

Performance of Certain Exotic Aphid Parasitoid Species Towards Cereal Aphids under Laboratory, Field Cage and Open Wheat Field Conditions in Egypt

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ABSTRACT

Aphid parasitoids' importation and colonization have a great potential as a classical and effective biological control method. Through an Egyptian/American collaborative project (1997-2002), four cereal aphid exotic parasitoid species were imported from different countries to provide additional mortality factors to the indigenous ones, against key cereal aphid species in Egyptian and American wheat fields. The exotic cereal aphid parasitoid species were collected from Syria, Morocco, and Iran, in localities near the reported areas of the origin of cereal species and from habitats of climatic patterns similar to those in Upper and Middle Egypt and Southern California, USA. *Aphidius matricariae* Haliday (Syria), *Diaeretiella rapae* M'Intosh (Morocco), *Aphidius rhopalosiphii* De Stefani (Hymenoptera: Aphidiidae) and *Aphelinus albipodus* Hayat & Fatima (Hymenoptera: Aphelinidae) (Iran) were the parasitoid species introduced and evaluated under laboratory, field cage and open wheat field conditions. The exotic parasitoid species showed different performances under several tested conditions. *A. matricariae* exceeded the other parasitoid species under similar conditions.

Key Words: Performance, exotic aphid parasitoids, cereal aphids, wheat field, Egypt

INTRODUCTION

Aphids are one of the insect groups whose economic importance increases with the development of agriculture (Stary, 1976). Cereal aphids are the serious pests attacking cereal crops, particularly wheat, barley and corn not only in Egypt (El-Hariry, 1979 and El-Heneidy, 1994) but also in many other countries; *i.e.* Southern Russia, Iran, Afghanistan, and countries bordering the Mediterranean Sea (Kindler *et al.*, 1991).

Importation and colonization of natural enemies associated with cereal aphids has great potential as an effective method for their control. Aphid parasitoids are one of the groups of which utilization in biological control has given significant results in many countries. (Stary, 1976).

Through the Egyptian – American collaborative project, Agricultural Technology Utilization and Transfer (ATUT), "Wheat crop protection based on plant resistance and biological control" which was carried out during 1997-2002, certain cereal aphid exotic parasitoid species were imported from different countries to provide additional mortality factors to the indigenous ones, against key cereal aphid species in Egypt as well as in the US (Final report of project, 2002). The survey for such included Syria, Morocco, and Iran, in localities near the reported areas of the origin of key cereal aphid species and from habitats of climatic patterns similar to those in Upper Egypt, was carried out to search for effective parasitoid species or biotypes (Gonzalez, *et al.* 1979 & 1980). Different parasitoid species attacking aphids in different geographical areas and also, genetic, behavioral, and bio-systematic differences among populations of parasitoids described under one species name were found (Gonzalez, *et al.* 1980 and 1990 and Unruh *et al.* 1989).

It is noteworthy to mention that some of these species have been recorded by several authors as indigenous parasitoids against wide range of aphid species in Egypt (Ibrahim, 1990 and El-Heneidy, 1994). Identification of the native and exotic parasitoid species was confirmed by

Dr. P. Stary, Institute of Entomology, Academy of Science of the Czech Republic to whom the authors are grateful.

In Egypt, *Rhopalosiphum padi* L., *R. maidis* F., *Schizaphis graminum* R. and *Sitibion avenae* F. were recorded as main aphid species on wheat plants (El-Hariry, 1979). The Russian species, *Duraphis noxia* Mord. was also added to the Egyptian cereal aphid fauna in wheat fields (Attia and El-Kady, 1988). *R. padi* is the common and most important species in Egypt (El-Heneidy, 1994).

The objective of the present work is to evaluate the efficiency of several exotic parasitoid species against cereal aphids in Egypt under laboratory, field cages and open field conditions.

MATERIALS AND METHODS

Foreign exploration for exotic natural enemies of *R. padi* and *S. graminum* was conducted in several geographical areas in Morocco, Syria and Iran. Parasitoid species found were imported as mummies first to the California Quarantine facilities, mass-reared and then shipped to Egypt for evaluations. The sites selected for the foreign exploration were all areas with long history in growing cereal crops, with temperatures patterns similar to those of upper and middle Egypt, where the highest infestation of cereal aphids usually occurs (El-Heneidy, *et al.*, 1991).

Cereal aphid cultures of *R. padi* and *S. graminum* were established on wheat seedlings in the laboratory in Egypt for the laboratory, field cages and open field evaluations of the exotic and native parasitoid species. Species provided most promising results from laboratory tests and from available information on their efficacy obtained during the foreign exploration have been selected for field cage and open field trials.

Laboratory trials:

Laboratory evaluation of the exotic and native parasitoid species, when parasitizing the cereal aphid

species; *R. padi* and *S. graminum* included duration of the life span, emergence rate and sex ratio for each species. No-choice trials included different parasitoid species in separate small cages (40 x 40 x 40 cm) with both aphid species were carried out under the laboratory conditions of 22 ± 2 °C and 50-60 % R.H. 30 replicates were used. Infested pots with each of the two aphid species separately as well the two species together were offered to each of the exotic and/or the native parasitoid species in the cages for evaluations. Promising parasitoid species were selected for further trials based on the preliminary assessment.

Field cage trials:

Locations: Three different geographical sites; Shandaweel (Sohag Governorate, representing Upper-Egypt), Sids (Beni-Suef Governorate, representing Middle-Egypt), and Zagazig (Sharkia Governorate, representing the Delta) were chosen for field cage evaluation.

Design: Six and eight cages (1 x 2 x 2 m covered with narrow-mesh cover) (Fig. 1) were used at each location in a random-choice test. Exotic and/or native parasitoid species were released 3 - 4 times at different wheat plant growth stages; stem elongation, booting and heading. Each parasitoid species was released in 2 of the cages as replicates.

Procedure: Shipments of the exotic parasitoids were approved to be introduced into Egypt by the Quarantine Committee of the Ministry of Agriculture. About 2000 mummies from each of the exotic parasitoid species were received regularly, every other week from California for about two months. 500 mummies/species were used for the laboratory evaluation. 500 mummies/species were provided to each location for each releasing date. Area under the cages was evacuated from predators and/or mummies of native parasitoids. In some cases, the laboratory culture of *R. padi* and *S. graminum* were used for artificial infestation, to establish a proper aphid / parasitoid ratio (approximately 4: 1) under the cages. Cages were left covering the infested plants for 10 - 12 days and then removed to promote parasitoid establishment. Formed mummies in the area of each cage were picked every 2 - 3 days; no. of mummies was counted, placed in vials and transferred to the laboratory for adult parasitoid emergence %, longevity and sex ratio estimates. These experiments were undertaken twice in the two seasons 1999/2000 and 2000/01 for confirmation.

Open Field Trials:

Locations: Two different agro-ecosystems; Shandaweel (representing Upper Egypt), and Zagazig (representing the Delta) were chosen. An area of about 1/4 feddan (1000 m²) at each site was selected for the open field releases in season 2001/02.

Procedure: Selected exotic parasitoid species; were mass-reared in Agricultural Research Center (ARC), Egypt, released and evaluated at each of the booting and heading growth stages of three semi-tolerant - tolerant wheat cultivars, coded 3, 5 and 8 plus the commercial variety, Sakha 69 (used as control) under both the field cages, described above and open field conditions in season 2001/02. 500 and 1000 individuals/ parasitoid species/release/site were used for the field cages and the

open field releases, respectively. Additional preliminary trial was carried out to compare both the native against the exotic species *Aphidius matricariae* under open field conditions at the two selected sites in the same season.

Obtained data were statistically analyzed using ANOVA.

RESULTS AND DISCUSSIONS

A list of the exotic parasitoid species searched and found in fourteen areas from the three countries were imported first to California, mass-reared and then shipped to Egypt for evaluations. Those included 7 identified species of parasitoids, 6 aphidiids and 1 aphelinid species. A summary of the geographical areas, parasitoid species and colonies' status are summarized in Table (1).

Evaluation of selected exotic parasitoids for trials was based on 3 criteria: 1) their initial potential effectiveness was based on the ratio of parasitoids originally collected in the country of origin relative to the numbers of their host aphids and their spatial distribution. For example, higher potential was assigned to relatively abundant numbers of parasitoids collected from sites where there were relatively scarce numbers of aphid hosts in patchy spatial distributions. 2) The relative abundance of the same parasitoid species collected from 3 or more of the sites. Under this criterion, the species having the greatest apparent potential over the 3-year period were *A. matricariae* and *Diaeretiella rapae*. 3) The third criterion was based on available literature records relative to the known host range of each parasitoid species. Under this criterion, *D. rapae* is reported to be widely polyphagous, attacking many aphid species on many crops. *A. matricariae* is reported to have a relatively much narrower host range with many records from cereal aphids. In this case, it was hypothesized that *A. matricariae* appeared to have greater potential for effectiveness than *D. rapae*.

Laboratory trials.

A. matricariae (Abo Kamal, Syria), *A. matricariae* (Marrakech, Morocco), *D. rapae* (Imitir, Morocco) and *A. rhopalosiphii* (Iran) were the exotic parasitoid species selected for preliminary assessment in Egypt. As well, the two native species; *A. matricariae* and *D. rapae* were also evaluated. No-choice trials included different species in separate cages with *R. padi* and *S. graminum* were carried out under the laboratory conditions of 22 ± 2 °C and 50-60 % R.H. included duration of the life-cycle, emergence rate and sex ratio for each species. Obtained data are summarized in Table (2). As shown in the table, insignificant differences were found among the four species under the laboratory conditions concerning duration of the life-cycle and relatively the sex ratio.

Against *R. padi* alone, greater total numbers of *R. padi* (mummies) were parasitized by *A. matricariae* than by *D. rapae*. Numbers of parasitoids emerging from parasitized *R. padi* mummies showed greater numbers of both female and male *matricariae* than *rapae*. Against *S. graminum* alone, approximately equal numbers of *S. graminum* (mummies) were parasitized by *matricariae* and *rapae* as well were the numbers of females emerged from both parasitoid species. Greater numbers of male *matricariae* emerged than those of *rapae*. *A. matricariae* parasitized

Table (1): Importations of Exotic Parasitoids of Cereal Aphids to Egypt and California, USA years 1999 and 2000

Country of origin	Species identification	Number imported	Quarantine status	Colony status
Morocco				
Zagora	Aphidiidae	1	unsuccessful propagation- original not recovered	
Imitir	<i>Diaeretiella rapae</i> (M'Intosh)	30	propagated and released	established
Tinahir	<i>D. rapae</i>	58	unsuccessful propagation-3rd generation produced only males	
Skora	no primary parasitoids	0		
Quarzazate	apparently 2 species of Aphidiidae	23	unsuccessful propagation- originals not recovered	
Marrakech	<i>Aphidius matricariae</i> Haliday <i>D. rapae</i>	19	propagated and released propagation-small numbers-2 nd generation produced only males	unsuccessful established
Syria				
Abu-Kamal	<i>A. matricariae</i>	61	propagated and released	established
Aleppo	<i>A. matricariae</i> <i>D. rapae</i>	> 300	propagated and released small numbers not established	established
Aleppo	<i>D. rapae</i>	22	Small numbers not established	
Iran				
S. of MarvDasht	<i>Aphidius rhopalosiphi</i>	2	Unsuccessfully propagated	
Badgah	<i>A. rhopalosiphi</i>	1	Unsuccessfully propagated	
S. of Sepidan	<i>A. rhopalosiphi</i>	3	Propagated and released	Established
Sepidan	<i>Praon volucre</i>	3	Unsuccessfully propagated	
Badgah	<i>P. volucre</i>	6	Unsuccessfully propagated	
Sepidan	<i>P. volucre</i>	1	Unsuccessfully propagated	
Khash	<i>D. rapae</i>	340	Propagated and released	Established
S. of Khash	<i>D. rapae</i>	71	Propagated and released	Established
Khash	<i>D. rapae</i>	165	Propagated and released	Established
Ahvaz	<i>Aphelinus albipodus</i>	11	Propagated and released	Established
Zabol	<i>Ephedrus persicae</i>	59	Unsuccessfully propagated	
Zabol	<i>E. persicae</i>	12	Unsuccessfully propagated	
Zabol	<i>E. persicae</i>	24	Unsuccessfully propagated	

Table (2): Performance of exotic parasitoid species under the laboratory conditions (22±2 °C and 50-60 % R.H.)

Parasitoid Species	Duration of life-cycle (days)			Emergency Rate %	Sex Ratio (M : F)
	Sting - Mummy	Mummy - Adult	Total		
<i>A. matricariae</i> (Abo-Kamal, Syria)	7 - 8	4	10 - 12	24 - 85	1 : 1.5
<i>A. matricariae</i> (Marrakech, Morocco)	7 - 8	3.5	10 - 13	36 - 90	1 : 1.04
<i>A. matricariae</i> (Native)	7 - 8	4	12 - 13	42 - 87	1 : 1.4
<i>D. rapae</i> (Imitir, Morocco)	8 - 9	3.3	11 - 14	33 - 56	1 : 1.3
<i>D. rapae</i> (Native)	8 - 9	4 - 5	12 - 14	51 - 76	1 : 1.4
<i>A. rhopalosiphi</i> (Iran)	8	4	12	66 - 100	1 : 1.5
N = 30					

a higher number of *R. padi* than *S. graminum* but it was vice versa in case of *D. rapae* when both aphid species were exposed together. Generally, highest emergency rates were recorded in case of the native *A. matricariae* and the exotic *A. rhopalosiphi* (Iran) (Table 2).

Field Cage Trials:

Results obtained from the field cage releases of the exotic parasitoid species; *A. matricariae* (from Abo-Kamal, Syria), *A. matricariae* (Marrakech, Morocco) and *D. rapae*, (Imitir, Morocco) in the first season 1999/2000 and *A. matricariae* (Abo-Kamal, Syria), *D. rapae* (Imitir, Morocco) and *A. rhopalosiphi* (Iran) in the second season 2000/01 in different experimental localities are summarized in Tables 3 and 4. As shown in the tables,

released parasitoid species showed different performances. Generally, the developmental periods of the released parasitoid species under the field cages at different environmental locations were different. Parasitoid species, weather, handling and collector influenced number of mummies collected from different locations. All tested parasitoid species showed greatest numbers of mummies and highest emergence rates during the second and third releases in the first season, respectively, mostly at the wheat booting growth stage, usually takes place around late February in most of the wheat fields in Egypt. *A. matricariae*, Abo-Kamal, Syria, parasitized greater numbers of cereal aphids than the numbers parasitized by *D. rapae* and *A. rhopalosiphi* Iran.

Table (3): Performance of exotic parasitoid species under field cages at different locations in Egypt, season 1999/2000.

Date of Release	Exposure Period (days)	Total Life-cycle (days)	No. collected Mummies	Emergence Rate %	Sex Ratio (M : F)
<i>Aphidius matricariae</i> (Abo-Kamal, Syria)					
February 4 - 6, 2000	11 - 12	14 - 16	74 - 350	50 - 93	1 : 1.2
Feb. 25 - 26	10 - 12	11 - 13	160 - 435	45 - 69	1 : 1.4
March 9 - 10	9 - 14	9 - 12	20 - 140	62 - 75	1 : 1.4
March 24 - 25	10 - 13	9 - 11	15 - 158	8 - 21	1 : 1
<i>Aphidius matricariae</i> (Marrakech, Morocco)					
February 4 - 6, 2000	11 - 12	14 - 16	41 - 104	50 - 92	1 : 1.1
Feb. 25 - 26	10 - 12	11 - 13	17 - 361	17 - 89	1 : 1.4
March 9 - 10	9 - 14	9 - 12	7 - 134	43 - 84	1 : 1.3
March 24 - 25	10 - 13	9 - 11	16 - 150	5 - 31	1 : 1.4
<i>Diaeretiella rapae</i> (Imitir, Morocco)					
February 4 - 6, 2000	11 - 12	14 - 16	52 - 76	41 - 84	1 : 1.5
Feb. 25 - 26	10 - 12	11 - 13	188 - 311	39 - 92	1 : 1.4
March 9 - 10	9 - 14	9 - 12	92 - 197	60 - 93	1 : 1.9
March 24 - 25	10 - 13	9 - 11	7 - 105	10 - 29	1 : 1.5

Table (4): Performance of exotic parasitoid species under field cages at different locations in Egypt, season 2000/2001.

Date of Release	Exposure Period (days)	Total Life-cycle (days)	No. collected Mummies	Emergence Rate %	Sex Ratio (M : F)
<i>Aphidius matricariae</i> (Abo-Kamal, Syria)					
January 28 - 29, 2001	10 - 15	14 - 15	21 - 68	40 - 56	1 : 1.4
February 18 - 19	10 - 15	12 - 14	35 - 86	45 - 71	1 : 1.5
March 1 - 2	11 - 13	10 - 12	61 - 134	60 - 69	1 : 1.5
March 23 - 24	9 - 11	10 - 12	49 - 131	60 - 67	1 : 1.4
<i>Aphidius rhopalosiphi</i> (Iran)					
January 28 - 29, 2001	-	-	-	-	-
February 18 - 19	10 - 15	14	23 - 47	45 - 66	1 : 1.6
March 1 - 2	11 - 13	12 - 13	22 - 113	51 - 57	1 : 1.4
March 23 - 24	9 - 11	11 - 13	60 - 113	55 - 64	1 : 1.8
<i>Diaeretiella rapae</i> (Imitir, Morocco)					
January 28 - 29, 2001	10 - 15	16 - 17	25 - 75	33 - 66	1 : 1.7
February 18 - 19	10 - 15	14 - 15	68 - 82	60 - 68	1 : 1.8
March 1 - 2	11 - 13	12 - 13	35 - 157	54 - 69	1 : 1.6
March 23 - 24	9 - 11	11 - 12	19 - 99	39 - 61	1 : 1.6
<i>Diaeretiella rapae</i> (Native)					
January 28 - 29, 2001	10 - 12	13 - 17	32 - 41	28 - 68	1 : 1.3
February 18 - 19	10 - 12	11 - 14	56 - 92	81 - 88	1 : 1.8
March 1 - 2	10 - 12	11 - 13	58 - 78	56 - 76	1 : 1.8
March 23 - 24	10 - 12	11 - 13	61 - 161	62 - 83	1 : 1.7

Table (5): Total numbers of cereal aphid mummies collected from the releases of exotic parasitoid species at Sohag and Sharkia Governorates, Egypt during the season 2001/02

Location	Parasitoid Species	Release Date	Cultivar 3		Cultivar 5		Cultivar 8		Sakha 69		Total	
			Caged	Opened	Caged	Opened	Caged	Opened	Caged	Opened	Caged	Opened
Sohag	<i>A. matricariae</i> (Syria - Exotic)	15/2	141	30	142	30	156	32	84	30	523	123
		14/3	244	49	234	54	265	45	104	50	847	199
	Total	No.	385	79	376	84	421	77	188	80	1370	322
		%	83	17	82	18	85	15	70	30	81	19
	<i>D. rapae</i> (Exotic)	15/2	113	32	100	34	108	35	62	30	382	131
		14/3	239	47	134	51	214	43	286	49	873	191
	Total	No.	351	79	234	85	322	78	347	79	1255	322
		%	82	18	73	27	81	19	81	19	80	20
Sharkia	<i>A. matricariae</i> (Syria - Exotic)	15/2	63	54	59	41	63	45	64	51	249	192
		14/3	67	68	65	63	65	66	70	70	268	267
	Total	No.	131	122	124	104	128	111	134	121	517	479
		%	52	48	54	46	54	46	53	47	52	48
	<i>D. rapae</i> (Exotic)	15/2	71	57	62	47	66	49	67	58	266	212
		14/3	69	71	67	67	67	68	72	74	275	280
	Total	No.	140	128	129	114	133	117	139	132	541	492
		%	52	48	53	47	53	47	51	49	52	48

Parasitoid species parasitized significantly greater numbers of *R. padi* than those of *S. graminum*. *A. matricariae* also exceeded the other species in most of the tested biological parameters included duration of the life cycle, number of collected mummies, emergence rate and sex ratio for each species, particularly in the first season (Table 3 and 4). From the results and the field observations, *A. matricariae* from Abo Kamal, Syria had a significantly better potential to parasitize higher numbers from *R. padi* and *S. graminum* than do the other species, particularly in areas of high temperatures, especially in Shandaweel, Sohag Governorate, Upper Egypt.

Accordingly, *A. matricariae* parasitized significantly greater numbers of *R. padi* than the numbers parasitized by *D. rapae* and *A. rhopalosiphi* not only under the laboratory conditions but also under the field cages.

Open Field Trials

Prior to initial open field releases in 2002, a survey for pre-existing "native" or already established cereal aphid parasitoids was made for several years (El-Heneidy *et al.*, 2001).

Results obtained from the field releases of the two exotic parasitoid species; *A. matricariae*, Abo-Kamal, Syria and *D. rapae*, Imitir, Morocco on the semi-tolerant and tolerant wheat cultivars, coded 3, 5 and 8 plus the commercial variety, Sakha 69 are summarized in table (5). As shown in the table, released parasitoid species showed different performances. The differences in the developmental periods of the released parasitoid species under the field cages at different environmental locations were relatively little. Number of mummies collected from different locations was influenced by wheat cultivar, parasitoid species, location, weather, and handling (Table 5). Generally, number of mummies collected from the two selected exotic parasitoid species, whether in the field cages or the open field was much higher in Shandaweel, Sohag Governorate than those collected from Zagazig, Sharkia Governorate which is more or less the influence of the weather factors. Also, *A. matricariae* parasitized significantly greater numbers of aphids than the numbers parasitized by *D. rapae*, particularly in the field cages at Shandaweel, Sohag while they were almost equal in the other respective cases in both sites. The releases carried out during the heading growth stage (on 14/3/2002) gave higher numbers of mummies from both parasitoid species than those of 15/2/2002, during booting growth stage in the two experimented sites. Obtained data agreed with the findings of El-Heneidy 1994.

As expected, the parasitization in the field cages was always higher than that in the open field in both sites. Therefore, in the control variety, Sakha 69, the numbers of aphids parasitized by *D. rapae* at Shandaweel in the field cages exceeded those parasitized by *A. matricariae* while they were equal in the opened field. At Zagazig, the numbers parasitized were almost equivalent in the two cases (Table 5). The performance of the two tested parasitoid species on the semi-tolerant - tolerant wheat cultivars, coded 3, 5 and 8 varied according to the cultivar, location and type of release. *A. matricariae* significantly parasitized greater numbers of aphids than the numbers parasitized by *D. rapae*, particularly in the

field cages at Shandaweel while there were almost no differences among the cultivars in the opened field. On the contrary, at Zagazig *D. rapae* relatively exceeded *A. matricariae* on the three cultivars and in the two releases types (Table 5).

Similar results were obtained from the comparative trial of both the native against the exotic species *A. matricariae* under open field conditions at the two selected sites. The exotic parasitoid species; *A. matricariae*, Abo-Kamal, Syria exceeded the native species at Shandaweel while they were equivalent at Zagazig when both were released at the same time and conditions.

The most promising species for its potential field effectiveness against cereal aphids was *A. matricariae* from Abu-Kamal (Euphrates River Valley), Syria. The assessments were based in part on the relative numbers of parasitoids originally collected at its country of origin, plus subsequent results from laboratory, field-cage and open-field experimental evaluations. Relatively high numbers of parasitoids originally collected from Syria from relatively scarce (low numbers and patchy distributions) of *R. padi* in the field provided initial evidence of potential that was verified in laboratory, field-cage and open-field trials.

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