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Host selection behavior of *Diaeretiella rapae* McIntosh (Hymenoptera:Braconidae)attackingcereal aphids in Upper Egypt

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ABSTRACT :

The present investigation was carried out in Assiut Governorate to study the relative abundance of cereal aphid parasitoids and evaluate the host selection and host-instar preference of *Schizaphis graminum*(Rondani) and *Rhopalosiphum padi*L.by the braconid parasitoid, Diaeretiella rapae McIntosh during 2015 wheat growing season. The obtained results revealed that the dominance percentages of the primary parasitoids were so high and presented by 81.53 % of the total caught parasitoids. However, the secondary parasitoids showed low dominance percentages and presented by 18.47 %. The parasitoids, *D. rapae*and *Alloxysta australiae* (Ashmead)revealed the highest dominance percentage and presented by 76.38 and 47.93 % of the total collected primary and secondary parasitoids, respectively.The aphid, *S. graminum*appeared as more relatively preferred for *D. rapae* than*R. padi* species. The development of *D. rapae*was found to be possible in any instar of *S. graminum* and *R. padi*. The second and third instars of *S. graminum*presented the optimal response for*D. rapae*growth and survival, while the third and fourth instars of *R. padi*presented the optimal response for parasitization by the same parasitoid species. The averages of the development times from oviposition until the appearance of the mummified aphid were 7.68and 8.01days for*S. graminum* and *R. padi*, respectively. Offspring production per female was high in the adult stage than others. Nymphs parasitized and mummified by *D. rapae* during the first and second instars may be reach to maturity but not produce any progeny.

INTRODUCTION

Wheat is one of the main crops in cereal groups. Many pests attack wheat plants from planting up to harvest.The main insect pests attacking wheat are aphids (Kindler *etal*., 1991). In Egypt, four aphid species were recorded amongstcerealinsect pests, i.e. Schizaphis graminum (Rondani), Rhopalosiphum padi L., R. maidis(Fitch.) and Sitobion avenae (Fab.).Also,five primary parasitoid species, i.e. *AphidiuscolimaniViereck, AphidiusmatricaraeHaiday, Diaeretiellarapae McIntosh, Ephedrus spp.* and *Praon spp.*were recorded as important parasitoid species associated with cereal aphids on wheat plants (Abdel-Rahman, 1997; El-Heneidy *etal*., 2001; Salem, 2007; 2012 and Salem and Mahmoud, 2012).

Many aphidiine wasps showed distinct preferences for particular aphid

species and/or instar which reflect acceptability of the host quality for the immature parasitoid (Cloutier *et al.*, 2000; Colinet *et al.,* 2005; Lukouressis *et al.,* 2009 and Rehman and Powell, 2010).

The parasitoid, *D. rapae* is reported to be successfully parasitize several economically important cereal aphids including the green-bug and the bird cherry-oat aphids (Ali et al., 2001; Salem, 2007 and Salem and Mahmoud, 2012). This parasitoid has been observed parasitizing a number of aphid hosts other than small grain aphids (Elliott et al., 1994).Throughout the last two decades, entomologists confirmed the use of the Integrated Pest Management (IPM), to control the insect pests when their population reaches the economic threshold injury level by using all other control methods and emphasized on biological control (Schuler *et al.*, 1999).

Therefore, this study aimed toidentify the primary and secondary parasitoids attackingthe principal cereal aphid species in wheat fields in Upper Egypt. Also, the host selection and specifietyof the parasitoid *D. rapae* to the different aphid instars in addition to its parasitizationinfluence on the aphid population growthrates was the corner stone of this investigation.

Materials and Methods

An area of about ½ feddan was cultivated with wheat cultivar (Seds 1) at Abnoub location, Assiut Governorate during 2015wheat growing season. The normal agricultural practices were performed and insecticides were completely prevented.

1 – Field activities:

Survey of cereal aphid parasitoids:

Samples of live individuals of *S. graminum* and *R. padi*(all forms) were collected from the wheat field. The specimens were kept in paper bags and transferred to the laboratory. Individuals of *S. graminum* were separated from those of *R. padi* using a fine hair Bruch. About 250individuals of each species were caged on wheat seedlings in plastic pots (7.5 cm in diameter and 8 cm in high). Aphids were then reared under laboratory conditions 23± 2°C, 65 ±5% RH and observed daily for more than 10 days to record the development of mummies. Any observed mummies were removed and individually placed in small vials provided with sterile cotton and covered with muslin cloth. The arenas were observed until the adult parasitoid emergence. Emerging adult parasitoids were identified according to Pike *et al.* (1997).

Dominance degrees for the parasitoid species were calculated according to Facylate equation (1971) as follows:

$$D = t / T. 100,\text{where}$$

t= Total number of each species collected during the study period.

T= Total number of all species collected during the study period.

2 - Laboratory activities:

2-1- Rearing of aphid species:

One colony fromboth of *S. graminum* and *R. padi* was established dependent on one female collected from the wheat field. Each colony was maintained continuously as parthenogenetic females on wheat seedlings under the

abovementionedlaboratory conditions and continuous light. To obtain groups of the same age, apterous were caged on plants for six hours. Any offspring produced during this period has been transferred to fresh plants and maintained as a synchronous colony until they reached the desired instar for experimentations.

2-2- Rearing of *D. rapae* parasitoid:

The braconid*D. rapae* colony used in this study was established from individuals emerged from *S. graminum* mummies collected from wheat fields in 2015 season. Mummified aphids were maintained under the same laboratory conditions. To obtain*D. rapae*mated females, mummies were placed together in plastic tubes (3 cm diameter) so that newly emerged males and females could bemate. Adult parasitoids were provided with a solution of equal parts of honey and water as food. The used nymphs and adult aphids (equal in age) were provided by fresh wheat seedlings and moistened small cotton pieces.

2-3- Host selection:

Ten pots (10 cm diameter), each contained 10 wheat seedlings infested with 250 nymphs (second and third instar) of both *S. graminum* and *R. padi* species which were taken from laboratory culture. Pots were transferred to the field and placed on 10 m distance betweeneach one. The pots were left to expose to the natural attack by the cereal aphid parasitoid species for 24 hours. After exposure the pots were transferred to the laboratory and covered with a cage of glasses and left under the laboratory conditions to allow the parasitoids to develop until mummification. Any observed mummies were removed and recorded. The experiment was repeated four times, 1st, 15th and 1st, 15th of February and March, respectively. Aphids that did not show any evidence of parasitism within 10 days following attack were discarded and any data relating to them were not considered in the evaluation. Data taken were the number of mummies and parasitism (%).

2-4- Host-instar preference:

In this experiment, individuals ofthe first, second, third, fourth nymphalinstars and adultstage of *S. graminum* and *R. padi* were collected from the laboratory stock culture (125 individuals / instar /species). Aphid individuals were transferredto wheat seedlings growing at 10 cm diameter plastic pots (4 replicates)placed in a box (60 cm in width, 80 cm in length and 50 cm in high). Ten mated *D. rapae*females were placed into the box and left to attack the aphids for 24 hours as described by Jones *etal.*(2003). After the exposure the parasitoid females were removed and the pots were covered with a cage of glasses and left under the laboratory conditions to allow parasitoids to develop until mummifications. The effect of parasitism on aphid instars and reproduction were assessed. Data taken were the number of mummies, average days to mummification, average days request to developing to adult stage, parasitism (%) and mean number of progeny per female.

Statistical analysis

Data of the host preference and host-instar selection and specifiety were

tested for differences by T- test at 0.05 probabilityusing (MSTAT_C 1988, Michigan University, Version, 2, 10), and presented as mean ± SD (standard deviation).

Results and Discussion

Relative abundance of cereal aphid parasitoids:

Data in Table (1) indicate the dominance percentages of cereal aphid parasitoid species inhabiting wheat plantation. The dominance percentages of the primary parasitoids were so high and presented by 81.53 %. However, the dominance percentages of the hyperparasitoid species were low and presented by 18.47 %.The parasitoid, *D. rapae* revealed the highest dominance percentage and presented by 76.38 %. The rest of the primary parasitoid species were presented in low dominance percentages and ranged between 0.55 and10.27 %. On the other hand, the secondary parasitoid species, *Alloxysta australiae* (Ashmead) revealed the highest dominance percentage and presented by 47.93 %, followed by *Chalcids sp.* (23.79 %). The megaspilid*Dendrucerus carpentrea*(Curtis) and the incyrtid *Aphidencyrtus sp.* were presented by an average of 16.72 and11.55%, respectively. These results confirmed those obtained by Pike *et al.* (1997); Ali *et al.* (2001) and Salem (2007) who reported that the parasitoid, *D. rapae* was recorded in high numbers on cereal aphids than other species. Also, *D. rapae* seem to be the most important primary parasitoid species as biological control agent due to its highest values of dominance and abundance degrees followed by *A. colemani* and *P. necans*. On the other hand, Salem (2007) and Salem and Mahmoud (2012) reported that *Alloxysta sp.*appeared as the most common and abundant primary parasitoids species on cereal aphids.

Host selection:

Data in Table (2) expressed about the relative abundance of mummies that emerged from live *S. graminum* and *R. padi* in different sampling dates during 2015 season in the field. The results indicated that the rate of parasitism ranged from 12.00 to 87.60 % for *S. graminum* with an average of 50.20 % and from 4.00 to 68.40 % for *R. padi* with an average of 37.40 %. The rate of parasitism was relatively low during the beginning of February being 12.00 % and 4.00 % for *S. graminum* and *R. padi*, respectively.It is important to note that; parasitism rate was increased gradually by time in both aphid species. Statistical analysis showed significant differences between the two aphid species.

In conclusion, it seemed that the aphid species, *S. graminum* was relatively preferred for the cereal aphid parasitoid, *D. rapae* than *R. padi* species. Similar results were previously recorded by several investigators on different aphid parasitoid species e.g. Schelt(1994) and Jones *etal.* (2003). In this approach, Elliott *etal.* (1994) reported that the percentage of nymphs parasitized was markedly different among species whereas, significantly greater percentage was performed by *S. graminum* than *Diuraphis noxia*, *R. maidis*and*R. padi*. Also, Colinet *etal.* (2005) reported that *Aphidius ervi* females accepted the aphid Myzus persicae for oviposition and their

progeny developed successfully in all host ages.

Host-instar preference:

Data in Table (3) show the number of mummies and percentage of parasitism in different instars of S. graminum and R. padi by the aphid parasitoid, *D. rapae* during 2015 season. The number of *S. graminum* and *R. padi* that died and became mummified by *D. rapae* varied among the five tested aphid instars. The percentages of parasitism were 20.80, 76.00, 69.60, 44.80 and 40.80 % and 9.60, 28.00, 56.00, 55.20 and 31.20 % for the first, second, third, fourthinstars and adult stage of *S. graminum* and *R. padi*, respectively. The highest parasitism percentage (76.00 %) was recorded during the second instar of *S. graminum*and during the third instar of*R. padi*(56.00 %). Meanwhile, the lowest was recorded during the first instar for both *S. graminum* and *R. padi*, by 20.80 and 9.60 %, respectively. Statistical analysis of the data revealed significant differences in the number of mummies in the first and second instars between the two aphids species ($P \geq 0.05$), while no significant differences in the third, fourth instars and adult stage in both aphid species ($P \leq 0.05$).

In conclusion, the development of the parasitoid, *D. rapae* is possible in any instar of *S. graminum* and *R. padi* but not necessary to produce any progeny. The second and the third instars of *S. graminum* were appeared asthe optimal for parasitoid growth and survival, while the third and the fourth instars of *R. padi* were appeared asthe most preferred instars for parasitized by *D. rapae.*This finding was previously approved byShirota*et al.* (1983) who found that the second and third instars ofSitobion avenae and Metopolophium dirhodium were preferred for oviposition by Aphidiusrhopalosiphi females. Also,Ibrahim (1996) and Chau and Mackauer(2001)observed that female parasitoidswere parasitized and development successfully until the mummy stage in all host ages from young nymphs to adult.

Development period and reproduction of *D. rapae*:

As shown in Table (4) development times of *D. rapae* from oviposition until mummified aphid appearancetook 7.97 days inside the third instar and 7.45 days inside the fourth instar of*S. graminum*. However, it tooks 8.50 days inside the first instar and 7.26 days inside the second instar of*R. padi*.The averages of the development times from oviposition until the appearance of the mummified aphid were 7.68 and 8.01days for *S. graminum* and *R. padi*, respectively. It is important to note that, nymphs parasitized and mummified by *D. rapae* during the first and second instarsmay able reaching to maturity but not produce any progeny. However,*S. graminum* and *R. padi* parasitized during the third, fourth instars and adult stage were found to be able to produce an average of 7.07, 10.96 and 17.14 and 5.81, 10.77 and 16.74 nymphs before being mummified, when compared with the average production of 68.56, 57.55 and 63.05 and 58.11, 78.33 and 70.26 nymphs per a non-parasitized aphids at the same instars of both aphid species, respectively. On the other hand, development times from oviposition to adult eclosion ranged from 12.23 to 12.66 days for D. rapae

emergedfrom *S. graminum,* while ranged from 12.29 to 13.07 days for those emerged from *R. padi*.

It could be generally concluded that, development times from oviposition to mummy or to adult stage varied between the different instars. Offspring production per female was high in the adult instar than others. No offspring produced in the first and second instars.These results are in agreement with those obtained by Salto *et al.* (1983) who found that the parasitoid, Lysiphlebus testaceipes needed an average of 8.1 days to complete the egg and larval development periods. On the other hand, the parasitoid, L. testaceipes spent an average of 12.4 days from oviposition to emergence.In the same approach, Ibrahim (1996) reported that Aphis craccivora parasitized by Lysiphlebus gracilis in the fourth instar produced 3.5nymphs as an average after reaching adult stage, while, adult parasitized inside adult stage produced 5.8nymphs as an average before being mummified when compared with the average production of 29.8nymphs per a non-parasitized aphids. Also, Krespi *et al.* (1997) stated that the adult aphid parasitoids, Praon volucra and Ephedrus plagiator emerged from mummies within 15 days of collection.

So, the present results provide essential baseline information for assessing the future changes in cereal aphid parasitoid species dynamics and possible using in the biological control of cereal aphids in the wheat agroecosystem in the studied area.

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Table (1) Dominance percentages of cereal aphid parasitoid species recovered from wheat fields, Assiut, 2015 season.

Order and family	Scientific name	N0. of parasitoids	Dominance (%)
Hymenoptera			
1- Primary parasitoids			81.53
Aphidiidae	Aphidius colimani Viereck.	263	10.27
	Aphidius matricariae Haliday	69	2.69
	Diaeretiella rapae (McIntosh)	1956	76.38
	Praon necans Mackauer	128	5.00
	Ephedrusplagiator (Ness)	73	2.85
	Trioxys sp.	14	0.55
Aphelinidae	Aphelinus sp.	58	2.26
Total		2561	-
2- Secondary parasitoids			18.47
Cynapidae	Alloxysta australiae (Ashmead)	278	47.93
Encyrtidae	Aphidencyrtus sp.	67	11.55
Chalcididae	Chalcids sp.	138	23.79
Megaspilidae	Dendrucerus carpentrea (Curtis)	97	16.72
Total	-	580	-
Grand total	-	3141	-

Table (2) The relative abundance of mummies and percentages of parasitism emerging from S. graminum and R. padi.

Date	No. of aphids/species	Aphid species				T. value		Probability (0.05)
		S. graminum		R. padi				
		No. of mummies	Parasitism (%)	No. of mummies	Parasitism (%)	Tab.	Cal.	
Feb. 1	250	30	12.00	10	4.00	2.262	3.4641	0.0071
15	250	91	36.40	52	20.80	2.262	4.8394	0.0009
Mar. 1	250	162	64.80	141	56.40	2.262	2.5231	0.0326
15	250	219	87.60	171	68.40	2.262	4.7143	0.0011
Total and avg.%	1000	502	50.20	374	37.40	-	-	-

Table (3) Number of mummies and percentage of parasitism in different instars of S. graminum and R. padi.

Host instar	No. of aphids/ species	species				T. value		Probability
		S. graminum		R. padi				
		No. of mummies	Percentage mummified (%)	No. of mummies	Percentage mummified (%)	Tab.	Cal.	(0.05)
1 st.	125	26	20.80	12	9.60	2.776	3.8103	0.0189
2 nd.	125	95	76.00	35	28.00	2.776	5.0736	0.0044
3 rd.	125	87	69.60	70	56.00	2.776	1.5115	0.8052
4 th.	125	56	44.80	69	55.20	2.776	1.5942	0.1861
Adult	125	51	40.80	39	31.20	2.776	1.1464	0.3192

Table (4) Development period (± SD) of S. graminum and R. padi parasitized by D. rapae in different instars.

Host instar	Mean days to mummy ± SD		Mean days to adult ± SD		Mean numbers of progeny/♀ ± SD			
					S. graminum		R. padi	
	S. graminum	R. padi	S. graminum	R. padi	Healthy	Mummified aphids	Healthy	Mummified aphids
1 st.	7.81 ± 1.13	8.50 ± 0.80	12.42 ± 1.76	12.42 ±1.08	43.40 ± 16.69	-	51.67 ±15.32	-
2 nd.	7.58 ± 1.28	7.26 ± 0.92	12.23 ± 1.69	12.29 ±1.62	75.50 ± 19.11	-	44.86 ±12.17	-
3 rd	7.97 ± 1.28	7.63 ± 1.45	12.66 ± 1.48	12.36 ±1.36	68.56 ± 17.01	7.07 ±3.63	58.11 ±21.19	5.81 ±3.98
4 th.	7.45 ± 1.16	8.43 ± 1.18	12.59 ± 1.40	13.07 ±1.57	57.55 ± 8.18	10.96 ±3.51	78.33 ±32.70	10.77 ±3.87
Adult	7.57 ± 1.49	8.23 ± 0.99	12.57 ± 1.80	12.92 ±1.22	63.05 ± 18.31	17.14 ±6.12	70.26 ±23.73	16.74 ±4.98
Mean ± SD	7.68 ± 0.21	8.01 ± 0.54	12.49 ±0.17	12.61 ±0.36	61.61 ±12.16	11.72 ±5.08	60.65 ±13.61	11.11 ±5.47

سلوك الأختيار العوائلي للطفيل ***McIntoshDiaeretiella rapae*** لحشرات من النجيليات في صعيد مصر

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معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقى – جيزة – مصر

الملخص العربي:

أجريت هذه الدراسة فى منطقة أبنوب – محافظة أسيوط – بهدف دراسة الوفرة النسبية للطفيليات الأولية والثانوية المصاحبة لحشرات من النجيليات و من الشوفان و قد بينت النتائج ما يلى:

وجد أن درجات السيادة بالنسبة للطفيليات الأولية كانت عالية مقارنة بالطفيليات الثانوية حيث كونت كلا منهما (81.53 و 18.47 %) من المجموع الكلى للطفيليات على الترتيب.أظهرت الدراسة أن كلا من الطفيل الأولى *Diaeretiellarapae*(McIntosh) و الطفيل الثانوى *Alloxystaaustraliae* (Ashmead) لهما درجة سيادة عالية مقارنة بباقى الطفيليات حيث كون كلا منهما (76.38 و 47.93 %) من مجموع الطفيليات الأولية و الثانوية على الترتيب.

عند دراسة تفضيل الطفيل لنوعى المن و عمر العائل المناسب لعملية التطفل بينت الدراسة أن حشرات من النجيليات كانت أكثر تفضيلا نسبيا للطفيل عن حشرات من الشوفان.كما وجد أن الطفيل *D. rapae*له قدرة على التطفل و النمو على كل أعمار نوعى المن تحت الدراسة. كذلك وجد أن العمر الثانى و الثالث لحشرات من النجيليات كانت الأكثر تفضيلا للطفيل فى حين كان العمر الثالث و الرابع هما الأكثر تفضيلا للطفيل في حالة حشرات من الشوفان .عند دراسة طول فترة النمو للطفيل بينت الدراسة أيضا أن فترة النمو من وضع البيض و حتى تكون المومياء كانت فى المتوسط (8.01 ، 7.68) يوما بالنسبة لحشرات من النجيليات و من الشوفان على الترتيب.كما وجد أيضا أن انتاج الولدات للحشرات المتطفل عليها كانت عالية للحشرات الكاملة مقارنة بالأعمالر الأخرى لحشرات من النجيليات و من الشوفان ، كما وجد أن العمر الأول و الثانى لم تنتج أى أفراد.