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Ecological and Biological Studies of *Diaeretiella rapae* (M'Intosh) (Hymenoptera: Aphidiidae), the Parasitoid of Some Aphid Species in Egypt

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ABSTRACT

Diaeretiella rapae (M'intosh) (Hym.: Aphidiidae), is a parasitoid of various aphid species infesting different host plants in Egypt. The role of this parasitoid in the biological control of *Brevicoryne brassicae* L. infesting cabbage in Sharkia Governorate, during the two seasons of 2005-06 and 2006-07 was studied. Highest rates of parasitism were 70.71% in the 1st week of March 2006 and 73.77% in the 3rd week of February 2007. Life cycle of the parasitoid at three temperatures (10, 16 and 28° C) on various aphid species was studied. The results indicated that the duration of the parasitoid was longer at 10° C, the longevity was affected by temperature and food but the sex ratio were not affected by host species. Studying the behavior of this parasitoid at varying host densities showed a decrease of host-searching and first sting times with increasing of host density but number of stings and number of mummies increased with increase of host density.

Key Words: *Diaeretialla rapae,* Aphid parasitoid, Biology, Ecology, Egypt.

INTRODUCTION

The hymenopteran parasitoid, *Diaeretialla rapae* (M'Intosh) is well known as a potential bio-agent for many aphid species in different countries (Abou Fakar and Kawar, 1998 and Ragab *et al.* 2002). It is an important primary parasitoid of a wide range of aphid species in the world and Egypt, such as cabbage aphid; *Brevicoryne brassicae* (L.), green peach aphid; *Myzus persicae*, Russian wheat aphid; *Diuraphis noxia*, *Rhopalosiphum padi* L. and *Schizaphis graminum* Sulz., cotton aphid; *Aphis gossypii* Glov., broad bean aphid *Aphis craccivora*; corn leaf aphid; *R. maidis* F.; reed plants aphid; *Hyalopterus pruni* and oleander aphid, *A. nerii* (Elliott *et al.* , 1994; Pike *et al.*, 1999, Saleh 2000& 2004, El-Heneidy *et al.*, 2006, Saleh *et al.* 2006 and Saleh & Gatwary, 2007). In Egypt, Saleh (2000) studied the biology of *D. rapae* as a parasitoid of *B. brassicae*. El-Batran *et al.* (1996) studied the most suitable temperature for the adult longevity of *D. rapa.* The life span of *D. rapae* as parasitoid of *B. brassicae* was also studied by Bueno and Souza (1992), and Ragab *et al.* (2002). Also, El-Heneidy *et al.*, 2006 studied the duration of the life cycle, emergency rate and sex ratio of *Aphidius matricariae* and *D. rapae* on cereal aphids *R. padi* and *S. graminum.*

The present study was conducted to survey the parasitoids associated with *B. brassicae* to estimate the rates of parasitism and to study some biological aspects of *D. rapae.*

MATERIALS AND METHODS

1. Survey of parasitoids and estimation of parasitism rate in the field:

To survey the aphid parasitoid species, infested samples from the aphid *B. brassicae* were collected from cabbage plant cultivated at Kafer Sakr district, Sharkia Governorate, Egypt, for two seasons 2005-06 and 2006-07. The samples were collected once a week and transferred to the laboratory in tight closed plastic bages. The size of samples was ten infested cabbage leaves, (ten inch^2 from each infested cabbage leaf).

All aphid individuals found in the plant samples were counted. Aphids were fed on their host and kept in Petri dishes (50 aphid/Petri dish) until formation of mummies. The mummies were isolated and kept in small glass tubes until emergence of adult parasitoids. Rates of parasitism were estimated. Counts of aphid mummies (A), living aphids containing parasitoid larvae (B) (which were kept until formation of mummies) and unparasitized aphids (C) were recorded. The percentage of parasitism was calculated according to Farrell and Stufkens (1990).

2. Biological studies:

2.1. Life cycle of *D. rapae* on different aphid species

A laboratory culture of the aphid, *B. brassicae* was maintained under laboratory conditions. The aphid species was reared on caged young seedling of its host or on either cut flowering shoots in a caged pot or on detached young leaves set flat on the bottom of clear plastic jar. The jars were inverted so that the aphids fed in a natural position on the under surface of the leaf and change the leaf daily. A laboratory culture of the

parasitoid, *D. rapae* started with mummies obtained from the field. Mummified aphids were placed singly in small glass tubes until the emergence of adult parasitoids which were fed on sugar solution.

To determine the durations of different immature stages of the parasitoid *D. rapae* on the nymphs of *B. brassicae*, *A. nerii*, *A. gossypii*, *A. craccivora*, *M. persicae* and *H. pruni* at three temperatures (10, 16, and 28 °C), nymphs of the host aphids were exposed to enough numbers of newly mated females of the parasitoid in a glass chimney and under cages for 2-6 hours. Twenty five nymphs of each parasitized host aphid were daily dissected to observe the development of different immature stages of the parasitoid *D. rapae*.

2.2. Effect of temperature and food supply on the adult longevity of the parasitoid *D. rapae*

Forty mated females and forty males of the parasitoid species were obtained from the laboratory culture (24 hours) after adult emerged from each aphid host. Each individual was confined in a small glass tube (9×2 cm). The females and males of the parasitoid species were divided into four groups, each of ten replicates, group (I) starved females and males, group (II) both sexes were supplied daily with droplets of honey and kept at room temperature (16° C), group (III) adult female and males also starved and group (V) was supplied daily with droplets of honey but kept in a refrigerator at 10° C.

2.3. Sex ratio:

Sex ratio of *D. rapae* reared on *B. brassicae* and *A. nerii* were determined depending on the ratio of females: males emerged from the total number of aphid mummies of each aphid host.

2.4. Behavior of the parasitoid *D. rapae* at varying host densities

Diaeretialla rapae on varying host densities 25, 50, 100, 150 and 200 nymphs of the aphid *B. brassicae* (mostly 3rd instars) on leaves of cabbage plant, were placed separately in Petri dishes lined with moistened filter paper. Freshly emerged to 12 h. old molted parasitoids females, fully fed with 50% honey solution were gently introduced into each Petri dish. The Petri dishes were covered with glass plates. The behavior of the parasitoid was observed for 30 min and recorded; 1- the period between introduction of the female and her first contact with the food plant, leaf (leaf–arrival time) and host (host-arrival time), 2- number of oviposition (No. of stings) and 3-No. of resulted mummies. The experiment was performed five times. All experiments were statistically analyzed using ANOVA.

RESULTS AND DISCUSSION

1- Role of *D. rapae* for controlling *B. brassicae* on cabbage

Two hyperparasitoid species; *Pachyneuron* sp. and *Alloxysta* sp. were recorded in small numbers and it existed from 24th January to the end of the first season and from 10th January to the end of the second season. The primary parasitoid *D. rapae* was the most dominate species with high relative densities during the two successive seasons. The percentages of parasitism ranged from 5.48 to 70.71% during the first season and from 3.64 to 73.77% during the second season. In the first season 2005-06, the percentages of parasitism started by 5.48 % at 21-18 °C and 62-65% R.H. in the second week of November and it increased until reached the peak of 70.71 % in the first week of March at 17.84 °C and 71.14 % R.H. In the second season 2006 –07, the parasitoid intiated in November with a relatively low percentage of 3.64 % at 24.65° C and 63.43 % R.H and it gradually increased until reached the maximum of 73.77 % in the third week of February at 15.17 °C and 65.07% R.H.%. The results indicated that the rate was relatively higher in 2006-07 than that in 2005-06, being 34.69 and 26.46%, respectively (Table 1).

According to Stary (1966), Bueno & Souza (1992), El-Maghraby (1993), Abd El-Megid (1999) and Saleh (2000 & 2004) *D. rapae* is a primary parasitoid. *Pachyneuron aphidis* was reported as a hyperparasitoid on *D. rapae* by Thakur *et al.* (1989) and Bueno & Souza (1992). The present results agree with those of Horn (1989) who stated that *D. rapae* parasitized cabbage and green peach aphids in Ohio and California, were themselves parasitized, mostly by *Asaphes lucens*, *Aphidencyrtus aphidivorus*, and *Alloxysta* spp.

2. Biological Studies:

2.1. Developmental period in various aphid species

The parasitoid *D. rapae* develops normally in various aphids. The experiment showed that temperature played an important role influencing the period of development of *D. rapae* in the various aphids; *B. brassicae*, *A. nerri*, *A. gossypii*, *A. craccivora*, *M. persicae* and *H. pruni*. Generally developmental periods of different stages of parasitoid decreased as the temperature increased from 10 to 28 °C (Table 2).

Table (1): Percentages of parasitism on *B. brassicae* by *D. rapae* on cabbage plants during the two successive seasons of 2005-06 and 2006-07.

Sampling dates	No. of dissected aphid	No. parasitoid aphids			Parasitism %	Emeraged parasitoids						Total	Temp.	R.H%
						D. rapae		*Pachyneuron* sp.		*Alloxysta* sp.				
		A	B	Total		N	RD%	N	RD%	N	RD%			
15/11/05	511	11	17	28	5.48	19	100	0	0	0	0	19	21.18	62.65
22/11	529	19	27	46	8.69	35	100	0	0	0	0	35	20.65	62.11
29/11	464	14	17	31	6.68	22	100	0	0	0	0	22	20.75	59.57
06/12	522	22	31	53	10.15	39	100	0	0	0	0	39	21.69	60.79
13/12	410	19	38	57	13.90	42	100	0	0	0	0	42	20.07	69.29
20/12	367	17	22	39	10.63	26	100	0	0	0	0	26	18.12	65.65
27/12	394	24	34	58	14.72	41	100	0	0	0	0	41	17.89	63.08
03/01/06	489	59	22	81	16.56	69	100	0	0	0	0	69	18.60	68.00
10/01	526	66	47	113	21.48	87	100	0	0	0	0	87	15.25	61.00
17/01	502	41	58	99	19.72	76	100	0	0	0	0	76	13.45	68.00
24/01	533	97	42	139	26.08	99	99	1	1	0	0	100	15.25	64.75
31/01	417	71	46	117	28.06	86	97.73	0	2.27	2	0	88	13.70	47.50
07/02	374	95	39	134	35.83	103	93.64	7	6.36	0	0	110	16.08	62.25
14/02	531	161	75	236	44.44	199	94.31	12	5.69	0	0	211	18.35	49.75
21/02	439	179	49	228	51.94	184	92.0	5	2.5	1	0.5	200	16.50	65.25
28/02	309	161	39	200	64.72	177	97.25	3	1.65	2	1.09	182	17.88	62.50
7/3/2006	362	211	45	256	70.71	213	97.26	5	2.28	1	0.46	219	17.84	71.14
1/11/2006	549	11	9	20	3.64	18	0	0	0	0	0	20	24.65	63.43
8/11	529	15	13	28	5.29	21	0	0	0	0	0	28	23.07	57.59
15/11	498	36	25	61	12.25	48	0	0	0	0	0	61	21.57	61.00
22/11	534	30	19	49	9.18	32	0	0	0	0	0	49	20.25	62.43
29/11	477	37	22	59	12.37	43	0	0	0	0	0	59	21.00	61.84
06/12	542	48	35	83	15.31	61	0	0	0	0	0	83	19.93	63.05
13/12	578	59	41	100	17.30	80	0	0	0	0	0	100	18.00	59.86
20/12	433	53	39	92	21.25	67	0	0	0	0	0	92	18.00	62.22
27/12	659	96	67	163	24.73	131	0	0	0	0	0	163	16.79	67.08
03/01/07	653	145	63	208	31.85	163	0	0	0	0	0	208	13.86	62.36
10/01	625	330	36	366	58.56	269	89.89	2	0.74	1	0.37	272	13.45	64.25
17/01	413	127	48	175	42.37	130	99.24	0	0	1	0.76	131	14.42	66.17
24/01	500	139	59	198	39.60	140	98.59	1	0.74	1	0.74	142	14.71	61.5
31/01	315	201	18	219	69.52	188	97.82	4	2.08	0	0	192	14.51	61.13
07/02	422	142	41	183	43.36	146	97.99	2	1.34	1	0.67	149	13.25	65.13
14/02	400	159	46	205	51.25	155	95.68	7	4.32	0	0	162	16.1	68.25
21/02	366	243	27	270	73.77	199	97.07	5	2.44	1	0.49	205	15.17	65.07
28/02	371	114	58	172	46.36	140	98.59	2	1.41	0	0	142	19.69	62.07
07/03	357	171	47	218	61.06	184	96.84	4	2.11	2	1.05	190	19.72	59.10
14/03	343	151	37	188	54.81	151	98.05	2	1.29	1	0.65	154	18.21	59.10

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

Table (2): Effect of aphid host species on the developmental period of the parasitoid *D. rapae* at the temperatures 10, 16 and 28 °C and R.H 77 %.

Temp. (C)	Host plant	Host aphid	Egg	Larva	Pupa	Development period
10° C	Cabbage	*Brevicoryne brassicae*	10.08^{a}±0.91	12.81^{a}b±0.76	10.74b±0.66	33.63b±0.67
	Dafla	*Aphis nerii*	10.72^{a}±0.90	11.34^{b}±0.59	12.37b±0.48	34.43b±0.39
	Luff	*Aphis gossypii*	9.67^{a}b±0.52	9.38^{c}±0.63	10.34b±0.75	29.39c±0.59
	Broad bean	*Aphis craccivora*	7.08^{b}±0.55	8.11^{c}±0.49	9.5b±0.27	24.69d±0.57
	Broad bean	*Myzus persicae*	7.38^{b}±0.69	12.35^{ab}±0.54	14.54a±0.91	34.27b±1.73
	Reed plants	*Hyalopterus pruni*	8.56^{b}±0.83	13.79^{a}±0.69	15.3a±0.71	37.65a±1.68
16° C	Cabbage	*B. brassicae*	5.36a±0.56	7.35b±0.35	7.16bc±0.31	19.87b±0.52
	Dafla	*A. nerii*	5.27a±0.91	9.62a±0.47	9.5a±0.49	24.39a±1.17
	Luff	*A. gossypii*	4.05a±0.52	6.65b±0.63	6.58bc±0.48	17.28cd±0.69
	Broad bean	*A. craccivora*	3.98a±0.5	6.47b±0.40	5.89c±0.37	16.34d±0.61
	Broad bean	*M. persicae*	3.75a±0.36	5.97b±0.53	8.48ab±0.89	18.2bc±1.12
	Reed plants	*H. pruni*	3.70a±0.45	6.07b±0.53	8.78ab±0.43	18.55bc±1.2
28° C	Cabbage	*B. brassicae*	2.2a±0.38	3.8b±0.28	3.3b±0.15	9.3c±0.39
	Dafla	*A. nerii*	2.66a±0.38	4.92a±0.26	4.25ab±0.25	11.83a±0.55
	Luff	*A. gossypii*	3.01a±0.43	5.08a±0.13	4.76a±0.19	12.85a±0.56
	Broad bean	*A. craccivora*	2.62a±0.29	2.88c±0.19	3.95ab±0.42	9.45bc±0.33
	Broad bean	*M.persicae*	2.39a±0.24	3.01^{bc}±0.38	3.92ab±0.38	9.32bc±0.35
	Reed plants	*H. pruni*	2.75a±0.39	3.38bc±0.24	4.96a±0.33	11.09ab±0.53

At 10° C, the incubation period varied significantly in various aphids. It recorded averages of 10.08, 10.72, 9.67, 7.08, 7.38 and 8.56 days in *B. brassicae, A. nerii, A. gossypii, A. craccivora, M. persicae and H. pruni*, respectively. The larval stage showed averages of 12.81, 11.34, 9.38, 8.11, 12.35 and 13.79 days in the last aphid species, respectively. The pupal stage in the same aphid species recorded 10.74, 12.37, 10.34, 9.5, 14.54 and 15.30 days, respectively. The total developmental period of the parasitoid lasted 24 to 37 days, with averages of 33.63, 34.43, 29.39, 24.69, 34.27 and 37.65 days in *B. brassicae, A. nerii, A. gossypii, A. craccivora, M. persicae* and *H. pruni*, respectively (Table 2).

At 16° C, the incubation period of eggs of the parasitoid eggs varied significantly in various aphids. It recorded an average of 5.36, 5.27, 4.05, 3.98, 3.75 and 3.70 days in *B. brassicae, A. nerri, A. gossypii, A. craccivora, M. persicae* and *H. pruni*, respectively. The larval stage showed averages of 7.35, 9.62, 6.65, 6.47, 5.97 and 6.07 days on the same aphid species, respectively. The pupal stage in the same aphid species recorded 7.16, 9.5, 6.58, 5.89, 8.48 and 8.78 days on the last aphid species. The total developmental period of the parasitoid lasted 16-24 days, with an average of 19.87, 24.39, 17.28, 16.34, 18.2 and 18.55 days in *B. brassicae, A. nerri, A. gossypii, A. craccivora, M. persicae* and *H. pruni*, respectively.

At 28° C, the incubation period of the parasitoid eggs averaged 2.20, 2.66, 3.01, 2.62, 2.39 and 2.75 days on *B. brassicae, A. nerri, A. gossypii, A. craccivora, M. persicae* and *H. pruni*, respectively. The larval stage showed average of 3.8, 4.92, 5.08, 2.88, 3.01 and 3.38 days on the same aphid species. The pupal stage showed averages of 3.30, 4.25, 4.76, 3.95, 3.92 and 4.96 days on the last aphid species. The total developmental period of the parasitoid lasted 9 to 13 days with averages of 9.30, 11.83, 12.85, 9.45, 9.32 and 11.09 on *B. brassicae, A. nerri, A. gossypii, A. craccivora, M. persicae* and *H. pruni*, respectively (Table 2). These results are in agreement with those of El-Batran *et al.*, (1996) who mentioned that the parasitoid *D. rapae* completed its life cycle in *B. brassicae* by average of 17.2, 12.6 and 10.3 days at 20, 25 and 30° C, respectively. Also, Ragab *et al.* (2002) 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*. Bueno and Souza (1992) studied the biology of *D. rapae* on *B. brassicae* and found that the parasitoid completed its life cycle in a period of 8.0 to 18 days at 26° C ± 1°C.

2.2. Effect of temperature and food supply on longevity of *D. rapae*.

As shown in Table (3), the adult longevity of starved females was longer than that of starved males when both were kept at room temperature of 16° C (Group 1). Also, the female lived longer than male when fed at room temperature (Group II), meanwhile, starved or fed females lived, longer than males kept in the refrigerator at 10° C (Group III). However, Stray (1970) reported that the adult life span of parasitoids was affected by many factors such as temperature, humidity, food and presence or absence of hosts. The obtained results are generally in agreement with those obtained by Ragab *et al.* (2002) on *D. rapae*.

2.3. Effect of aphid species on sex ratio.

A total number of 653 *D. rapae* parasitoid adults emerged from 809 *B. brassicae* mummies, with an average of 80.72% (min. 72.0 to max. 82.0). Number of females was 329 female and males were 324. The sex ratio was 1.015 female: 1 male. Meanwhile, a number of 429 *D. rapae* parasitoid individuals emerged from 662 mummies of *A. nerii*. That means the percentage of adult emergence was 64.80%, with range of 48-78. Number of females was 225 and the number of males was 204, sex ratio of 1.102 female: 1 male.

Table (3): Effect of temperature and food supply on the longevity of *D. rapae* emerged from *B. brassicae* and *A. nerii*.

Host plant	Group	Treatment	Temp. °C	Adult longevity in days			
				Female		Male	
				Range	Mean ±S.E	Range	Mean ±S.E
Cabbage	I	-	16	(2-7)	6.3^{d}±0.24	(2-4)	3.9^{D}±0.12
	II	+	16	(9-17)	13.6^{c}±0.71	(5-9)	8.01^{C}±0.34
	III	-	10	(15-24)	19.33^{b}±0.41	(6-14)	12.99^{B}±0.33
	IV	+	10	(47-54)	51.30^{a}±1.23	(29-35)	30.84^{A}±0.53
Dafla	I	-	16	(3-5)	4.38^{d}±0.19	(2-3)	2.97^{D}±0.18
	II	+	16	(5-9)	7.46^{c}±0.33	(4-7)	6.15^{C}±0.36
	III	-	10	(11-17)	14.42^{b}±0.55	(6-10)	9.89^{B}±0.29
	IV	+	10	(32-52)	42.69^{a}±1.73	(20-28)	24.70^{A}±0.71

- Unfed + Supplied with droplets of honey

Table (4): Behavior of the parasitoid *D. rapae* on cabbage at varying *B. brassicae* densities.

Host density	Leaf-arrival time (min.)	Host-arrival time (min.)	First sting time (min.)	No. of sting (ovipostion)	No. of mummies
25	6.11^{a}±0.32	3.43^{d}±0.23	9.81^{c}±0.23	18.60^{c}±0.83	7.0^{c}±0.99
50	5.97^{a}±0.45	5.95^{c}±0.27	9.96^{c}±0.38	26.4^{c}±1.63	12.0^{c}±0.63
100	3.49^{b}±0.03	8.18^{b}±0.31	17.69^{d}±0.87	41.8^{b}±2.68	20.6^{b}±0.96
150	1.33^{c}±0.18	9.06^{b}±0.27	21.29^{a}±0.60	56.4^{a}±3.85	29.4^{a}±2.53
200	0.90^{c}±0.13	12.39^{a}±0.64	22.02^{a}±0.85	78.2^{a}±2.68	33.20^{a}±2.47

The sex ratio of the parasitoid *D. rapae* was not affected by the host species. These results are in agreement with those of Saleh (2000) who mentioned that the sex ratio of parasitoid *D. rapae* was 1.023 female: 1 males.

2.4. Behavior of the parasitoid *D. rapae* at varying host densities

As shown in table (4), leaf-arrival and host-arrival times (host-searching time) are measures of the attractive potency of the semiochemicals emitted by the food plants and the hosts (Brown *et al.* 1970). Host-searching time and first sting time decreased with increasing host density but increased number of oviposition (No. of stings) and number of mummies with increasing host density. The increased number of antennal encounters, oviposition and number of mummies with increase of host density might be due to increased concentration of the kairomones which enhance the activity of the parasitoid (Srivastava & Singh 1988 and Saleh, 2004) and increased surface area of contact of the hosts (Woets and Lenteren, 1976).

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الملخص العربى

دراسات ايكولوجية وبيولوجية على طفيل مَنّ الكرنب *Diaeretiella rapae* (M`Intosh) المتطفل على بعض أنواع المَنّ فى مصر

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توضح الدارسة أن الطفيل *Diaeretiella rapae* (M'Intosh) يتطفل على بعض أنواع المَنّ التي تصيب نباتات مختلفة في مصر. تم حصر الطفيل على الكرنب حيث انه يتطفل على أفراد من *Brevicoryne brassicae* فى محافظة الشرقية خلال موسمي الدراسة ٢٠٠٥-٢٠٠٦، ٢٠٠٦-٢٠٠٧. كانت أعلى نسبة تطفل ٧٠,٧١ % في الأسبوع الأول من مارس خلال عام ٢٠٠٦ وكانت ٧٣,٧٧% من الأسبوع الثالث من فبراير خلال عام ٢٠٠٧ . كما تم دراسة تأثير ثلاث درجات حرارة (١٠، ١٦، ٢٨ درجة مئوية على دورة حياة الطفيل *D. rapae* على بعض أنواع المن المختلفة وأظهرت النتائج أن دورة حياة الطفيل تطول على درجة حرارة ١٠ درجة مئوية وكذلك تتأثر طول حياة الطفيل بدرجة الحرارة وإمداد الغذاء. وكذلك تم دراسة سلوك الطفيل على كثافات العائل المختلفة وأوضحت النتائج قلة الوقت المستغرق في البحث عن العائل وكذلك وقت أول وخزه (طعنة) مع زيادة كثافة العائل وعلى العكس يزداد عدد الطعنات وعدد الموميات مع زيادة كثافة العائل.