Egyptian Journal of Biological Pest Control, 16(2), 2006, 103-106

Life Tables of the Aphid Parasitoid Species, *Aphelinus albipodus* Hayat & Fatima (Hym.: Aphelinidae) and Its Host the Oat Bird Cherry Aphid *Rhopalosiphum padi* L. (Homo.; Aphididae).

Adly*, D.; A. H. El-Heneidy*; A. Agamy and M. M. El-Hussieni****
*Plant Protection Research Institute, ARC, Giza, Egypt.
**Biological Control Center, Faculty of Agriculture, Cairo University, Giza, Egypt.

(*Received, November 12, 2006; Accepted, December 8, 2006*)

ABSTRACT

Rhopalosiphum padi L., *Schizaphis graminum* Rond, and *Sitobion avenae* Fab. were recorded as main aphid species on wheat plants in Egypt. *Aphelinus albipodus* Hayat & Fatima has been imported from China to Egypt for the biological control of cereal aphids particularly, *R. padi*. Developmental periods of the parasitoid were shorter on *S. avenae* than that on *R. padi;* period from egg to adult was 12.45 and 13.55 days and the first adult parasitoid emerged at 12, 13 days on *S. avenae* and *R. padi,* respectively. The net reproductive rate and the intrinsic rate of increase of *R. padi* were greater than that for *A. albipodus* on *R. padi* and *S. avenae*. They were 58.32, 24.06, 13.98 and 0.37, 0.195, 0.181 for *R. padi* and *A. albipodus* on *R. padi* and *S. avenae*, respectively. These results suggest that the exotic parasitoid *A. albipodus* hasn't the potential to be used for controlling *R. padi* and *S. avenae* on wheat plants in Egypt.

Key Words: Life table, *Aphelinus albipodus, Rhopalosiphum padi*, *Sitobion avenae,* wheat, Egypt.

INTRODUCTION

Aphids are one of the insect groups whose economic importance increases with the development of agriculture (Stary, 1976). Aphids are the serious pests attacking cereal crops, particularly wheat, barley and corn not only in Egypt but also in many other countries; Southern Russia, Iran, Afghanistan, and countries bordering the Mediterranean Sea (Kindler *et al.,* 1991). 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 to the cereal aphid fauna (Attia and El-Kady, 1988). *R. padi* was recorded as the most common and important cereal aphid species on wheat plants in Egypt (El-Heneidy, 1994).

Aphelinus albipodus Hayat & Fatima (Hymenoptera: Aphelinidae) [formerly *Aphelinus sp.* nr. varipes; see Hayat & Fatima (1992) and Gonzalez *et al.* (1994)] was collected from Russian wheat aphid, *D. noxia* hosts in the vicinity of Tahcheng, People's Republic of China and imported to the USA in 1992 for biological control of the latter pest species then exported to Egypt in 2001 for the biological control of cereal aphids particularly, *R. padi*.

There is no relation between the numbers of eggs laid by animals and the abundance of these animals in nature. The number in nature depends upon a balance struck between birth rate and death rate. An animal's innate capacity for increase depends upon its fecundity, longevity, and speed development. With a population, these are measured by the birth rate and the survival rate (Andrewartha and Birch, 1954).

Birch (1948) identified the life table parameters to be used in calculating insect population development by adapting human demography values. The intrinsic rate of increase, r_m is frequently used as a measure of a parasitoid population's potential rate of increase under specific environmental conditions. The parameter r_m combines reproduction and mortality estimates into a single value; thus, it is a practical measure of the potential performance of an organism in a given environment. Accordingly, r_m has been used as a relative measure of the potential impact that a parasitoid may have on its host's population (Force & Messenger, 1968, Messenger, 1970 and Kambhampati & Mackauer, 1989). Ambient temperatures, among other factors, are known to affect the r_m of parasitoid populations (Force & Messenger, 1964, Botto *et al.,* 1988 and Steenis, 1993, 1994). Estimates of r_m obtained over a range of temperatures in the laboratory have been used to: 1) advanced prediction of the geographic distribution and relative effectiveness of a parasitoid to be introduced, and 2) examining the possibilities that several parasitoid species may interfere with one another in their capacities to control the pest insect (Force & Messenger, 1968 and Messenger,1970). The analysis of Force and Messenger supports the use of the parameter r_m as an effective aid in assessing the potential relative performances of parasitoids imported for biological control of pests. Other studies (Kambhampati & Mackauer, 1989; Holler & Haardt, 1993), however, do not support the use of reproductive parameters, by themselves, as indices of the potential relative performances of introduced parasitoids.

The objective of the study reported here was to examine the difference between life tables (demographic statistic) of *A. albipodus* on each of *R. padi* and *S. avenae* as hosts under laboratory conditions.

MATERIALS AND METHODS

Host and parasitoid cultures

Founder individuals for the exotic parasitoid *A. albipodus* culture were collected from Tahcheng, PRC, by Gonzalez during 1992 and shipped to the Texas A & M University Quarantine Facility, College Station, Texas, USA, then exported to Egypt in 2001.The parasitoid culture was maintained in the Department of Biological Control, Agricultural Research Center, Giza, Egypt.

Specimens of native *Aphelinus* spp. emerged from cereal aphid species were sent to Dr. M. Hayat, Department of Zoology, Aligarh Muslim University, Aligarh, India for identification. The result showed that the native and the exotic parasitoid species were the same. The aphid species was collected from Egyptian wheat fields. Detailed rearing conditions and methods for the laboratory cultures of both the hosts and the parasitoid were described by Adly (2002).

Experimental method

Life cycle, survival rate and sex ratio were experimented under the laboratory conditions of 23±1^{o}C (this temperature was the most suitable for rearing the parasitoid *A. albipodus* (EL-Heneidy, *et al,* in press), photoperiod L: D 16:8 and 60-70%R.H.

Life cycle:

One hundred nymphs, almost 2nd and 3rd nymphal instars from *R. padi* and *S. avenae* were placed on wheat seedling, cultivated in small pots and kept in small cages (20 replicates / treatment) individually. In each cage, aphids were exposed to 10 mated females for one hour. Afterwards, parasitoid females were removed, and then the cages were placed inside the incubators at the selected temperature 23±1^{o}C to determine the durations of different parasitoid stages (egg-mummy, mummy-adult and egg-adult). Parasitized aphids were dissected daily by a very fine needle, in a drop of Ringer's solution using a stereomicroscope.

Survival and Sex Ratio:

Mummies of the parasitoid were placed individually in small glass vials until adult emergence. Newly emerged adult females of the parasitoid were provided daily, with 100-120 nymphs (2nd and 3rd instars) individually 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) until their death. The survival rate of the parasitoid was estimated on the aphid species *R. padi* and *S. avenae*. Parasitized aphids were allowed to feed on wheat plants in the small cages until the parasitoids completed their life cycles. Mummies were collected daily. The number of mummified aphids produced daily per female was recorded (65 replicates / treatment).

Statistical analysis

The iterative equation of Birch (1948),

$$RML= \sum l_x m_x \exp(-r_m x)=1,$$

was used to obtain an estimate of the intrinsic rate of increase r_m at the temperature study. In Birch's equation,

Age intervals (the female age in days) = x.

Age specific survival (the fraction of females alive at age x = l_x.

Age specific fecundity (the number of female offspring per female parent) = m_x.

The net reproductive rate $R_o = \sum l_x m_x$.

The mean generation time $T_c = \sum l_x m_x\, x / R_o$.

The intrinsic rate of increase $r_m = \ln R_o / T_c$.

The finite rate of increase exp. $r_m = e^{rm}$.

Population doubling time = $\ln 2 / r_m$.

Analysis of the life table study was analyzed following Birch (1948), using life 48 Basic Computer Program (Abou-Setta *et al*., 1986). Statistical Analyses System SAS Institute SAS/ATAT (1988).

RESULTS AND DISCUTION

Presented data included the life cycle, survival rate, sex ratio and life tables of the parasitoid females on the two tested aphid species *R. padi* and *S. avenae* under fore mentioned laboratory conditions.

Life cycle:

Data presented in table (1) indicate life cycle of the parasitoid *A. albipodus* on the tested aphid species *R. padi* and *S. avenae*. Developmental times were shorter on *S. avenae* than that on *R. padi;* period from egg to adult was 12.45 and 13.55 days, respectively. The first adult parasitoid emerged at 12, 13 days on *S. avenae* and *R. padi,* respectively. Statistical analysis of the durations of the parasitoid showed no significant differences among the parasitoid stages (egg-mummy, mummy-adult and egg-adult) on *R. padi* and *S. avenae* at 23±1^{o}C.

Table (1): Developmental times in days of the parasitoid *Aphelinus albipodus* on *R. padi* and *S. avenae* on wheat at 23±1^{o}C, photoperiod L: D 16:8 and 60-70%R.H.

Host Insect		*R. padi*	*S. avenae*
Egg - Mummy	Mean±S.D	7.35±0.48	6.57± 0.44
	Range	(7-8)	(6-7)
Mummy	Mean±S.D	6.2±0.41	5.7± 0.47
	Range	(6-7)	(4-5)
Egg to adult	Mean±S.D	13.55±0.51	12.45±0.51
	Range	(13-14)	(12-13)

Survival rate:

Total numbers of mummies / female were (39.1±9.97), and (23.31±10.5) on *R. padi* and *S. avenae,* respectively. Statistical analysis of the survival rates of the parasitoid showed no significant differences among the parasitoid stages on *R. padi* and *S. avenae* at 23±1^{o}C.

Information concerning the fecundity of the aphelinid species on aphids is relatively scarce if compared, with that available on the aphidiid species. The fecundity of aphelinid females was known to vary with ambient temperatures and other factors (Stary, 1988). Moreover, aphelinids are mostly synovigenic (Viggiani, 1984); thus the availability of adequate food is of particular importance. Authors (Force & Messenger, 1964, Holler & Haardt, 1993, and Julio *et al*., 1997) reported considerably higher fecundity in species such as; *A. semiflavus, A. abdominalis* and *A. albipodus*. Julio *et al.,* 1997 reported that the fecundity was 294.7 ±27.6, 214.8±33.5, and 56.9±11.7 mummies on *D. noxia* at 26.7, 21.1 and 10 ^{o}C, respectively.

Sex Ratio:

All adults of *A. albipodus* were females. The majority of aphelinids are biparental (arrhenotokous), although some uniparental (thelytokous) species are known, and certain otherwise biparental species have been found to include uniparental strains (Viggiani, 1984 and Stary, 1988). *A. albipodus* is an arrhenotokous species (Bernal & Gonzalez, 1996). The offspring sex ratio of parasitoids is known to vary with a number of environmental and intrinsic (i.e. to the female parasitoid) factors (King, 1987). In the aphelinidae, ambient temperatures have been shown to have a significant effect on the offspring sex ratio (Stary, 1988). Commonly, offspring sex ratios (=proportion of females) in parasitic wasps were highest at intermediate temperatures and lowest at extreme temperatures (King, 1987). Julio *et al.,* 1997 observed that offspring sex ratio was highest at 21.1 ^{o}C (although not significantly different from that at 10 ^{o}C). Reports concerning the offspring sex ratio of *Aphelinus* species show high variability. Reported sex ratios were in the range 0.00 to 0.84(Force & Messenger, 1964, Raney *et al.,*1971, Haardt & Holler, 1992, Holler & Haardt, 1993, and Julio *et al.,* 1997), in some cases reflecting the effect of different temperatures, and in others the effect of different hosts or different parental isofemale lines. In general, the offspring sex ratio decreased with the age of the parental female, and perhaps male. King (1987) reported that the offspring sex ratio commonly declined with age in female parasitoids and such reduction could result from sperm depletion or reduced sperm viability. In addition, King suggested that the age of the female's mate might also affect the offspring sex ratio. Bernal & Gonzalez, 1996 stated that the age of the male mate also contributed to the reduction in offspring sex ratio with female parent age in this parasitoid.

Life Table:

Life table parameters are known to be affected by a number of environmental factors. In general, factors which affect the developmental time, survivorship, offspring sex ratio, or fecundity of parasitoids will affect parameters such as r_m , R_o , and T_c . In this study, the only variable was temperature which is known to have a strong effect on these parameters (Force & Messenger, 1964, Botto *et al*., 1988 and Steenis, 1993, 1994).

Table (2): Life table parameters of *Aphelinus albipodus* and its host *Rhopalosiphum padi* on wheat at 23 ± 1^{o}C, photoperiod L: D 16:8 and 60-70%R.H.

Parameters	*A. albipodus*		*R. padi*
Host insect	*R. padi*	*S. avenae*	
The generation time(T)	13.55	12.45	6.25
Survival rate of maturity	0.615	0.6	96%
The sex ratio (Female/total)	1*	1*	--
Sum of RML	1.055	0.718	
R_o	24.06	13.98	58.32
T_c	16.34	14.54	10.88
r_m	0.195	0.181	0.37
exp. r_m	1.22	1.19	1.45
Population doubling time	3.55	3.83	1.85

* *A. albipodus* are all females.

Data in table (2) presented, the net reproductive rate, mean generation time, intrinsic rate of increase, finite rate of increase, population doubling time values for *A. albipodus* and its host *R. padi* (El-Heneidy, *et al*, 2004).

The net reproductive rate of *A. albipodus* was greater on *R. padi* than that on *S. avenae;* it was 24.06 and 13.98 on *R. padi* and *S. avenae*, respectively. Generation time for this parasitoid was longer on *R. padi* than that on *S. avenae;* it was 13.55 and 12.45 on *R. padi* and *S. avenae*, respectively. The intrinsic rate of increase for the *A. albipodus* was nearly on both species, it was 0.195 and 0.181 on *R. padi* and *S. avenae*, respectively.

The net reproductive rate of *R. padi* was greater than that for *A. albipodus* on *R. padi;* it was 58.32 while it was 24.06 for *A. albipodus* on *R. padi*. Generation time of this parasitoid was longer than its host; it was 6.25 and 13.55 on *R. padi* and *A. albipodus* on *R. padi,* respectively. The intrinsic rate of increase for the *R. padi* was more than twice that of its parasitoid on *R. padi,* it was 0.37 and 0.195 on *R. padi* and *A. albipodus* on *R. padi*, respectively.

Several factors may influence the ability of a parasitoid to reduce host populations in the field. Any r_m value calculated from laboratory experiments is of use only as an indicator of the potential of a parasitoid (Froud and Stevens, 1997).These data indicate that the exotic parasitoid *A. albipodus* hasn't the potential to be used for controlling *R. padi* and *S. avenae* in wheat fields in Egypt. Further studies on the life table of the indigenous species should be conducted to evaluate their efficiency against cereal aphids in Egypt.

Force & Messenger, 1964 reported that r_m values for *A. semiflavus* were very low at 10 ^{o}C and 0.34 at 26.7 ^{o}C, followed by a decline to a negative value at 32.2 ^{o}C. Our estimate of r_m in *A. albipodus* at 23 ± 1^{o}C was nearly that of Julio *et al.,* 1997 at 21.1^{o}C (0.1884) but lower than those of Force & Messenger, 1964.

REFERENCS

Abou-Setta, M. M., Sorrel, R. W. and Chiders, C.C. 1986. Life 48: A basic computer program to calculate life table parameters for an insect or mite species. Florida Entomologist, 69(4): 690-697.

Adly, Dalia. 2002. Biological and ecological studies on the parasitoid *Aphidius matricariae* Hal. (Hymenoptera: Aphidiidae) parasitizing the cereal aphids. M. Sc. Thesis, Fac. Agric., Cairo Univ., Egypt. 134pp.

Andrewartha H. G. and Birch L. C. 1954. The distribution and abundance of animals. The University of Chicago press. U.S.A. 782 pp.

Attia, A. A. and El-Kady, E. M. 1988. *Diuraphis noxia* Mordivolko, a recent addition to the aphid fauna of Egypt. Bull. ent. Soc. Egypt. 68: 259-266.

Bernal, J. S. and Gonzalez, D. 1996. Thermal requirements of *Aphelinus albipodus* (Hayat and Fatima) (Hym., Aphelinidae) on *Diuraphis noxia* (Mordwilko) (Hom., Aphididae). Appl. Ent. 120: 631-638.

Birch, L. C. 1948. The intrinsic rate of natural increase of an insect population. J. Anim. Ecol. 17: 15-26.

Botto, E. N., Gonzalez, D. and Bellows, T. S. Jr 1988. Effect of temperature on some biological parameters of two populations of *Aphidius ervi* Haliday (Hymenoptera: Aphidiidae). In Gupta V.K. (ed.): Advances in Parasitic Hymenoptera Research. E. J. Brill. New York, pp. 367-377.

El-Hariry, M. A. 1979. Biological and ecological studies on aphids attacking corn and wheat in Egypt. M. Sc. Thesis, Fac. Agric., Ain – Shams Univ., Egypt. 187pp.

El-Heneidy, A. H. 1994. Efficacy of aphidophagous insects against aphids at wheat fields in Egypt. Egypt J. Biol. Pest Control 4(2): 113-123.

El-Heneidy, A. H., El-Husseini, M. M., Agamy, E. A. and Adly, D. Thermal requirements of *Aphelinus albipodus* Hayat and Fatima (Hym,: Aphelinidae) on *Rhopalosiphum padi* (Homo,: Aphididae) as a host. Egypt .J. Biol. Pest Cont. (in press).

El-Heneidy, A. H., Sobhy, H. M., Abd-El Wahed, S. M. N. and Mikhail, W. Z. A. 2004. Biological aspects and life table analysis of cereal aphid species and their parasitoid, *Aphidius colemani* Viereck (Hymenoptera: Aphidiidae). Egyptian J. Biol. Pest Control. 14(1): 43-51.

Force, D. C. and Messenger, P. S. 1964. Fecundity, reproductive rates, and innate capacity for increase of three parasites of *Therioaphis maculate* (Buckton). Ecology 45: 706-715.

Force, D. C. and Messenger, P. S. 1968. The use of the laboratory studies of three hymnopterous parasites to evaluate their field potential. J. Econ. Entomol. 61: 1374-1378.

Froud, J.K. and Stevens P. S. 1997. Life table comparison between the parasitoid *Thripobius semiluteus* and its host greenhouse thrips. Proc. 50th N. Z. Plant Protection Conf. 232-235.

Gonzalez, D., Gilstrap, F., Zhang, W., McKinnon, L., Wooley, J. B., Stary, P., Waggoner, M. and Zhang, G. 1994. Foreign exploration, for natural enemies of Russian wheat aphid in southern Xinjiang, People's Republic of China. In Peairs F.B., Kroening M. K. & Simmons C.L. (comp.): Proceedings of the Sixth Russian Wheat Aphid Workshop. Great Plains Agricultural Council, Fort Colins, pp. 208-222.

Haardt, H. and Holler, C. 1992. Differences in life history traits between isofemale lines of the of the aphid parasitoid *Aphelinus abdominalis* (Hymenoptera: Aphelinidae). Bull. Entomol. Res. 82: 479-484.

Hayat, M. & Fatima, K. 1992. Taxonomic studies on *Aphelinus* (Hymenoptera: Aphelinidae). 5. Description of a new species and futher records of *Aphis gossypii*, with a new synonymy. Entomon 17: 103-107.

Holler, C. and Haardt, H. 1993. Low field performance of an aphid parasitoid *Aphelinus abdominals* efficient in the laboratory (Hym., Aphelindiae). Entomophaga. 38: 115-124.

Julio, S., Bernal, Marcella Waggoner and Gonzalez, D. 1997. Reproduction of *Aphelinus albipodus* (Hymenoptera: Aphelinidae) on Russian wheat aphid (Hemiptera: Aphididae) hosts. Eur. J. Entomol. 94:83-96.

Kambhampati, S. and Mackauer, M. 1989. Multivariate assessment of inter- and intra-specific variation in performance criteria of several pea aphid parasites (Hymenoptera: Aphidiidae). Ann. Entomol. Soc. Am. 82: 314-324.

Kindler, S. D., Breen, J. P., and Springer, T. L. 1991. Reproduction and damage by Russian wheat aphid (Homoptera: Aphididae) as influenced by fungal endophytes and cool season turfgrasses. J. Econ. Entomol., 84 (2): 685-692.

King, B.H. 1987. Offspring sex ratio in parasitoid wasps. Q. Rev. Biol. 62: 367-396.

Messenger, P.S. 1970. Bioclimatic inputs to biological control. In Rabb R. L. & Guthrie F. E. (eds) Concepts of Pest Management. North Carolina State University, Raleigh. Pp. 88-102.

Michels,G. J., Kring, T. J., Behle, R. W., Bateman, A. C. and Heiss, N. M. 1987. Development of the green bug (Homoptera: Aphididae) on corn: geographic variations in the host plant range of biotype. E. J. Econ. Entomol. 80: 394-397.

Raney H. G., Coles, L. W., Eikenbary, R. D., Morrison, R. D. and Starks, K. J. 1971. Host preference, longevity, developmental period and sex ratio of *Aphelinus asychis* with three sorghum-fed species of aphids held at controlled temperatures. Ann. Entomol. Soc. Am. 64:169-176.

Stary, P. 1976. Aphid parasites (Hymenoptera: Aphidiidae) of the Mediterranean area. Transactions of the Czechoslovak Academy of Sciences, Series of Mathematical and Natural Sciences, 86: 1-95.

Stary, P. 1988. Aphelinidae. in Minks A.K. & Harrewijn P. (ed): Aphids, Their Biology, Natural Enemies and Control. Vol. B. Elsevier, Amsterdam, pp. 185-188.

Steenis, M. J. VAN 1993. Intrinsic rate of increase of *Aphidius colemani* Vier (Hym., Braconidae), a parasitoid of Aphis gossypii Glov. (Hom., Aphididae), at different temperatures. J. Appl. Entomol. 116: 192-198.

Steenis, M. J. VAN 1994. Intrinsic rate of increase of *Lysiphlebus testaceipes* Cresson (Hym., Braconidae), a parasitoid of *Aphis gossypii* Glov. (Hom., Aphididae), at different temperatures. J. Appl. Entomol. 118: 399-406.

Viggiani, G. 1984. Bionomics of the Aphelinidae. Annu. Rev. Entomol. 29: 257-276.