70.92±2.38	8.33±2.01	25.51±1.57	1.17±0.48	3.57±1.02	23±3.6		

A = No. of mummified host counted at the date of inspection
B = No. of mummified host counted during the laboratory rearing
N = Number
RD = Relative density

Table (2): Monthly mean percentages of parasitism of *A. craccivora* by *D. rapae* and *Ephedrus* sp on broad bean plants in Zagazig region during 2007-08 season.

Sampling date	No. of examined aphid	No. of parasitized aphids (mummies A	B	Total)	Total % parasitism	Emerged parasitoids: Primary parasitoids *D. rapae* N	RD %	*Ephedrus sp.* N	RD %	Hyperparasitoid *Aphidencyrtus sp.* N	RD %	Total	Mean Temp.	Mean RH %
Oct-07	866	0	0	0	0	0	0	0	0	0	0	0	29.2	59.29
Nov-07	564	1	16	17	3.01	12	100	0	0	0	0	12	25.89	61.93
Dec-07	618	8	36	44	7.12	26	72.22	10	27.78	0	0	36	20.23	61.82
Jan-08	519	16	35	51	9.83	29	67.44	13	30.23	1	2.33	43	17.85	66.89
Feb-08	503	18	40	58	10.74	32	69.57	11	23.91	3	6.52	46	16.15	64.99
Mar-08	437	12	23	35	8.01	20	68.96	8	27.59	1	3.45	29	19.63	65.72
Mean	584.5±61.49				6.45±1.3	19.83±4.9	71.69±5.60	7.0±2.31	25.30±1.06	0.67±0.47	3.01±0.89	27.67±5.50		

A = No. of mummified host counted at the date of inspection
B = No. of mummified host counted during the laboratory rearing
N = Number
RD = Relative densi

study; meanwhile the maximum relative humidity exerted highly significant positive correlations in the first season. As a mean of the two years, relative humidity was positively correlated with *A. craccivora* population density in 2007-08 season and negatively correlated with aphids population in the subsequent season. In similar studies in Egypt, Saleh (2000) stated that the effect of temperature ranged from slight negative or positive correlation and the minimum relative humidity showed slight positive correlation but the maximum relative humidity cleared significant positive correlation on the population density of *A. craccivora.*

Results in Table (4) shows the values of correlation coefficient between each of the temperature & relative humidity and the population density of *Ephedrus* sp. and *D. rapae* during the two the seasons of study.

1. *Ephedrus* sp.

In 2006-07, temperatures (minimum, maximum and mean temperature) exhibited highly significant negative correlation with population density of

Table (3): Simple correlation coefficient values between temperature & relative humidity and the total numbers of *Aphis craccivora* in Zagazig region, Egypt during 2006-07 and 2007-08 broad bean seasons.

Weather variables	2006-2007 r ± SE	P	2007-2008 r ± SE	P
Minimum Temp.	0.1903±0.2314	ns	0.4126±0.1988	ns
Maximum Temp.	0.3536±0.2205	ns	0.2991±0.2082	ns
Mean Temp.	0.3192±0.2234	ns	0.3772±0.2021	ns
Minimum RH	0.1621±0.2326	ns	-0.3921±0.2007	ns
Maximum RH	0.7885±0.1450	**	-0.2250±0.2126	ns
Mean RH	0.4442±0.2112	*	-0.4965±0.1894	*

Ephedrus sp. While the relative humidity showed slight positive correlation on the population density. Also, in the second season (2007-08), the minimum and maximum temperatures induced highly significant negative correlations; -0.7926** and -0.7923**, respectively, also it was highly significant negative effect on the mean temperature. The relative humidity exerted varied effect with values ranging from slight positive correlation to negative

Table (4): Simple correlation coefficient values between temperature relative humidity and the total numbers of two parasitoids *D. rapae* and *Ephedrus* sp. in Zagazig region, Egypt during 2006-07 and 2007-08.

Weather variables	*Ephedrus* sp.				*D. rapae*			
	2006-2007		2007-2008		2006-2007		2007-2008	
	r ± SE	P	r ± SE	P	r ± SE.	P	r ± SE	P
Minimum Temp.	-0.5492±0.1970	*	-0.7926±0.1330	**	-0.4221±0.2137	ns	-0.8096±0.1281	**
Maximum Temp.	-0.6993±0.1685	**	-0.7923±0.1331	**	0.5011±0.2040	*	-0.8370±0.1194	**
Mean Temp.	-0.6425±0.1806	**	0.7881±0.1343	**	-0.4248±0.2134	ns	-0.8320±0.1211	**
Minimum RH	0.3702±0.2190	ns	0.2925±0.2087	ns	0.4755±0.2074	*	0.5099±0.1877	*
Maximum RH	0.2709±0.2270	ns	-0.0919±0.2173	ns	0.01717±0.2357	ns	0.0167±0.2182	ns
Mean RH	0.2186±0.2300	ns	0.4367±0.1963	*	0.3991±0.2161	ns	0.3512±0.2043	ns

correlation. The mean relative humidity showed a significant positive correlation (0.4367*) in the second season (Table 4). On the contrary to the present results, Saleh (2000) mentioned that a non-significant correlation with temperatures and relative humidity occurred on the population density of *Ephedrus* sp. in relation to *A. craccivora*

2. *D. rapae*:

In 2006-07 season, the maximum temperature and the minimum relative humidity showed significant positive correlations with population density of *D. rapae*. Meanwhile, in the second season, the temperature (minimum, maximum and mean) exhibited significant negative correlation (Table 4). Whereas, the minimum relative humidity showed a significant positive correlation with the population density (r= 0.5099*).

In contrast to the present results, Saleh (2000) showed that the mean combined effect of temperature and relative humidity was lower than their single effect on the population density of *D. rapae* in relation to *A. craccivora.*

As shown in Table (5), population of each of the two parasitoids *D. rapae* and *Ephedrus* sp. had negative correlations with that of *A. craccivora* but the correlation coefficient value was mostly non significant, it was only significant in case of *D. rapae* in 2006-07 faba bean season in relation to *A. craccivora.*

Table (5): Correlation coefficient values between *Aphis craccivora* and two aphid parasitoids in Zagazig region during the two broad bean seasons 2006-07 and2007-08.

Aphid	Parasitoids	Corr. (r S.E)	Slope	Y Inta	Significance
		2006-07 season			
Aphis craccivora	*D. rapae*	-0.5756±0.0034	0.0136	28.6077	*
	Ephedrus sp.	-0.3285±0.0098	0.0067	15.0579	ns
		2007-08 season			
	D. rapae	-0.2036±0.1944	0.0204	34.1169	ns
	Ephedrus sp.	-0.1233±0.0065	0.0115	11.4969	ns

2. Biological studies

2.1. Life cycle of *D. rapae* and *Ephedrus* sp. on *A. craccivora.*

Results in Table (6) showed that the temperature played an important role influencing the period of development of *D. rapae* and *Ephedrus* sp. on *A. craccivora.* Generally, developmental periods of different stages of parasitoids shortened as the temperature increased from 10 to 28 °C. At 10 °C, the incubation period of egg averaged 6.95 and 8.29 days in *D. rapae* and *Ephedrus* sp., respectively. Larval period averaged 9.89 and 10.66 and pupal stage recorded 10.32 and 11.53 days, respectively. The total developmental periods of the two parasitoids lasted 27.16 and 30.48 days, respectively.

At 15 °C, the incubation period of eggs, larval and pupal stages of *D. rapae* and *Ephedrus* sp. averaged of 3.87 & 4.08, 6.63 & 7.31 and 6.25 & 6.99 days, respectively. The total averages for developmental period of the two parasitoids recorded 16.75 and 18.38 days, respectively. Correspondent periods at 28 °C, were 2.33 & 2.44, 4.53 & 5.05 and 4.31 & 4.89 days. The averages of total developmental period of the two parasitoid species lasted 11.17 and 12.38 days, respectively (Table 6). These results agree with those of Ragab *et al.* (2002a) who reported that *D. rapae* completed its life cycle in a period of 11-15 days, with an average 11.93 days on *A. craccivora* at 19.5 °C. According to Contreras *et al.* (1996), the total developmental time of *Ephedrus plagiator* was 14-16 day, with an average of 15.31 days on *S. avenae* on wheat plants.

Longevity of adult aphidiids is affected by many factors such as; temperature, humidity, adult food, presence or absence of hosts, etc. (Stary 1970). The results showed that the adult longevity was longest at 10 °C, and also that of females was longer than males at the three temperatures (10, 15 and 28 °C). Recorded longevities of males and females were 7.3 & 10.01, 3.67 & 4.89 and 1.61 & 2.78 days at the three temperatures, respectively (Table, 6).

Table (6): Developmental periods of immature stages and longevity of adults (in days) of the two parasitoids *Ephedrus* sp. and *D. rapae* on *A. craccivora* infesting broad bean plants at 10, 15 and 28 °C and 63 ± 5 % RH.

Temp. °C	Parasitoids Stage	*Ephedrus* sp. Duration mean ±S.E	*Ephedrus* sp. Longevity Female	*Ephedrus* sp. Longevity Male	*D. rapae* Duration mean ±S.E	*D. rapae* Longevity Female	*D. rapae* Longevity Male
10	Egg	8.29a±0.69	8.90±0.36	5.64±0.25	6.95a±0.76	10.01±0.13	7.30±0.56
	Larva	10.66a±0.64			9.89a±0.69		
	Pupa	11.53a±0.46			10.32a±0.38		
	Total (egg-adult)	30.48a±0.59			27.16b±0.61		
15	Egg	4.08a±0.51	4.86±0.25	3.09±0.27	3.87a±0.46	4.89±0.41	3.67±0.21
	Larva	7.31a±0.49			6.63a±0.54		
	Pupa	6.99a±0.58			6.25a±0.49		
	Total (egg-adult)	18.38a±0.53			16.75a±0.52		
28	Egg	2.44a±0.24	2.29±0.22	1.44±0.37	2.33a±0.35	2.78±0.72	1.61±0.38
	Larva	5.05a±0.35			4.53a±0.44		
	Pupa	4.89a±0.29			4.31a±0.36		
	Total (egg-adult)	12.38a±0.26			11.17a±0.38		

Sex ratio

A total number of 386 *D. rapae* adults emerged from 517 *A. craccivora* individuals. That means the percentage of parasitoid adult emergence was 74.73%. Females were 203 and males 183 indicating sex ratio of 1.1 female: 1 male. Meanwhile, a number of 238 *Ephedrus* sp. adults emerged from 345 *A. craccivora* mummies showing 68.99 % emergence. The number of females was 123 and that of males was 115. The sex ratio was 1.069 female: 1 male.

These results agree with those of Saleh (2000) who recorded that the percentage of *D. rapae* adult emergence was 76.76 % and sex ratio was 1.168 female: 1 male.

In conclusion, results obtained in this study revealed that, relatively, low percentage of parasitism of *D. rapae* and *Ephedrus* sp. on *A. craccivora* infesting broad bean leaves in Sharkia governorate (8.17 and 6.45 % in 2006/07 and 2007/08 seasons, respectively). These low percentages are supposed to be increased by mass production and releasing these parasitoids. Data showed also that temperature and relative humidity had considerable effects on changes in the population of *A. craccivora*, *D. rapae* and *Ephedrus* sp.

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