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Evaluating the Role of *Diaeretiella rapae* (M' Intosh) (Hymenoptera: Aphidiidae) Parasitizing the Cabbage Aphid, *Brevicoryne brassicae* L. (Homoptera: Aphididae) at Sharkia Governorate, Egypt

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ABSTRACT

Rate of parasitism by *Diaeretiella rapae* (M' Intosh) on the cabbage aphid, *Brevicoryne brassicae* L., as well the hyperparasitism at Kafer Sakr district, Sharkia Governorate, Egypt for the four seasons 2005-06 - 2008-09 was recorded. Total means of parasitism rates with *D. rapae* were 29.87, 36.44, 25.74 and 37.64 % during the four seasons, respectively. Respective total means of percentage adult emergence were 82.74, 80.09, 81.71 and 81.81 %. Two hyperparasitoid species; *Pachyneuron* sp. and *Alloxysta* sp. were recorded on *D. rapae*. Seasonal means of hyperparasitism percentage were 4.84, 3.53, 5.68 and 3.40 % in the four seasons, respectively. *D. rapae* abundance was negatively correlated with temperature in the four seasons. Also, *D. rapae* had significant negative correlations with the host. Parasitoid density in relation to host density had influenced percentage of parasitism. Highest percentage reached 91.40 % at 16 *D. rapae* female parasitoids per cage while the minimum was 55.6 % at one female per cage. Sex ratio (females: males) was 1.7:1. By rearing the parasitoid for five successive generations, sex ratio was almost 1:1 in the first three generations, but males dominated in the 4th and 5th generations.

Key words: *Diaeretiella rapae, Brevicoryne brassicae,* evaluation, parasitism, hyperparasitism, Egypt.

INTRODUCTION

The aphid *Brevicoryne brassicae* L. is a major pest, on cruciferous plants, in several parts of the world, especially cabbage in Egypt (Herakly and Abou El-Ezz, 1970 and Saleh, 2000). The parasitoid *Diaeretiella rapae* was found to parasitize *B. brassicae* and some other aphid species allover the world (Hafez, 1965, Abou Fakar and Kawar, 1998 and Saleh, 2008). *D. rapae* is attacked by hyperparasitoids that reduce its efficient role. Recorded hyperparasitoids on *D. rapae* in Egypt were; *Pachyneuron* sp. and *Alloxysta minuta* (Hafez, 1965, Herakly and Abou El Ezz, 1970, El-Maghraby, 1993 and Saleh, 2008).

The present study aims to highlight the role of primary and hyperparasitoid species associated with *B. brassicae* infesting cabbage.

MATERIALS AND METHODS

1- Estimation of parasitism rates in the field:

This work was carried out on cabbage plants cultivated in about two feddan area, located at Kafr-Sakr district, Sharkia Governorate, Egypt, for four cabbage seasons; 2005-06 - 2008-09. Random samples of five infested cabbage leaves/ sample were picked weekly, placed into plastic bags and transferred to the laboratory. All aphid individuals in an area of 20 square inches/ leaf were counted. Aphids were fed on their host plant and kept in Petri dishes (50 aphid individuals /Petri-dish) until formation of mummies. The mummies were isolated and kept in small glass tubes until emergence of adult parasitoids. At the same time, hyperparasitoid adults emerged from mummies, were classified, counted and their percentages were also calculated. Emerged parasitoids were mounted and identified at the Biological Control Department, ARC, Giza, Egypt. Percentage of parasitism was calculated as monthly means according to Ferrell and Stufkens (1990) also, percentage of adult's emergence and sex-ratio were calculated. Daily records of both minimum and maximum temperatures along with relative humidity throughout the four seasons were obtained from the Agrometereological Station at Zagazig region. Correlation between weekly average numbers of *B. brassicae, D. rapae* and corresponding weekly means of temperature and relative humidity were estimated.

2- Effect of parasitoid densities on parasitization rate:

D. rapae and *B. brassicae* were reared in the laboratory. Young potted cabbage seedlings bearing about 200 hosts (mixed ages) were used. The experiments were carried out in iron cages (200 x 50 x 50 cm) using different densities of the parasitoid; 4, 8, 12 and 16 per cage, fresh emerged mated females were fed on honey solution. Mated female parasitoids were gently introduced into each cage and kept for 24h., then the parasitoids were removed and the hosts were left until they mummified. After mummification, the mummies were gently placed with parts of cabbage leaves, on a moisten filter paper in marked Petri dishes. The mummies were observed until the adults emerged, then sexed and recorded. Five replicates were performed for each parasitoid density.

3- Sex ratio

Sex-ratio of *D. rapae* reared on third nymphal instar of *B. brassicae* was calculated. The culture was reared for up to five generations. Sex-ratio was determined depending as females: males emerged from the total number of aphid mummies (in the field and in the laboratory five generations). Also, percentages of adult's emergence were calculated.

Costat Software program (1990) was applied for statistical analysis of data.

RESULTS AND DISCUSSION

1- Estimation of parasitism rate in the field:

Data in (Tables 1&2) indicate that *B. brassicae* was the dominant aphid species infesting cabbage plants in the experimental area. Seasonal means of the aphid's counts were 499.6, 508.5,470 and 496.4 individuals/20 inch^2 of cabbage leaf during the four seasons, respectively. *D. rapae* was the single primary parasitoid species emerged from *B. brassicae* mummies. As well, two hyperparasitoid species; *Pachyneuron* sp. and *Alloxysta* sp. were also recorded during the period January- March in the four seasons (Table 1). Percentages of parasitism ranged between 2.97 - 62.18, 5.27 - 72.71, 20 - 55.45 and 6.61 - 76.77 % in 2005/06, 2006/07, 2007/08 and 2008/09 seasons, respectively. The mean percentages of parasitism were; 29.87±10.12, 36.44±8.31, 25.74±7.66 and 37.64±8.27 %, respectively and the mean numbers of adult emergence were 82.09±2.32, 77.99±2.89, 80.01±2.6 and 81.48±1.86 in the four seasons, respectively.

Ratio between mummies: aphids were 1:3.85, 1:3.01, 1: 4.48 and 1:2.84 in the same respective seasons (Tables 1& 2). According to Herakly and Abou El-Ezz (1970), Bueno & Souza (1992), El-Maghraby (1993) and Saleh (2000 & 2008) *D. rapae* is the primary parasitoid of *B. brassicae*. *Pachyneuron aphidis* and *Alloxysta* sp. were reported as hyper parasitoids on *D. rapae* by Thakur *et al.* (1989), Kolaib (1991) Bueno & Souza (1992) and Saleh (2008). On the other hand, Bahana and Karuhize (1986) mentioned that percentage of parasitism on *B. brassicae* by *D. rapae* in Kenya ranged from 27.1 to 76.1%.

Table (3) shows simple correlation coefficient values between temperature& relative humidity and the population density of *B. brassicae* during the four seasons of study. Minimum temperature, minimum relative humidity and mean relative humidity exerted highly significant positive correlations in 2005-06. Meanwhile, maximum relative humidity showed a significant positive correlation in the second season. In 2007/08 season, temperature and relative humidity showed insignificant negative correlations. Meanwhile, the minimum and mean temperature showed significant positive correlations on the population density of *B. brassicae*.

Table (4) shows the simple correlation coefficient values between temperature & relative humidity and the population density of *D. rapae* during the four seasons of study. Maximum temperature showed a significant positive correlation; meanwhile, minimum temperature, R.H. and mean relative humidity exerted highly significant negative correlations in the first season 2005-06. In the second season, temperature showed a significant negative correlation. Meanwhile in the third season, minimum temperature showed a significant negative correlation, but maximum relative humidity showed a significant positive correlation. On the other hand, minimum and mean temperature exerted a highly significant negative correlation, while maximum and mean relative humidity showed significant positive correlations, on the population density of *D. rapae* in the last season 2008-09.

Data in Table (5) summarize the correlations among temperature, relative humidity and the population density of *B. brassicae* and *D. rapae* during the four seasons of study.

B. brassicae

In the first season 2005-06, minimum relative humidity showed a significant positive effect on the population density of *B. brassicae* but, the mean relative humidity exerted a highly significant positive effect. On the other hand, the minimum and mean relative humidity cleared significant positive effects on *B. brassicae* in the second season 2006-07. In the third season, 2007-08, the maximum temperature, maximum and mean relative humidity cleared highly significant positive effect on the numbers of *B. brassicae*. In the last season, 2008-09, temperature showed a highly significant positive effect on the population density of *B. brassicae* (Table 5).

D. rapae

In the first season 2005-06, maximum, mean temperatures and maximum relative humidity cleared highly significant correlations, but minimum temperature and mean relative humidity showed significant positive effects on the numbers of *D. rapae*. In 2006-07, the temperature and mean relative humidity cleared a significant positive effect on the population density of *D. rapae*. Meanwhile, in 2007-08, the maximum temperature cleared a significant positive effect, while maximum and minimum relative humidity cleared highly

Table (1): Monthly mean percentages of parasitism on *B. brassicae* by *D. rapae* on cabbage plants at Sharkia Governorate, Egypt during the four successive seasons 2005/ 06- 2008/ 09.

Sampling dates	No. of aphids	No. of mummies			% Parasitism	*D. rapae*		*Pachyneuron* sp.		*Alloxysta* sp.	
		A	B	Total		*N.*	*R.D%*	*N.*	*R.D%*	*N.*	*R.D%*
Means	499.6	88.8	41	129.8	29.87±10.12	100.4	95.15	5	3.40	2	1.44
Means	508.5	130.7	38.5	169.2	36.44±8.31	129	96.47	6	2.08	2.7	1.45
Means	470	66.6	38.8	105.4	25.74±7.66	53.4	94.32	5.2	4.12	2	1.56
Means	496.4	99.4	75.4	174.8	37.64±8.27	136.8	96.69	3.6	1.89	2.6	1.51

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

Table (2): Mean seasonal percentages of parasitism and adults' emergence of *D. rapae* on *B. brassicae* on cabbage plants at Sharkia Governorate, Egypt during the four successive seasons 2005/ 06- 2008/ 09.

Seasons	No. of samples	Total numbers of aphids (Mean± S.E.)	Mean number of mummies	Ratio of mummies: aphid	Percentages of parasitism %		Mean number of adult emerged	Percentage of adult emergence % (Mean ± S.E.)
					Minimum	Maximum		
2005-06	17	499.6±61.70	129.8±33.29	1:3.85	2.97	62.18	107.4±27.34	82.74±2.32
2006-07	22	508.5±42.84	169.17±29.57	1:3.01	5.27	72.71	135.5±26.45	80.09±2..89
2007-08	18	470.0±52.67	105±19.52	1:4.48	3.20	55.45	85.8±17.83	81.71±2.60
2008-09	18	496.4±38.22	174.8±28.12	1:2.84	6.61	76.77	143.0±23.88	81.81±1.86

Table (3): Simple correlation coefficient among temperature, relative humidity and the total numbers of *B. brassicae* at Sharkia Governorate, Egypt during the four seasons 2005/06- 2008/ 09.

Weather factors	Corr. (r) ±S. E.	Slope (b)	S	Corr. (r) ±S. E.	Slope (b)	S
	2005-06			2006-07		
Mean temp.	-0.3005±0.5506	-0.1002±0.1836	ns	0.2979±0.4773	0.8101±0.1298	ns
Mean R. H%.	0.9092±0.2403	0.2409±0.6369	**	0.2928±0.4781	0.1154±0.1883	ns
	2007-08			2008-09		
Mean temp.	-0.0971±0.5746	-0.3092±0.1829	ns	0.4644±0.5113	0.1451±0.1597	*
Mean R. H.%	-0.0674±0.5760	-0.1975±0.1688	ns	-0.1996±0.5657	-0.4704±0.1333	ns

Corr. =Simple correlation S.E. = Standard error S= Significance

Table (4): Simple correlation coefficient among temperature, relative humidity and the total numbers of *D. rapae* at Sharkia Governorate, Egypt during the the four seasons 2005/ 06- 2008/ 09.

Weather factors	Corr. (r) ±S. E.	Slope (b)	S	Corr. (r) ±S. E.	Slope (b)	S
	2005-06			2006-07		
Mean temp.	0.31186±0.5473	0.5729±0.9843	ns	-0.6599±0.3757	-0.1238±0.7052	*
Mean R. H%.	-0.8188±0.3314	-0.1171.0.4739	**	0.2471±0.4844	0.6718±0.1317	ns
	2007-08			2008-09		
Mean temp.	-0.0651±0.5761	-0.7679±0.6795	ns	-0.6776±0.4245	0.1557±0.9757	**
Mean R. H.%	0.3907±0.5314	0.4244±0.5773	ns	0.4853±0.5048	0.8413±0.8752	*

Corr. = Simple correlation S.E. = Standard error S= Significance

Table (5): Numerical relation between temperature, relative humidity and the total numbers of *B. brassicae* and *D. rapae* at Sharkia Governorate, Egypt during the four seasons 2005/06-2008/09.

Weather factors	Regression equation (*B. brassicae*)							
	R^2	S	R^2	S	R^2	S	R^2	S
	2005-06		2006-07		2007-08		2008-09	
Mean temp.	0.6685	*	0.2519	ns	0.3292	ns	0.9157	**
Mean R. H.%.	0.9939	**	0.4788	*	0.0095	ns	0.2329	ns
	Regression equation (*D. rapae*)							
Mean temp.	0.9521	**	0.6072	*	0.2879	ns	0.6344	*
Mean R.H.%.	0.6755	*	0.6326	*	0.1527	ns	0.4972	*

R^2 = Regression equation S= Significance

Table (6): Correlation coefficient values between *B. brassicae* and aphid parasitoid *D. rapae* on cabbage plants at Sharkia Governorate, Egypt during the four seasons 2005/06-2008/09.

Aphid	Parasitoid	Correlation (r± S. E.)	Slope (b)	S	Correlation (r ± S. E.)	Slope (b)	S
		2005-06			2006-07		
B. brassicae	*D. rapae*	**-0.6783±0.4261**	**-0.3642±0.2299**	*	-0.6966±0.3587	-0.4806±0.2475	*
		2007-08			2008-09		
		-0.9381±0.2000	-0.3476±0.0741	**	-0.8399±0.3133	-0.6179±0.2304	**

S = Significance S. E. = Standard error

Table (7): Effect of parasitoid density on the number of mummies, percentage of parasitism and adult emergence in the laboratory under 20±1 °C and 74±3% R.H.

Parasitoid density	Mean ± SD				
	No. of mummies	No. of emerged adults	No. of non emerged adults	Percentage of parasitism	Percentages of adult emergence
4 ♀	112.2d±4.02	85.4c±2.67	**25.8c±1.98**	55.6d±2.01	**76.88a±1.21**
8 ♀	148.00c±3.87	110.6b±2.69	**37.4b±1.91**	74.0c±1.93	**74.76b±0.91**
12 ♀	171.4b±2.08	**130.2a±1.28**	41.2ab±1.77	85.7b±1.04	75.99ab±0.81
16 ♀	**182.8a±3.49**	136.4a±5.83	46.4a±3.30	91.4a±1.75	74.52b±1.99
F. value	83:5661***	42.0239***	14.1099***	**83.5660*****	3.6469*
$LSD_{0.05}$	10.3681	10.6228	**6.9828**	5.1840	1.883

Means followed by the same letter in a column are not significantly different at 5% level of probability.

Table (8): Sex ratio and percentage of adult emergence of *D. rapae* when parasitized *B. brassicae* in the fields at Sharkia Governorate, Egypt and in different laboratory reared generations.

Source parasitoid		Total number of mummies	Number of adults emerged	Number ♀	Number ♂	Sex ratio Male: Female	Percentage of adult emergence
In the field		774	632	401	231	1:1.74	81.65[a]
Generations	One	423	335	183	152	1:1.204	79.19[b]
	Two	337	233	122	111	1:1.099	69.14[c]
	Three	337	217	109	108	1 : 1	64.39[d]
	Four	252	111	44	67	1.52:1	44.05[e]
	Five	228	82	30	52	1.73:1	35.96[f]

Means followed by the same letter in a column are not significantly different at 5% level of probability

significant positive effects. In the last season 2008-09, the maximum temperatures cleared highly significant positive effect while, the minimum, mean temperature, minimum and mean relative humidity cleared significant positive effects on the population density of *D. rapae* (Table 5).

According data in Table (6), population density of the parasitoid *D. rapae* had a significant negative correlation with that of *B. brassicae* in the two seasons 2005-06 and 2006-07, highly significant negative correlation was detected in the two seasons 2007-08 and 2008-09.

In this respect, El- Maghraby (1993) reported that temperature and relative humidity play a great role in regulating the population density of *B. brassicae.* Saleh *et al.* (2006) mentioned that temperature and relative humidity showed insignificant effect on the role of *D. rapae* when parasitized *Hyalopterus pruni.* Also, Saleh *et al.* (2009) stated that the maximum temperature and minimum relative humidity had positive significant effects on the parasitoid when parasitized *Aphis craccivora.*

2- Effect of parasitoid densities on parasitization rate:

Table (7) shows that the parasitoid density had influenced the percentage of parasitism. Maximum percentage was 91.40 % for *D. rapae* kept at rate of 16 parasitoid females per cage and the minimum was 55.60% at one parasitoid per cage. There were significant differences in the total numbers of mummies and the total percentage of parasitism at all densities. Highest percentage of adult's emergence was 76.88% for *D. rapae* at one parasitoid per cage. These findings agree with that of (Sinha and Singh 1979, Ragab and Ghanium 1997 and El- Naggar *et al.* 2008).

Table (8) shows the sex ratio and percentages of adult emergence of *D. rapae* in the field and in different laboratory generations. In the field, the percentage of adult emergence was 81.65 %, with a sex ratio of 1.74 female: 1male. In the laboratory generations, percentage of adult emergence was 79.19%, with a sex ratio of 1.204 female: 1 male, 69.14%, with a sex ratio of 1.099 female: 1 male, 64.69%, with a sex ratio 1 female: 1 male, 44.05%,

with a sex ratio of 1 female: 1.52 male and 35.96 %, with a sex ratio of 1 female: 1.73 male in the first, second, third, fourth and fifth generations, respectively.

In conclusion, by increasing generations, percentage of adult emergence decreased and number of males increased. Saleh (2000) recorded a sex ratio of 1 male: 1.023 female when *D. rapae* was reared on *B. brassicae* and 1 male: 1.168 female when it was reared on *A. craccivora*. Kumar *et al.* (1988) found that the presence of male parasitoid caused a significant decrease in the emergence of F1 generation of *Trioxys indicus*.

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