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Biological studies on certain aphid species and their parasitoid *Aphidius matricariae* Hal. (Hymenoptera: Aphidiidae)

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ABSTRACT

Aphids are the serious insect pests attacking wheat plants in Egypt. Among their most important aphid parasitoid species is *Aphidius matricariae* Hal. (Hymenoptera: Aphidiidae). Biological studies on two key cereal aphid species; *Rhopalosiphum padi* L., *Schizaphis graminum* Rond. and their parasitoid *A. matricariae* were undertaken under the laboratory conditions of, 20 ±1^{o}C, 50-70 % R.H. and 16: 8 L: D. Effect of the host plants; wheat and barely on developmental time, longevity and fecundity of *R. padi* and *S. graminum* were studied. Longevity and life cycle of *R. padi* were longer on wheat (13.11 ± 6.1 and 17.39 ± 4.3 days) than on barley (12.2 ± 4.85 and 16.2 ± 4.4 days) and vice- versa for *S. graminum* (14.31 ± 3.68 and 19.63 ± 3.7 days on wheat and 19.13 ± 4.3 and 24.33 ± 4.4 days on barley), respectively. Fecundity of *R. padi* was higher (50.15 ± 18.98 nymphs/female) on wheat than on barley (40.33 ± 14.41) and vice-versa for *S. graminum* (42.81 ± 14.33 nymphs/female on wheat and 59.77 ± 13.16 on barely). Duration of different immature stages, fecundity, survival rate, sex ratio, longevity, host preference and mummies storage period for *A. matricariae* were estimated. Total life cycle was (16.23 ± 0.43 days on *R. padi* and 15.6 ± 0.5 days on *S. graminum*). Total number of eggs/ female (e/f), total number of mummies/female (m/f) and percentage of adult emergence were higher on *R. padi* than on *S. graminum*. They reached 86.7 ± 21.8 e/f, 66.83 ± 26.39 m/f and 74.36 % on *R. padi* and 83.4 ± 14.62 e/f, 63 ± 21.71 m/f and 70.86 % on *S. graminum*, respectively. Sex ratio (females: males) was 1: 0.9 on *R. padi*, and 0.7: 1 on *S. graminum*. Longevity averaged 12.47 ± 1.7 for females and 9.23 ± 3.25 days for males. Superior performance of *A. matricariae* was recorded on *R. padi*. Highest emergence rates (94 and 80%) were estimated at 8 ^{o}C in the mummies stored for one and two weeks, respectively.

Key Words: Biology, *Rhopalosiphum padi, R. maidis, Schizaphis graminum, Aphidius matricariae,* wheat, barley.

INTRODUCTION

Wheat (*Triticum aestivum* L., Fam. Gramineae) is the most important cereal crop in Egypt. Aphids (Aphididae: Homoptera) are the serious insect pests attacking wheat plants not only in Egypt but also in many other countries bordering the Mediterranean Sea (Kindler *et al.*,1991). Aphids are also efficient vectors of different strains (types) of Barley Yellow Dwarf Virus (BYDV). The virus has recently been identified in some parts of Egypt (ICARDA 1995).

Damages to the crop caused by aphids were estimated by up to 23%, particularly in upper Egypt, where highest infestation mostly occurs (Tantawi, 1985). In Egypt, *Rhopalosiphum padi* L., *R. maidis* Fitch, *Schizaphis graminum* Rond, and *Sitobion avenae* Fab. were recorded as main aphid species on wheat plants (El-Hariry, 1979).The Russian

wheat aphid, *Diuraphis noxia* Kurdj. was recently added (Attia and El-Kady, 1988). *R. padi* was recorded as the most common and important cereal aphid species on wheat in Egypt (EL-Heneidy, 1994).

Utilization of aphid parasitoids in biological control has given significant results in many countries of the world. Aphidiids form the major part of the primary parasitoid spectrum of aphids, while the aphelinids form the other small group. *Aphidius matricariae* Hal. (Hymenoptera: Aphidiidae) is one of the widely distributed aphidiid parasitoid species in almost all the Mediterranean countries, and has a wide range of hosts in agroecosystems. (Stary,1976). The species was recently recorded as one of the most abundant parasitoid species in wheat fields in Egypt (El-Heneidy *et al* 2001).

The present study is concerned with the biology of the parasitoid, *A. matricariae* when reared on the key cereal aphid species *R. padi* and *S. graminum* under laboratory conditions.

MATERIALS AND METHODS

Both cereal aphid species *R. padi* and *S. graminum* and the parasitoid *A. matricariae* were collected from wheat fields in Egypt. Detailed rearing conditions and methods for the laboratory cultures of the hosts and the parasitoid were described by Adly (2002). Biological studies on both aphid species were carried out on the two host plants; wheat and barley. Biological studies were carried out under laboratory conditions of 20 ±1^{o}C, 50-70% R.H. and 16:8 L:D photoperiod.

Aphid Biology: Newly deposited nymphs from the aphid apterous adults (50 individuals /replicate and treatment n =50) from both aphid species were used as start for biological studies. Each individual of the first nymphal instar of *R. padi* and *S. graminum* was placed on an one- week old wheat or barley seedling, in a small pot and kept in small cage. Cages were placed inside an incubator at 20 ±1^{o}C. Individual nymphs were observed daily to record the duration for each nymphal instar (through molting and removing the caste skin regularly) and the time to reach the adult stage. Longevity and fecundity (reproductive rates and periods) for the apterous adults were daily estimated by recording number of progeny per adult.

Parasitoid Biology: **Duration of Feeding Immature Stages**: One hundred nymphs from each of *R. padi* or *S. graminum* , (almost 2nd and 3rd nymphal instars), were placed on wheat seedlings cultivated in small pots and kept in small cages (30 individuals / replicate and treatment n =30). In each cage, aphids were exposed to 10-mated parasitoid females for one hour. Afterwards, parasitoid females were removed, and then the cages were placed inside an incubator at 20 ±1^{o}C. To determine duration, of different parasitoid stages (egg, larval instars, pre-pupa and pupa), parasitized aphids were dissected daily by a very fine needle, in a drop of Ringer's solution using a stereomicroscope.

Fecundity, Survival Rate, Sex Ratio, Longevity and Host Preference:
All these studies were experimented at 23±1^{o}C.

Fecundity: Ten mated females of the parasitoid were provided daily, until their death, with 100 nymphs (*R. padi* or *S. graminum*, 2nd and 3rd instars) in a Petri-dish containing droplets of honey and wheat leaves; their ends were dipped in moistened paper towels, following the technique of Michels *et al*. (1987). Parasitized aphids were dissected daily to determine the number of eggs laid by each parasitoid female per day and the total number of eggs (10

replicates / treatment). Thirty pairs of ovaries of newly emerged mated females were also dissected in Ringer's solution to count the number of eggs / ovary.

Survival and Sex Ratio: Each mated female of the parasitoid was provided daily with 100-120 aphid nymphs (2^{nd} and 3^{rd} instars) on wheat plants, in the small cages until mortality. Parasitized aphids were allowed to feed on wheat plants until the parasitoids completed their life cycle. Mummies were collected daily. The daily number of mummified aphids produced per female was recorded. Mummies were kept in small vials until adult emergence. Number of mummies and adults emerged per each parasitoid female (30 replicates / treatment) were counted. Emerged adults were sexed to estimate the sex ratio.

Longevity: Formed mummies of parasitoid were placed individually in small glass vials until adult emergence. Two groups (30 pairs; males and females) from each of the newly emerged adults were left to complete their longevity; the 1^{st} group was left unfed and the 2^{nd} group was fed on droplets of honey, then the longevity for each sex was estimated.

Host Preference: Ten mated females of *A. matricariae* were provided with adequate number of nymphs of each aphid species (*R. padi*, *S. graminum*, and *R. maidis*) for 24hrs Each replicates (10 replicates / treatment) consisted of 100 2^{nd} and 3^{rd} nymphal instars from each species, when one species of the aphids was exposed; 50 nymphs from each species when the two species of the aphids were exposed, and 33 nymphs from each species when the three species of aphids were exposed. Caged plants were placed in a growth chamber. Aphids were fed on wheat plants until forming mummies. Mummies were collected and kept in small glass vials. Three variables were measured for each replicate, the proportion of parasitized aphids within 24hrs, sex ratio and longevity of emerged adults.

Storage of Mummies: Newly formed mummies from the laboratory cultures of the parasitoid were used for this study. Five replicates (20 mummies/ replicate) were stored at each temperature. Mummies (at the pupal stage of parasitoid) were divided into two groups, the first was stored in an incubator at 4, 6 and 8 $\pm 0.5^{o}$C directly and the other group was stored at 11 $\pm 1^{o}$C for 24 hrs and then transferred to 6 $\pm 0.5^{o}$C. Mummies were stored for one month. Every week, five replicates (100 mummies) were taken out of the incubator for evaluating emergence rate, sex ratio and fecundity for each treatment. Five newly emerged mated females from each treatment were provided with adequate number of aphids in a growth chamber at 23 $\pm 1^{o}$C until their death. Number of formed mummies was counted to estimate the effect of storage on reproduction.

Statistical Analysis: All data on both the aphids and the parasitoid were statistically analyzed using the software for Statistical Block of Social Science program SAS (Statistical Analysis System) ANOVA.

RESULTS AND DISCUSSION

Biological Studies of Cereal Aphids

Developmental Period (Duration): Obtained results of different biological studies on *R. padi* and *S. graminum* on the two host plants; wheat and barley are summarized in tables 1-3. Significant differences were found between the effect of wheat and barley on the time to adult of *R. padi* and *S. graminum* at 20 ^{0}C. Statistical analyses showed no significant differences between *R. padi* and *S. graminum* regarding the developmental time of different nymphal instars on the two tested host plants; 20 ^{0}C. Total mortality rates of both aphid species were

higher on barley than on wheat(Table 1). Thus, mortality rates were higher in *S. graminum* than those in *R. padi*, they reached 63.2 and 47.6 % on wheat and barley, respectively. In this study, mean durations of the immature stages of *R. padi* agreed with those reported by Yang (1990), Abd-El-Rahman (1997) and El-Fateh (2000).

Longevity: As show in table 2, longevity and total life cycle of *R. padi* were longer on wheat (13.11 ± 6.1) than on barley (12.2 ± 4.8), while they were vice- versa for *S. graminum*, 14.31 ± 3.6 and 19.13 ± 4.3, respectively. It was longer in *S. graminum* than in of *R. padi* on both tested host plants. Generation period was nearly equal for *R. padi* and *S. graminum* on wheat and barley it ranged 4-7 days (Table 2). Statistical analysis showed no significant difference between wheat and barley for the longevity and total life cycle of *R. padi*, but significant differences between both of them in *S. graminum*. Significant differences were found between *R. padi* and *S. graminum* in the longevity and the total life cycle on the two tested host plants. The results disagree with those of, Hutchinson and Bale (1994) who stated that the life span of *R. padi* was 17 ± 1.14 days on barley at 20 ^{0}C. El- Fateh (2000) found that the life cycle, life span and mean generation time of the *R. padi* lasted 7.37, 11.94, and 10.13 days, respectively on wheat at 22 ± 2.5 ^{0}C and 55% R. H. El-Gantiry *et al.* (1999) stated that the life cycle of *S. graminum* was 6.55 days at 20^{0}C.

Fecundity: As shown in table (3), parturition and post parturition periods of *R. padi* were always longer on wheat than on barley, and *vice- versa* in case of *S. graminum.* Daily produced progeny of *R. padi* and *S. graminum* was nearly equal on the two host plants. Total fecundity of *R. padi* was always higher on wheat than on barley; 50.15 ± 18.9 and 40.33 ± 14.41 nymph/female, respectively, and *vice- versa* in case of *S. graminum*; 42.81 ± 14.33 and 59.77 ± 13.16 nymph/female, respectively. Statistical analysis showed no significant difference between them for the parturition periods, significant difference was recorded between wheat and barley for daily fecundity (nymphs/ female/ day)of *R. padi* and *S. graminum.* Significant differences appeared between wheat and barley for the fecundity (total nymphs/female) of *R. padi* and *S. graminum*. Significant differences between *R. padi* and *S. graminum* for the parturition periods, and the total fecundity (no. of nymphs/ female), but was insignificant in the daily fecundity (nymph/ female/ day) on the two tested host plants were found. Obtained results agreed with those of Dean (1973) who stated that *R. padi* was more fertile on wheat than on barley. The same author in (1974) reported that the fecundity of *R. padi* reached its maximum at 20 ^{0}C. The present results disagree with those of Lopez *et al.* (1993) who mentioned that the nymphal, pre- parturition, parturition and post- parturition periods of *R. padi* lasted 8, 1, 23, and 6 days, respectively and fecundity was 33 nymphs/ female under 20 ^{0}C, 70-80% R.H. and L: D 16:8. Hutchinson and Bale (1994) reported that the mean total fecundity of *R. padi* on barley was 89.36 ± 1.28 nymphs/ adult, at 20 ^{0}C and L: D 16:8. Leather *et al.* (1989) estimated the total fecundity of *R. padi* on wheat and barley by 26.38 ± 1.76 and 28.54 ± 2.36 nymphs/ female, respectively at 20 ^{0}C and 16 h photoperiod.

Aphid Parasitoid *Aphidius matricariae*

Obtained results of different biological studies of *A. matricariae* on *R. padi* and *S. graminum* are summarized in tables 4-8.

Developmental Period (Duration): Average incubation period of egg stage was 2.7 ± 0.47 and 2.5 ± 0.51 days on *R. padi* and *S. graminum*, respectively. Average duration of first larval instar was 2.7 ± 0.47 and 2.57 ± 0.5 days; second larval instar was 1.4 ± 0.5 and 1.53 ± 0.51 days and third larval instar was 2.77 ± 0.43 and 2.13 ± 0.35 days on *R. padi* and *S. graminum*, respectively.

Full-grown larva uses its mandibles to spin a cocoon inside the empty aphid skin. At this stage, the aphid skin becomes mummified. The mummy in this phase was clear enough, so that the internal parasitoid is clearly visible through the ventral surface, and the larva continues spinning layers of silk inside the mummy, thus, the developing parasitoid becomes not visible through the ventral surface and the color turns into shiny brown. Average duration of pre-pupa was 1.17 ± 0.38 and 1.27 ± 0.45 days and that of pupa was 5.5 ± 0.51 and 5.67 ± 0.48 days on *R. padi* and *S. graminum*, respectively. Meconia are found inside the cocoon after adult emerge.

Total developmental period to adult: Adult parasitoid always emerges from the mummy through an emergence hole by the help of its mandibles, the emergence hole is circular and has an emergence lid that is easily broken. Males usually emerge earlier than females. Males are apparently ready to mate as soon as they emerge. Males and females were easily identified by the posterior abdominal segment. Average duration was 16.23 ± 0.43 and 15.6 ± 0.5 days on *R. padi* and *S. graminum*, respectively. Duration of *A. matricariae* of all stages and time to adult were very close in both *R. padi* and *S. graminum* (Table 4). The parasitoid species *A. matricariae* had only three larval instars, only the first and third larval instars have mandibles, the first larval instar uses it to kill other competitive larvae which may be found inside the same aphid and the third larval instar uses it to consume the host tissuse and to spin a very thin silky cocoon inside the body of its host.

The literature on larval development in aphid parasitoids (Hymenoptera: Aphidiidae) is inconsistent and often contradictory. The present results agree with those of O'Donnell (1987 a, b) who provided convincing evidence that there are only three larval instars in aphidiines and with Schlinger and Hall (1960) who stated that the second larval instar lacks mandibles, and the third larval instar was the first to have spiracles and was again equipped with mandibles. The present results disagree with those of Shalaby and Rabasse (1979) who reported four instars for *A. matricariae* at 20^{o}C on the aphid *Myzus persicae* in France. Average durations of *A. matricariae* were 3.67, 1.17, 0.92, 1.0, 1.75, 0.5, 4.25 and 4.44 days for the incubation periods of eggs, the four larval instars and the prepupal and pupal stages for males and females, respectively; and with those of Julio (1991) who estimated the developmental time from egg to mummy, mummy to adult and from egg to adult of *A. matricariae* at 21.1^{o}C on *D. noxia* by 8.677, 15.55, 4.625 days, respectively.

Fecundity: Data presented in table (5) indicate ovipositional periods, daily, and total number of eggs laid by the parasitoid females on the two tested aphid species. Pre- ovipositoin period was always less than 24hrs. Mean the daily number of eggs/ female / day reached 16.44 ± 4.54 on *R. padi* and 13.25 ± 3.86 egg/ female / day on *S. graminum*, while the total number of eggs/ female on *R. padi* (86.7 ± 21.8) was higher than on *S. graminum* was (83.4 ± 14.62). Average number of eggs / ovary of *A. matricariae* virgin parasitoid females were 83.8 ± 24.3. Statistical analysis showed no significant difference between *R. padi* and *S. graminum* for ovipositoin period and total fecundity, while significant differences appeared between them for the daily fecundity. The present results disagree with those of Shalaby and Rabasse (1979) who reported respective averages of 10.8 and 2.9 days for oviposition and post ovipostion periods of *A. matricariae* females, respectively. The average number of eggs laid by a single mated female was 308.7 eggs (range 221-407 eggs). Stary (1970); Hart *et al*. (1978); stated that in Aphidiidae, the reproductive capacity is variable. It can reach an amount of several hundred eggs per female, but only one individual parasitoid is able to emerge from the host individual.

Survival Rate: Data presented in table (6) show daily, total numbers of mummies / female and percentage of adult emergence, (12.52 ± 5.1 and 9.41 ± 3.5 mummies/ female/ day, and 66.83 ± 26.39 and 63 ± 21.71 mummies/ female, and 74.36 and 70.86% emergence on *R. padi* and *S. graminum*, respectively. These values were higher on *R. padi* than on *S. graminum.* Statistical analysis showed significant difference between *R. padi* and *S. graminum* for the parasitoid concerning the mean number of mummies/ female/ day, but insignificant among in the mean number of total mummies/ female. Giri *et al* (1982) used *M. persicae* as a host for *A. matricariae* to estimate the optimum degree for progeny production and survival during the mummy stage at 12.8-21^{o}C, Julio (1991) estimated emergence rate52.63, % for *A. matricariae* at 21.1^{o}C on *D.noxia*.

Sex Ratio: Sex ratio was always in favour of the females in *A. matricariae* on *R. padi*, and *vice –versa* on *S. graminum* (Table 6). Shalaby and Rabasse (1979) reported the sex-ratio (females: males) for *A. matricariae* by 1.3:1 on *M. persicae* in the laboratory while Julio (1991) estimated the sex ratio of *A. matricariae* at 21.1^{o}C on *D. noxia*, by only 30% females.

Longevity: Longevity of both sexes of the parasitoid was longer when they were fed on honey droplets (12.47 ± 1.7, 9.23 ± 3.25 days) compared with unfed individuals (2.77 ± 0.77, 2.93 ± 0.91 days) for female and male, respectively.

Parasitoids' Host Preference: *A. matricariae* was provided with known number of nymphs (1st and 3rd instars) of the cereal aphid species *R. padi, S. graminum*, and *R. maidis* for 24hrs, in three different combinations to test *A. matricariae* host preference. The sex ratios of the three experiments were biased towards an excess of females in all the hosts aphid, when one, two and three aphid species were exposed except in case of the two hosts (*R. padi* + *R. maidis*) and (*S. graminum* + *R. maidis*) were exposed for the parasitoid, it biased towards an excess of males. Superior performance of *A. matricariae* was recorded on *R. padi*, specially when it was exposed together with *S. graminum.* Highest number of mummies for the parasitoid was estimated when it was exposed to *R. padi* with *S. graminum* together than in any other case. *R. padi* and *S. graminum* were highly suitable as laboratory hosts for rearing *A. matricariae*. Conversely, *R. maidis* showed a relatively poor performance as a host for rearing *A. matricariae*. (Table 7). Stary (1970) and Mackaurer (1973) reported that although host preference under free choice experiments and certain laboratory conditions may help for certain extent, to choose the proper host species for rearing of aphid parasitoids, the parasitoid itself has mostly other behavioral considerations under field conditions.

Storage of Parasitoid Mummies: Newly formed mummies (<than 24hrs) from the laboratory cultures of the parasitoid species *A. matricariae* were used for the study of storage capability. The sex ratio was biased towards an excess of females in the adults emerged from the mummies stored for one and two weeks, while in those stored for three weeks showed an excess to males at 8 ^{o}C. Generally, emergence rates were almost zero in the mummies stored for two weeks at 4 ^{o}C, and for three weeks at 6, and 11 to 6 ^{o}C. Among all the tested temperatures, the lowest emergence rates, (44, 14%) were estimated when the mummies were stored at 11 to 6 ^{o}C for one and two weeks, respectively. For the same temperature, there were some replicates in which the emergence rate was equal to zero. On the contrary, highest numbers of mummies/ female (92.2, and 71.4) were recorded at the same periods and temperature, respectively.

Highest emergence rates were estimated at 8 ^{o}C on the mummies stored for one (94%) and two weeks (80%). Lowest number of mummies/ female (15.2 mummies) was recorded at

the same temperature in the mummies stored for three weeks. Accordingly, the transition period had an adverse effect on the emergence rate, while it favored. Formation of the number of mummies produced by female progeny. Mummies of the parasitoid *A. matricariae*, could be stored at 8 ^{o}C for three weeks with highest emergence rate and number of mummies / female. Negative correlation was recorded between the emergence rate of the stored mummies and the storage period. The reduction attained 14.9 and 25% from the first to the second week and from the second to the third week, respectively. Four weeks after storage of mummies, the parasitoid adults emerged only from those stored at 8 ^{o}C (Table 8). Statistical analysis showed significant differences among the temperatures 4, 6, 8, and 11 to 6 ^{o}C concerning the emergence rates and total number of mummies/ female. This result agree with that Polgar (1987) but disagree with those of Shalaby and Rabasse (1979), who reported that the percentage of emergence, when the mummies were kept at transition period, before conservation in refrigerator at 8 ^{o}C, was generally higher than those passed at the higher temperature of 20-23 ^{o}C, before conservation. The present results disagree, also, with Archer *et al.* (1973), who stated that the acclimatization did not adversely affect storage survival. Scopes *et al*. (1973), mentioned that the lower temperature storage of *A. matricariae* was possible. Storage of pupae at 7^{o}C for 20 days before transfer to 22^{o}C resulted in a 98% survival rate and cool storage, did not affect fecundity.

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Table (1): Mean duration (days) of different nymphal instars of *Rhopalosiphum padi* and *Schizaphis graminum* on wheat and barley, at 20 ^{o}C, 50-70% R.H., and L:D 16:8

Aphid species		***R. padi***		***S. graminum***	
Nymphal instar	**Host Plant**	**Wheat**	**Barley**	**Wheat**	**Barley**
First	Mean ± S.d	1.48 ± 0.51	1.23 ± 0.42	1.56 ± 0.5	1.3 ± 0.47
	Range	(1-2)	(1-2)	(1-2)	(1-2)
	% Mortality	8	14	18	12
Second	Mean ± S.d	1.17 ± 0.38	1.43 ± 0.5	1.28 ± 0.46	1.33 ± 0.48
	Range	(1-2)	(1-2)	(1-2)	(1-2)
	% Mortality	2	4	12	16
Third	Mean ± S.d	1.39 ± 0.49	1.2 ± 0.41	1.25± 0.44	1.13 ± 0.35
	Range	(1-2)	(1-2)	(1-2)	(1-2)
	% Mortality	2	2	6	12
Fourth	Mean ± S.d	1.26± 0.44	1.05 ± 0.22	1.25 ± 0.44	1.1 ± 0.31
	Range	(1-2)	2%	(1-2)	(1-2)
	% Mortality	2	2	2	2
Time to Adult	Mean ± S.d	5.3 ± 0.76	4.9 ± 0.59	5.34 ± 0.65	4.87 ± 0.78
	Range	(4-7)	(4-6)	(4-7)	(4-6)
	Mortality	14	22	38	42

Table (2): Mean longevity, total life cycle and generation period (days) of apterous females of *Rhopalosiphum padi* and *Schizaphis graminum* on wheat and barley, at 20 ^{o}C, 50-70% R.H. and L:D 16:8

	R. padi			***S. graminum***	
	Host Plant	**Wheat**	**Barley**	**Wheat**	**Barley**
Longevity	Mean ± S.d	13.11 ± 6.1	12.2 ± 4.85	14.31 ± 3.68	19.13 ± 4.3
	Range	(6-24)	(6-21)	(9-21)	(11-26)
Total life cycle	Mean ± S.d	17.39 ± 4.3	16.2 ± 4.4	19.63 ± 3.7	24.33 ± 4.4
	Range	(11-24)	(10-24)	(15-26)	(18-32)
Generation period	Mean ± S.d	5.54 ± 0.75	5.3 ± 0.76	6 ± 0.62	5.33 ± 1.06
	Range	(4-7)	(4-7)	(4-7)	(4-7)

Table (3): Mean parturition periods (/days) and mean fecundity (mean number of nymphs/ female) of *Rhopalosiphum padi* and *Schizaphis graminum* on wheat and barley, at 20 ^{o}C, 50-70% R.H. and L: D 16:8

		R. padi		*S. graminum*	
Periods	**Host Plant**	**Wheat**	**Barley**	**Wheat**	**Barley**
Pre-parturition	Mean ± S.d	0.24 ± 0.43	0.4 ± 0.5	0.66 ± 0.48	0.47 ± 0.57
	Range	(0-1)	(0-1)	(0-1)	(0-2)
Parturation	Mean ± S.d	10.24 ± 4.07	9.55 ± 3.68	10.41 ± 3.39	12.93 ± 3
	Range	(5-18)	(5-18)	(7-20)	(6-17)
Post-parturition	Mean ± S.d	2.63 ± 2.85	2.25 ± 2.07	3.25 ± 1.97	5.73 ± 2.35
	Range	(0-10)	(0-9)	(0-10)	(3-12)
Daily mean	Mean ± S.d	5.01 ± 1.04	4.29 ± 0.81	4.2 ± 1.1	4.58 ± 0.89
	Range	(2.45-7.67)	(2.6-6)	(2.4-6.3)	(3-6.5)
Total mean	Mean ± S.d	50.15±18.98	40.33±14.41	42.81±14.33	59.77±13.16
	Range	(23-75)	(22-66)	(24-80)	(27-80)

Table (4): Mean duration (/days), for different immature stages of *Aphidius matricariae* reared on *Rhopalosiphum padi* and on *Schizaphis graminum* at 20 ^{0}C, 50-70% R.H. and L:D16:8

Host Insect		*R. padi*	*S. graminum*
Egg	**Mean ± S.d**	2.7 ± 0.47	2.5 ± 0.51
	Range	(2-3)	(2-3)
1st larval insrar	**Mean ± S.d**	2.7 ± 0.47	2.57 ± 0.5
	Range	(2-3)	(2-3)
2nd larval insrar	**Mean ± S.d**	1.4 ± 0.5	1.53 ± 0.51
	Range	(1-2)	(1-2)
3rd larval insrar	**Mean ± S.d**	2.77± 0.43	2.13± 0.35
	Range	(2-3)	(2-3)
Pre-pupae	**Mean ± S.d**	1.17 ± 0.38	1.27 ± 0.45
	Range	(1-2)	(1-2)
Pupae	**Mean ± S.d**	5.5 ± 0.51	5.67 ± 0.48
	Range	(5-6)	(5-6)
Time to adult	**Mean ± S.d**	16.23 ± 0.43	15.6 ± 0.5
	Range	(16-17)	(14-16)

Table (5): Mean ovipositoin periods (/days) and fecundity (number of eggs/ female) for *Aphidius matricariae* on *Rhopalosiphum padi* and *Schizaphis graminum*, at 23^{0}C, 50-70% R.H. and L:D 16:8

	Values	***R. padi***	***S. graminum***
Oviposition period	Mean ± S.d	5.4 ± 1.17	5.3 ± 0.95
	Range	(4-8)	(4-7)
Post oviposition period	Mean ± S.d	1 ± 1.05	0.9 ± 1.2
	Range	(0-3)	(0-3)
Daily laid eggs	Mean ± S.d	16.44 ± 4.54	13.25 ± 3.86
	Range	(11.2-23.8)	(7.58-19.05)
Total	Mean ± S.d	86.7 ± 21.8	83.4 ± 14.62
	Range	(56-119)	(66-109)

Table (6): Mean number of mummies / female, emergence rate, and sex ratio for *Aphidius matricariae* on *Rhopalosiphum padi* and *Schizaphis graminum* at 23 ^{0}C, 50-70% R.H. and L:D 16:8 .

Aphids species		***R. padi***	***S. graminum***
Mummies/female/day	Mean ± S.d	12.52 ± 5.1	9.41 ± 3.5
	Range	(5.25-28)	(4.67-21)
Total mummies/female	Mean ± S.d	66.83 ± 26.39	63 ± 21.71
	Range	(34-113)	(34-110)
Emergence	%	74.36	70.86
Sex ratio	F:M	1:0.91	0.67:1

Table (7): Mean number of mummies / *Aphidius matricariae* female and sex ratio of the parasitoid when three aphid species were exposed in three different experiments,at 23 ^{0}C, 50-70% R.H. and L:D 16:8

Values	**No. of aphid exposed**			**Mean no. of mummies**			**Sex ratio**
	R. padi	*S. graminum*	*R. maidis*	*R. padi*	*S. graminum*	*R. maidis*	F: M
Mean ± Sd	100			12.8 ± 4.5			1:0.64
Range				(5-20)			
Mean ± Sd		100			8.1 ± 3		1:0.72
Range					(4-15)		
Mean ± Sd			100			5.7 ± 2.3	1:0.74
Range						(4-11)	
Mean ± Sd	50	50		14.8 ± 1.9	3.5 ± 0.7		1:0.1
Range				(12-17)	(3-4)		
Mean ± Sd	50		50	11 ± 1.1		6.1 ± 0.9	0.9:1
Range				(9-12)		(5-7)	
Mean ± Sd		50	50		9.7 ± 2.8	6 ± 1.4	0.9:1

Range					(6-15)	(5-8)	
Mean ± Sd	33	33	33	12 ± 5.7	2.6 ± 0.5	2.6 ± 0.5	1:0.9
Range				(7-21)	(2-3)	(2-3)	

Table (8): Mean percentage of adult emergence rates, sex ratio, and number of mummies/ female of *Aphidius matricariae* emerged from stored mummies at four temperatures

Temperature	**Week(s)**	**Values**	**% Adult emergence**	**Sex ratio F:M**	**No. of mummies/ female**
4 ^{0}C	One	Mean ± S.d	70	1:0.8	27 ± 6.6
		Range	(40-90)		(21-37)
6 ^{0}C	One	Mean ± S.d	40	1:0.14	47 ± 10.9
		Range	(30-60)		(33-60)
	Two	Mean ± S.d	26	1:0.44	35.8 ± 3.4
		Range	(10-50)		(31-40)
8 ^{0}C	One	Mean ± S.d	94	1:0.45	64.4 ± 13.9
		Range	(80-100)		(50-87)
	Two	Mean ± S.d	80	1:0.67	28.8 ± 6.6
		Range	(70-90)		(23-37)
	Three	Mean ± S.d	60	0.67:1	15.2 ± 1.8
		Range	(30-80)		(13-17)
11 to 6 ^{0}C	One	Mean ± S.d	44	1:0.7	92.2 ± 39.9
		Range	(20-80)		(59-146)
	Two	Mean ± S.d	14	1:0.17	71.4 ± 69.5
		Range	(0-30)		(79-158)