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Performance of the Aphid Parasitoid, *Diaeretiella rapae* (M'Intosh) towards Certain Aphid Species in Egypt

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ABSTRACT

Survey and population of the aphid species *Brevicoryne brassicae* L., *Aphis craccivora* (Koch), *Aphis nerii* Boyer de Fonscolombe., *Hyalopterus pruni* (Geoffroy) and *Hypermoyzus lactucae* L. and its parasitoids were studied at Kafr Saqr district during two successive seasons 2011-2013. Obtained results and showed that *Diaeretiella rapae* (M'Intosh) was the dominant on aphid species in this study, where it occupied 81.79, 55.25, 51.20, 54.95% and 86.94, 63.77, 52.61, 52.53% on aphid species, *B. brassicae, A. craccivora, A. nerii* and *H. pruni* during the two seasons, respectively. The mean percentages of parasitism were 39.32, 9.14, 16.08, 4.66 and 43.45, 8.68, 13.22, 5.37 on the same aphid species on cabbage, faba bean, dafla and reed plants in both seasons, respectively. Total developmental times (Sting-Adult) were 15.58±0.69, 12.17±0.75, 17.52±0.70 and 15.37±0.71 days. Sex ratio were (Female:Male) 1.2:1, 1.07:1, 1.014:1 and 1:1.09 on last aphid species, respectively during the two seasons. A significant positive relationship was found between higher parasitism percentages of *D. rapae* and higher nutrient composition of both total lipids and free amino acids in tested aphids.

Key words: *Diaeretiella rapae*, aphids, survey, biology, physiology

INTRODUCTION

Aphids are one of the insect groups whose economic importance increases with development of agriculture. The parasitoid *Diaertiella rapae* (Hymenoptera: Aphidiidae) was considered by several authors to be important in the control of the cabbage aphid, *Brevicoryne brassicae* (Hagvar and Hofsvang, 1991). Biological control is satisfactory program in an integrated pest management. Control of insect pests by parasitoids is defined as the action of parasitoids that maintains a pest population at a lower level. Parasitism of aphid has been shown to be density dependent (Walker *et al*., 1984).

Diaeretiella rapae is an important primary parasitoid of a wide range of aphid species including major aphid pests such as cabbage aphid, *B. brassicae* L., green peach aphid, *Myzus persicae* Sulzar, Russian wheat aphid, *Diuraphis noxi*a Mord, cotton aphid, *Aphis gossypii* (Glover), bird cherry-oat aphid, *Rhopalosiphum padi* L. and corn leaf aphid, *Rhopalosiphum maidis* (Fitch), cowpea aphid, *Aphis craccivora* Koch., reed plants aphid, *Hyalopterus pruni* (Geoffroy) and oleander aphid, *Aphis nerii* Boyer de Fonscolombe (El-Maghraby 1993; Elliot *et al*., 1994; Pike *et al*., 1999; Saleh *et al*., 2009a; Saleh, 2012). *Diaeretiella rapae* is well known as a potential bio-agent for many aphid species in different countries (Zaki *et al*., 1999; Maghraby, 2012). Several hypotheses concerning the apparent adaptive significance of such effects of parasitoids can be proposed. For example, a paralyzed host may exhibit reduced defensive capabilities and also

reduced tissue uptake of haemolymph nutrients, thereby providing a greater supply of nutrients for parasitoid (Vinson and Iwantsch, 1980). Therefore, the present research dealt with the following points:

- Survey and population density of certain aphids (*B. brassicae, A. craccivora, A. nerii* and *H. pruni*) and estimation the percentage of parasitism during the two seasons 2011-2013
- Studying the biological aspects, host suitability, physiology of the most aphid parasitoid, *D. rapae* on certain aphid species
- Performance of parasitoid *D. rapae* and the biology on certain aphid species on both laboratory and field

MATERIALS AND METHODS

Survey of parasitoids and estimation of parasitism rate in the field on certain aphid species: To survey the aphid parasitoids, random samples of the following aphid species *B. brassicae, A. craccivora, A. nerii* and *Hyalopterus pruni* were collected from different host plants cultivated at the experimental farm located at Kafr Sakr District, Sharkia Governorate, Egypt during the two successive seasons, 2011-2013. These host plants were cabbage, faba bean, reed plants (Hagna) and Dafla, which were kept free from any pesticide application. Weekly samples were chosen from heavily infested plant parts with the previous aphid species collected. Infested plant parts were placed in tight closed paper bags and transferred to the laboratory, the size of samples of each crop were as follows: from cabbage seven leaves, each of about 20 inch^2, from faba bean 20 leaves and from reed plant (Hagna) and Dafla fifteen leaves. All individuals from each aphid species found on the host plant samples 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 Farrell and Stufkens (1990) also sex ratio was calculated.

Biology

Life cycle: A laboratory culture of the aphid species (*B. brassicae, A. craccivora, A. nerii, H. pruni* and *Hyperomyzus lactucae* L.) were maintained under laboratory conditions. Fifty nymphs, almost 3rd nymphal instars from the last aphid species were placed on the last host plants under small cages (10 replicates/treatment). In each cage or jar, aphids were exposed to five mated females for 2 h. Afterwards, parasitoid females were removed and then the cages or jars were placed in the laboratory at 21±1°C and 68±5% R.H. to determine the durations of different parasitoid stages (egg-mummy, mummy-adult and egg-adult). Parasitized aphids were dissected daily by a very fine needle, in a drop of ringer's solution.

Host preference: The experiment was carried out under laboratory conditions of 21.0±1°C and 68.0±5% R.H. the aphid species tested were *B. brassicae, A. craccivora, A. nerii, H. pruni* and *H. lactucae*. Five mated females of *D. rapae* were exposed to 150 aphids, almost 3rd nymphal instars. The experiment was replicated five times in plastic jars. The experiments of host suitability

were examined and counts of aphid mummies, no. of emerged adults and no. of non emerged mummies were recorded. The percentages of parasitism were calculated.

Biochemical assessment: Sample preparation included 150 apterous adult use of each aphid species was assembled and placed in clean jars. Apterous adults were homogenized for 3 min. In distilled water (150 adults 5 mL^{-1}) using a teflon homogenizer surrounded with a jacket of crushed ice. The homogenates were centrifuged at 3500 r.p.m for 10 min at 5°C to remove the haemocytes. The samples were divided into three small portions and kept in deep freezer at (-20°C) until required. The supernatant were immediately assayed to determine total soluble protein, total carbohydrate and free amino acid. The haemolymph was assayed to determine total lipids:

- **Determination of total soluble protein colorimetric:** Determination of total soluble protein in homogenized aphids was carried out at as described by Gornall *et al.* (1949):
- **Determination of total lipids:** Total lipids were estimated by the method of Knight *et al.* (1972)
- **Free amino acids determination:** Total amino acids were calorimetrically assayed by ninhydrin reagent according to the methods described by Lee and Takahashi (1966)
- **Total carbohydrates:** Total carbohydrates were estimated through acid extract of aphids by the phenol-sulphuric acid reaction of Dubois *et al.* (1956). Total carbohydrates were extracted and prepared for assay according to Crompton and Birt (1967)

Statistical analysis: The significance of the main effects was determined by analysis of variance (ANOVA). The significance of various treatments was evaluated by Duncan's multiple range test ($p<0.05$) (Snedecor and Cochran, 1980). Data were subjected to statistical analysis using a software package CoStat Statistical Software (2005). A product of Cohort Software, Monterey, California.

RESULTS

Survey of aphid parasitoids on certain plants

Cabbage aphid: (*B. brassicae*):
Primary parasitoids: *Diaeretilla rapae* (Mcintosh)
Secondary parasitoids: *Pachyneuron* sp. and *Alloxysta* sp.

Faba bean aphid (*A. craccivora*):
Primary parasitoids: *D. rapae, Ephedrus persicae* Frogatt and *Trioxys* sp.
Secondary parasitoids: *Aphidencyrtus* sp.

Oleander aphid (*A. nerii*):
Primary parasitoids: *D. rapae, Aphidius matricariae* Hal. and *Aphelinus* sp.
Secondary parasitoids: *Pachyneuron* sp., *Alloxysta* and *Aphidencyrtus* sp.

Hagna aphid (*H. pruni*):
Primary parasitoids: *D. rapae, Aphidius colemani* Viereck and *Aphelinus* sp.

Role of *D. rapae* for controlling *B. brassicae*, *A. craccivora*, *A. nerii*, *H. pruni* on

***B. brassicae*:** The primary parasitoid *D. rapae* was the demonstrate species with high relative densities during the two successive seasons. The highest total percentage of parasitism was 83.4% in the fourth week of February in the first season and 91.21% in the second week of March on cabbage in the second season. Seasonal means of the aphid's count were 447±32.39 and 444±48.26 while the mean percentages of parasitism were 39.32±12.46 and 43.45±12.93 on cabbage during the two seasons, respectively (Table 1).

***Aphis craccivora*:** The primary parasitoid *D. rapae* was the highest relative densities (60.87 and 72.73%) during the third week of January and the second week of December during the both studied seasons, respectively. The mean relative densities was (55.25 and 63.77%) during the both seasons, respectively. The highest percentages of parasitism were 13.94% in the fourth week of January during the first season 2011-12 and 15.26% in the first week of March. Meanwhile, the mean percentages of parasitism were 9.14±4.78 and 8.2±4.42 during the two seasons, respectively (Table 2).

***Aphis nerii*:** The parasitoid *D. rapae* was the highest relative densities (61.91 and 62.50%) during the second week of November in the first season, while the first week of December in the second season, respectively. The mean relative densities were (51.20 and 52.61%) during both seasons, respectively.

***Hyalopterus pruni*:** The parasitoid *D. rapae* was the highest relative densities (66.67 and 83.3%) in the second week of October in the first season and the third week of October. The mean relative densities were (54.95 and 32.97%) during both seasons, respectively. The highest percentage of parasitism was 8.39% in the third week of February and 7.71 in the second week of March. The mean percentage of parasitism was 4.66±1.15 and 5.37±2.15 during the both seasons, respectively (Table 4).

Data in Table 5 indicated that the mean seasonal percentages of parasitism were ranged between 4.72-83.84, 2.58-13.94, 1.01-35.14, 2.22-6.36% and 4.01-91.21, 1.37-15.01, 1.85-40.78, 0.76-7.25% on *B. brassicae* (cabbage), *A. craccivora* (faba bean), *A. nerii* (Dafla) and *H. pruni* (Reed plant) during the two seasons, respectively. Ratio between mummies: aphids were 1:2.78, 1:12.23, 1:9.51, 1:23.18 and 1:2.61, 1:13.41, 1:10.84, 1:19.22 on the same last aphid species during 2011-2013 seasons, respectively.

Biology: Presented data included the life cycle, longevity and sex ratio of the parasitoid female on the aphid species *B. brassicae, A. craccivora, A. nerii, H. pruni* and *H. lactucae* under laboratory conditions. Females of *D. rapae* parasitized and developed to adults in all last aphid species except *H. lactucae*, they could not develop to adulthood in it.

Life cycle: Data presented in (Table 6) indicate life cycle of the parasitoid *D. rapae* on the tested aphid species *B. brassicae*, *A. craccivora*, *A. nerii*, *H. pruni*. Developmental time from (Sting-Mummy) were 11.6±0.62, 9.05±0.63, 12.37±0.84, 11.67±0.82 days, meanwhile, the period from (Mummy-Adult) lasted 4.42±0.67, 3.12±0.67, 5.15±0.33 and 3.70±0.43 days. On the other hand, total developmental times (Sting-Adult) were 15.58±0.69, 12.17±0.75, 17.52±0.70 and 15.37±0.71 days on last aphid species, respectively.

Table 1: Monthly percentage of parasitism of *Brevicoryre brassicae* by *Diaeretiella rapae* on cabbage plants at Sharqia Governorate during successive seasons 2011-2012 and 2012-2013

						Emerged parasitoids						
						Primary parasitoid		Hyper parasitoids				
	No. of	No. of mummies				*D. rapae*		*Pachyneuron* sp.		*Alloxysta* sp.		
Sampling date	examined aphids	A	B	Total	Parasitism (%)	No.	RD (%)	No.	RD (%)	No.	RD (%)	Total
Cabbage season 2011-2012												
Nov. 2011	514	15	20	35	6.81	27	100.00	0	0	0	0	27.0
Dec. 2011	481	49	38	87	18.09	69	100.00	0	0	0	0	69.0
Jan. 2012	499	133	52	185	37.07	130	83.38	15.0	9.67	10.0	6.45	155.0
Feb. 2012	393	180	68	248	63.10	143	75.26	27.0	14.21	20.0	10.52	190.0
Mar. 2012	348	193	56	249	71.55	131	76.61	24.0	14.04	16.0	9.35	171.0
Total	2235			804	196.62	500		66.0		46.0		612.0
Mean±SE	447±32.39			160.8±43.08	39.32±12.46	100	81.79	13.2	10.78	9.2	7.52	122.4
Cabbage season 2012-2013												
Nov. 2012	527	25	18	43	8.16	30	100.00	0	0	0	0	30.0
Dec. 2012	536	64	48	112	20.89	77	100.00	0	0	0	0	84.0
Jun. 2013	499	172	58	230	46.09	178	89.90	12.0	6.06	8.0	4.04	198.0
Feb. 2013	360	176	59	235	65.28	170	84.16	19.0	9.41	13.0	6.43	202.0
Mar. 2013	298	165	64	229	76.85	151	79.47	23.0	12.11	16.0	8.42	190.0
Total	2220			849	217.27	606		54.0		37.0		697.0
Mean±SE	444±48.26			169.8±39.17	43.45±13.39	121.2	86.94	10.8	7.75	7.4	5.31	139.4

A: No. of mummies counted at the date of inspection, B: No. of mummified host appeared during laboratory rearing, RD: Relative density, SE: Standard error

Table 2: Monthly percentage of parasitism of *Aphis craccivora* by *Diaeretiella rapae* on faba bean plants at Sharqia Governorate during successive seasons 2011-2012 and 2012-2013

						Emerged parasitoids								
						Primary parasitoid						Hyper parasitoids		
	No. of	No. of mummies				*D. rapae*		*Ephedrus persicae*		*Trioxys* sp.		*Aphidencyrtus* sp.		
Sampling data	examined aphid	A	B	Total	Parasitism (%)	No.	RD (%)	No.	RD (%)	No.	RD (%)	No.	RD (%)	Total
Faba bean season 2011-2012														
Oct. 2011	759	0	13	13	1.71	0	0	0	0	0	0	0	0	0
Nov. 2011	677	8	36	44	6.49	16	53.34	10	33.33	4	13.33	0	0	30
Dec. 2011	621	11	48	59	9.50	25	58.14	12	27.91	6	13.95	0	0	43
Jan. 2012	457	18	46	64	14.00	28	60.87	13	28.26	3	6.52	2	4.35	46
Feb. 2012	409	13	39	52	12.71	21	55.26	10	26.32	2	5.26	5	13.16	38
Mar. 2012	317	12	21	33	10.41	10	41.67	6	25.00	1	4.17	7	29.17	24
Total	3240			265		100	55.25	51	28.18	16	8.84	14	7.73	181
Mean±SE	540±70.0			44.1±7.68	9.14±4.78	16.6		8.5		2.6		2.3		30.03
Faba bean season 2012-2013														
Nov. 2012	676	0	8	8	1.18	8	100	0	0	0	0	0	0	8
Dec. 2012	581	5	29	34	5.85	16	72.73	5	22.73	1	4.54	0	0	22
Jan. 2013	553	18	40	58	10.49	28	63.64	9	20.45	4	9.09	3	6.82	44
Feb. 2013	430	15	34	49	11.39	20	60.61	7	21.21	2	6.06	4	12.12	33
Mar. 2013	389	18	29	47	12.08	16	51.61	5	16.13	4	12.9	6	19.36	31
Total	2629			196	8.2±4.42	88	63.77	26	18.84	11	7.97	13	9.42	138
Mean±SE	525.8±51.98				39.2±8.68		17.60		5.20		2.20		2.60	27.6

B: No. of mummified host appeared during laboratory rearingm RD: Relative density, SE: Standard error, A: No. of mummies counted at the date of inspection

Table 3: Monthly percentage of parasitism of *Aphis nerii* by *Diaeretiella rapae* on oleander plants (Dafla) at Sharqia Governorate during the two successive seasons 2011-2012 and 2012-2013

						Emerged parasitoid												
						Primary parasitoid						Secondary parasitoid						
Sampling	No. of	No. of mummies			Total	*D. rapae*		*A. matricariae*		*Aphelinus* sp.		*Pachyne-uron* sp.		*Alloxysta* sp.		*Aphidencyrtus* sp.		
date	examined aphid	A	B	Total	parasitism (%)	No.	RD (%)	No.	RD (%)	No.	RD (%)	No.	RD (%)	No.	RD (%)	No.	RD (%)	Total
2011-2012																		
Sep. 2011	1039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct. 2011	926	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov. 2011	619	9	19	28	4.52	13.0	61.91	8	38.09	0	0	0	0	0	0	0	0	21
Dec. 2011	562	20	28	48	8.54	19.0	57.58	11	33.33	3	9.09	0	0	0	0	0	0	33
Jan. 2012	509	49	38	87	17.09	30.0	51.72	18	31.03	7	12.07	2	3.46	1.0	1.72	0	0	58
Feb. 2012	421	58	49	107	25.42	38.0	50.00	23	30.26	9	11.84	3	3.95	2.0	2.63	1	1.32	76
Mar. 2012	318	66	63	129	40.57	46.0	55.42	18	21.69	5	6.03	7	8.43	4.0	4.82	3	3.61	83
Apr. 2012	286	50	43	93	32.52	24.0	39.34	13	21.31	7	11.48	9	14.75	6.0	9.84	2	3.28	61
Total	4680			429	128.60	170.0	51.20	91	27.41	31	9.34	21	6.33	13.0	3.92	6	1.80	332
Mean±SE	585±96.07			61.5±17.48	16.08±5.45	21.2		11.3		3.8		2.6		1.6		0.7		41.5
2012-2013																		
Oct. 2012	1107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov. 2012	961	0	13	13	1.35	8	100.00	0	0	0	0	0	0	0	0	0	0	8
Dec. 2012	719	15	33	48	6.68	20.0	62.50	8	25	3	9.38	1	3.12	0	0	0	0	32
Jan. 2013	582	37	45	82	14.09	29.0	50.88	17	29.82	6	10.53	3	5.26	2.0	3.51	0	0	57
Feb. 2013	489	60	51	111	22.69	33.0	50.77	12	18.46	9	13.85	5	7.69	4.0	6.15	2	3.08	65
Mar. 2013	403	76	63	139	34.49	41.0	47.13	15	17.24	11	12.64	10	11.49	6.0	6.89	4	4.60	87
Total	4261			393	79.3	131.0	52.61	52	20.88	29	11.65	19	7.63	12.0	4.82	6	2.41	249
Mean±SE	710.1±112.55			65.5±22.43	13.22±5.48	21.8		8.6		4.8		3.1		2.0		3		41.5

A: No. of mummies counted at the date of inspection, B: No. of mummified host appeared during laboratory rearing, RD: Relative density

Table 4: Monthly percentage of parasitism of *Hyalopterus purni* by *Diaeretiella rapae* on (Hagna) plants at Sharqia Governorate during two successive seasons 2011-2012 and 2012-2013

Sampling date	No. of examined aphid	No. of mummies			Total parasitism (%)	Emerged parasitoid						
						D. rapae		*Aphidius colemani*		*Aphelinus* sp.		
		A	B	Total		No.	RD (%)	No.	RD (%)	No.	RD (%)	Total
Season 2011-2012												
Sep. 2011	569	0	0	0	0	0	0	0	0	0	0	0
Oct. 2011	497	0	6	6	1.21	2	66.67	1	33.33	0	0	3
Nov. 2011	449	7	13	20	4.45	7	50.00	6	42.86	1	7.14	14
Dec. 2012	471	12	19	31	6.58	12	52.19	8	34.78	3	13.04	23
Jan. 2012	454	9	16	25	5.51	7	50.00	5	35.71	2	14.29	14
Feb. 2012	381	13	19	32	8.39	14	63.64	6	27.27	2	6.09	22
Mar. 2012	355	10	13	23	6.48	8	53.33	4	26.67	3	20.00	15
Total	3176			137	32.62	50	54.95	30	32.97	11	12.08	91
Mean±SE	453.7±26.91			19.5±4.61	4.66±1.15	7.1		4.2		1.5		13
Season 2012-2013												
Oct. 2012	573	6	4	10	1.75	5	83.30	1	17.70	0	0	6
Nov. 2012	458	8	11	19	4.15	8	61.54	5	38.46	0	0	13
Dec. 2012	576	14	18	32	5.56	11	50.00	8	36.36	3	13.64	22
Jan. 2013	491	10	20	30	6.11	9	47.37	6	31.58	4	21.05	19
Feb. 2013	448	12	19	31	6.92	11	52.38	7	33.33	3	14.29	21
Mar. 2013	415	15	17	32	7.71	8	44.44	8	44.44	2	11.12	18
Total	2961			154	32.2	52	52.53	35	35.35	12	12.12	99
Mean±SE	493.5±27.46			25.6±3.73	5.37±2.15	8.6		5.8		2		16.5

A: No. of mummies counted at the date of inspection, B: No. of mummified host appeared during laboratory rearing, RD: Relative density

Table 5: Mean seasonal percentage of parasitism of aphid parasitoids on certain aphid species on some plants at Sharqia Governorate during the two successive seasons 2011-2012 and 2012-2013

Host plants	Host aphid	No. of samples	Total No. of aphids	Mean No. of mummies	Ratio of mummies: Aphid	Percentages of parasitism	
						Min.	Max.
Season 2011-2012							
Cabbage	*B. brassicae*	20	447.00±32.39	160.62±12.46	1:2.78	4.72	83.84
Faba bean	*A. craccivora*	20	540.00±70.00	44.16±7.680	1:12.23	2.58	13.94
Dafla	*A. nerii*	27	585.00±96.07	61.50±17.48	1:9.51	1.01	35.14
Hagna	*H. pruni*	24	453.71±26.91	19.57±4.610	1:23.18	2.22	6.36
Season 2012-2013							
Cabbage	*B. brassicae*	19	444.00±48.26	169.80±39.17	1:2.61	4.01	91.21
Faba bean	*A. craccivora*	22	525.80±51.98	39.20±8.680	1:13.41	1.37	15.01
Dafla	*A. nerii*	24	710.17±112.55	65.50±22.43	1:10.84	1.85	40.78
Hagna	*H. pruni*	22	493.50±27.46	25.67±3.730	1:19.22	0.76	7.25

Longevity: From data presented in Table 6, it could be generally observed that adult females lived for a longer period than male ones.

Sex ratio: Data presented show the sex ratio of adult parasitoids of *D. rapae* in the two generations on the last aphid species its were (Female:Male) 1.2:1, 1.07:1, 1.1014 and 1.09:1 on *B. brassicae*, *A. craccivora*, *A. nerii* and *H. pruni*, respectively.

Table 6: Development time in days of the parasitoid *Diaeretiella rapae* on certain aphid species at 20± 1°C and 50 RH (%)

		Duration of life cycle (days)					
					Longevity		
Host plants	Host aphid	Sting-mummy (Mean±SD)	Mummy-adult (Mean±SD)	Total (sting-adult)	♀	♂	Sex ratio ♀♂
Cabbage	*Brevicoryne brassicae*	11.16±0.62^{ab}	4.42±0.67^{bc}	15.58±0.69^{b}	6.10±0.14	3.5±0.210	1.2:1
Faba bean	*Aphis craccivora*	9.05±0.63^{c}	3.12±0.67^{a}	12.17±0.75^{c}	4.96±0.33	3.36±0.18	1.07:1
Dafla	*Aphis nerii*	12.37±0.84^{a}	5.15±0.33^{b}	17.52±0.70^{a}	4.50±0.22	2.78±0.14	1.014:1
Reed plants	*Hyalopterus pruni*	11.67±0.82^{b}	3.70±0.43^{c}	15.37±0.71^{b}	5.01±0.13	3.24±0.43	1.09:1
Sowthstil	*Hypermoyzus lactucae*	0	0	0			
$LSD_{0.05}$		1.846	1.393	1.786			
p		0.0000***	0.0000***	0.0000***			

Data expressed as Mean±SD, *p≤0.05 **,***p≤0.01. Mean under each variety having different letters in the same raw denote a significant different (p≤0.05)

Table 7: Performance of the parasitoid *Diaeretiella rapae* towards certain aphid species under laboratory conditions 20±1 C and 68±5 % RH

H. aphid species	*B. brassicae*	*Aphis nerii*	*A. craccivora*	*H. pruni*	*Hypermoyzus lactucae*
No. of mummies/Jar	66.78±2.3^{a}	42.44±3.59^{b}	28.42±3.35^{c}	17.51±1.39^{d}	0
Parasitism (%)	44.52±1.54^{a}	28.29±2.40^{b}	18.95±2.23^{c}	11.79±2.06^{d}	0
Emergence (%)	81.42±1.73^{a}	61.25±2.94^{c}	73.48±1.53^{b}	57.05±3.35^{c}	0

Host preference: Data presented in (Table 7) indicated performance the parasitoid *D. rapae* towards certain aphid species under laboratory conditions. Total numbers of mummies were 66.78±2.3, 42.44±3.59, 28.42±3.35 and 17.52±1.39 on *B. brassicae*, *A. nerii*, *A. craccivora* and *H. pruni*, respectively. Statistical analysis of data showed significant differences among the parasitoid and aphid species at 20±1°C. highest percentage of parasitoid reached 44.52% at *B. brassicae* while the minimum was 11.79% at *H. pruni*. Aslo, the highest percentage of adult emergence was 81.42 on *B. brassicae* while the minimum was 57.05% on *H. pruni*.

Nutrient compounds of different aphid species: Data presented in (Table 8) show the level of total protein in the supernatant of the homogenated aphid species *Hypermoyzus lactucae* and *H. pruni* recorded the highest significant level (34.733±1.22 and 34.533±1.23 mg g^{-1} t. wt., respectively). While *B. brassicae* gave the lowest significant one (12.89±0.560 mg g^{-1} t. wt.), p = 0.0000.

Results also indicate significant increase in the total carbohydrate was regarded in the case of *H. pruni* (23.10±0.95 mg g^{-1}. t. wt). Reversely, *A. nerii*, *B. brassicae* and *A. craccivora* recorded the lowest significant reduction (10.73±0.45, 10.49±0.33 and 10.42±0.40 mg g^{-1}. t. wt., respectively p = 0.0000 (Table 8).

As for total lipids, *B. brassicae* manifested the highest significant level of total lipids (4.616±0.27 mg g^{-1} t. wt.) followed by *H. pruni* 1.573±0.09, *A. craccivora* 1.21±0.006, *Hypermoyzus lactucae* 1.143±0.04 and *A. nerii* 0.88±0.04 mg g^{-1}. t. wt.) p = 0.0000 (Table 8).

A. craccivora and *B. brassicae* produced the highest significant increase in free amino acids (4.266±0.15 and 1.65±0.09 mg g^{-1}. b.wt.), respectively (Table 8). On the other hand, *Hypermoyzus lactucae* recorded the least significant decrease (0.556±0.04 mg g^{-1} t. wt., p = 0.0000).

Table 8: Nutrient compounds of different aphid species

Species	Total protein (mg g^{-1} b.wt.)	Total carbohydrates (mg g^{-1} b.wt.)	Total lipids (mg g^{-1} b.wt.)	Free amino acids (mg g^{-1} b.wt.)
B. brassicae	12.896±0.56^{e}	10.49±0.33^{e}	4.616±0.27^{a}	1.65±0.09^{b}
H. pruni	34.533±1.23^{a}	23.10±0.95^{a}	1.573±0.09^{b}	0.596±0.06^{e}
A. craccivora	30.00±1.04^{b}	10.42±0.40^{e}	1.21±0.006^{bc}	4.266±0.15^{a}
A. nerii	32.033±0.98	10.73±0.45^{e}	0.88±0.04^{c}	0.726±0.01^{c}
H. lactucae	34.733±1.22^{a}	12.903±0.64^{b}	1.143±0.04^{c}	0.556±0.04^{c}
$LSD_{0.05}$	3.260	1.884	0.419	0.298
p	0.0000****	0.0000***	0.0000***	0.0000***

Data expressed as Mean±SD, *p≤0.05 **-***p≤0.01, mean under each variety having different letters in the same raw denote a significant different (p≤0.05)

DISCUSSION

In the current study, we found that the primary parasitoids associated with four aphid species in the field namely, *B. brassicae, A. craccivora, A. nerii, H. pruni*. These species infested cabbage, faba bean, Dafla and reed plants (Hagna). The results indicated those three aphids parasitoids were emerged from the mummified aphids of *B. brassicae* namely; *D. rapae*, *Pachyneuron* sp. and *Alloxysta* sp. Four aphids parasitoids were emerged from the mummified aphids of *A. craccivora* namely; *D. rapae*, *Ephedrus persicae*, *Trioxys* sp. and *Aphidencyrtus* sp. *Aphis nerii* was the dominant aphid species infesting Dafla plants. Six aphids parasitoids were emerged from its mummies namely; *D. rapae, Aphidius matricariae*, *Aphelinus* sp., *Pachyneuron* sp., *Alloxysta* and *Aphidencyrtus* sp. Meanwhile, three aphid parasitoids were emerged from the mummified aphids of *H. pruni* namely; *D. rapae, Aphidius colemani* and *Aphelinus* sp. Obtained results showed that *D. rapae* was the dominant aphid species in this study.

The results agree with (El-Maghraby, 1993; Abdel-Megid, 1999; Zhang and Hassan, 2003) and Saleh (2012) found that *B. brassicae* was the aphid species infesting cabbage and cauliflower crops and the main parasitoid emerged from the mummified aphid was *D. rapae*. On the other hand, Abdel-Samad (1996), Ragab *et al.* (2002a), Rakhshani *et al.* (2006) and Saleh *et al.* (2009b) mentioned the parasitoid, *D. rapae*, *L. fabarum*, *Ephedrus* sp. and a hyperparasitoid, *Aphidencyrtus* sp., emerged from mummified aphid *A. craccivora*. Meanwhile on oleander plants, Kavallieratos *et al.* (2001) and Maghraby (2012) showed that the most common parasitoid species attacking *A. nerii* were *A. colemani, Binodoxys angelicae, D. rapae* and *P. volucre*. Also, (Vaz *et al.*, 2004) found that parasitoids on *A. nerii* were *L. testaceipes* and *A. colemani* and the hyperparasitoids were *Pachyneuron* sp. and *S. aphidivorus*. These results agree with those of (Ibrahim and Afifi, 1994; Megahed, 2000) and Saleh *et al.* (2006) who mentioned that the aphid *H. pruni* is one of the important aphid species infesting common reed and plum trees in Egypt. On reed plants (Stary, 1970; Ibrahim and Afifi 1994; Megahed, 2000) and (Maghraby, 2012) who showed that *A. colemani* and *D. rapae* are considered among important parasitoid species on the aphid *H. pruni*.

The results in this investigation indicated that the mean seasonal percentages of parasitism were ranged between 4.72-83.84, 2.58-13.94, 1.01-35.14, 2.22-6.36% and 4.01-91.21, 1.37-15.01, 1.85-40.78, 0.76-7.25% on *B. brassicae* (cabbage), *A. craccivora* (faba bean), *A. nerii* (Dafla) and *H. pruni* (Reed plant) during both seasons, respectively (Table 5).

However (Vaz *et al.*, 2004; Saleh, 2012) and (Maghraby, 2012) showed that the aphid *B. brassicae* is a major pest on crucifer plants in several parts of the world especially cabbage in

Egypt, also, reported that *D. rapae* played the major role towards suppressing *B. brassicae* population. (Saleh, 2012) mentioned that the total means of parasitism rates of *D. rapae* were 23.58 and 28.06 on cauliflower plants during two seasons. In addition (Maghraby, 2012) in Egypt showed that the mean parasitism rates were 34.6, 36.13 and 28.73 and 32.24 on cabbage and cauliflower plants during 2010-2012 seasons, respectively.

However, Abdel-Samad (1996) in Egypt, reported that the rate of parasitism on *A. craccivora* ranged between 15.4 and 22.0% during March on this 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. Saleh *et al.*, (2009a) showed that the *Ephedrus* sp., on *A. craccivora* were 8.17 and 6.45% during the two seasons of their study.

The highest percentages of parasitism on *A. nerii* were 40.57% in the first of March 2011-12 and 34.49% during the third week of March in the second one 2012-13, respectively. The mean percentage of parasitism was 16.08±5.45 and 13.22±5.48 during both seasons, respectively (Table 3). These results agree with those of (Mackauer and Volki, 1993) who mentioned that the parasitism rates on *A. nerii* tend to range between 1.0 and 10.0%. Although parasitism rates ranged between 30.0 and 45.69% on some host plants Asclepias and Dafla plants (Sandra *et al.*, 2004; Saleh *et al.*, 2009b).

Results agree with findings of Megahed (2000) and (Saleh *et al.*, 2006), who mentioned that the percentage of parasitism mentioned that the percentage of parasitism on *H. pruni* ranged between 6.64-7.5%.

In the respect of biological parameters (Saleh *et al.*, 2009a) reported that sex ratio of the parasitoid *D. rapae* (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.

However, El-Batran *et al.* (1996) mentioned that the parasatoid *D. rapae* completed its life cycle in *B. brassicae*. Also, Ragab *et al.* (2002b) reported that *D. rapae* completed its life cycle in a period of 12-18 days at 19.5°C on *B. brassicae* and 11-15 days on *A. craccivora*. On the other hand, Saleh (2008) reported that the total development period of the parasitoid *D. rapae* lasted 16-24 days, with an average of 19.87, 24.39, 16.34 and 18.55 days in *B. brassicae*, *A. nerii*, *A. craccivora* and *H. pruni*, respectively at 16°C and 77% R.H.

The results in this research indicated that performance of the parasitoid *D. rapae* towards certain aphid species under laboratory conditions. Total numbers of mummies were 66.78±2.3, 42.44±3.59, 28.42±3.35 and 17.52±1.39 on *B. brassicae*, *A. nerii*, *A. craccivora* and *H. pruni*, respectively.

Similar finding was recorded by Elliot *et al.* (1994) in USA and Ragab *et al.* (2002a) in Egypt who mentioned that *D. rapae* parasitized on many aphid species (*B. brassicae*, *A. craccivora*, *A. nerii*, *M. persicae*, *S. avane*, *H. pruni* and *A. gossypii*). On the other hand El-Naggar *et al.* (2008) and (Ralec *et al.*, 2011) showed that the parasitoid density in relation to host density had influenced percentage of parasitism and emergence. The percentage of parasitism increased with the increase in numbers of parasitoid.

Due to the nutrient compounds of different aphid species, available informations indicated that, there are few researches about the relation between parasitism percentages and nutrition components of different species of aphids. A result of the ongoing needs of parasitoids to get their food to continue to grow and develop, they are looking for a suitable host that ensures it is available

source of nutrition. Parasitoids larvae grow at different rates in different aphid hosts of similar sizes, which makes us suggest that this preference is linked to the quality of the nutrition they provided these hosts (Sequeira and Mackauer, 1993). The host species may influence the rate of development and the survival of a parasitoid. A host may be unsuitable due to the lack of some necessary nutritional or hormonal resource (Carver and Sullivan, 1988; Kant *et al.*, 2008). Our data on *D. rapae* showed that host aphid species, *B. brassicae, A. nerii* and *A. craccivora* were nutritionally and physiologically suitable for parasitoid development but *B. brassicae* was considered the best host among the species tested, adult emergence and higher parasitization.

That is probably attributed to its higher nutrient composition of total lipids and free amino acids. These amino acids rapidly incorporate to produce large amounts of proteins which are necessary for the developing parasitoid. Lipids can convert to proteins to substitute the reduction in protein content or produce supplementary energy used for growth and development. In addition, they include important hormones and pheromones (Downer, 1978).

However (Abdul Rehman and Powell, 2010) mentioned that aphid parasitoids have considerable potential as biological control agents but their efficiency is dependent upon their presence in the right place at the right time and right host: parasitoid ratio. Understanding parasitoid behavior, together with identification of physical and chemical cues regulating the behavior, is providing exciting opportunities for manipulation of parasitoids in the field, as populations introduced through inundative releases.

CONCLUSION

Diaeretialla rapae is an important primary parasitoid of a wide range of aphid species and is considered a promising biological control agent against aphid species especially cabbage aphid in cabbage and cauliflower fields and it recommended to be an item of Integrated Pest Management Programs in Egyptians fields designed to control *B. brassicae*.

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