BIOLOGICAL STUDIES OF TWO STRAINS OF *ERETMOCERUS MUNDUS* (HYMENOPTERA: APHELINIDAE) ON *BEMISIA ARGENTIFOLII* (HOMOPTERA: ALEYRODIDAE) FROM IRAN

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Abstract

Longevity, fertility, preimaginal, developmental time and superparasitism of two strain populations of *Eretmocerus mundus* Mercet (Hymenoptera: Aphelinidae), parasitizing *Bemisia argentifolii* Bellowsand Perring (Homoptera: Aleyrodidae) were reared on two host plants, *Lantana camara* and *Convolvulus arvensis*, at two temperatures 24 ± 1 and 30 ± 1ºC. The populations of *E.mundus* were provided from Isfahan (I parasitiods) and Mazandaran (M parasitoids) provinces, which are located in central and northern Iran, respectively. Significant differences in preimaginal developmental time were not detected between populations at different temperatures and host plants. Adult longevity was greatest at lower temperature than at higher one. Mean longevities varied from 13.33 days at 24 ± 1 ºC to 6.6 days at 30±1ºC. Fertility on *Convolvulus arvensis* was higher than on *L. camara* and at 30±1ºC was higher than other temperature. Sex ratio of "M" population depended on temperature and host plant, but in "I" population, all progeny were female. Significant differences in superparasitism were found between populations, temperatures and host plants. Superparasitism or self-superparasitism was observed in "M" parasitoids, while "I" parasitoids completely avoided superparasitism.

INTRODUCTION

The differences in the effective role of *Eretmocerus mundus* Mercet (Hymenoptera: Aphelinidae) strains in controlling *Bemisia tabaci* biotype "B" have been studied by Abd-Rabou (2003). The research reported here in is part of a project that describes the efficiency of different populations of *E. mundus* attacking the silverleaf whitefly, *Bemisia argentifolii* Bellowsand Perring (Homoptera : Aleyrodidae), on a variety of host plant in different regions of Iran. *E.mundus* is the principal species of parasitic Hymenoptera attacking *B. argentifolii* in Isfahan province (Ghahari, 2000).

However, percentage parasitism by *E. mundus* varies greatly among agricultural, ornamental and native plant species in this area (Ghahari and Ostovan, 2002). The

major whitefly pest of ornamental plants such as *Lantana camara* and *Convolvulus arvensis* in central regions of Iran is the silverleaf whitefly, *Bemisia argentifolii* [= the "B" strain of *Bemisia tabaci* (Gennadius) (Ghahari, 2000).

In this study, the biology of two populations of *E. mundus*, one from Isfahan and the other from Mazandaran provinces were examined. The females of the two populations are indistinguishable, and the two populations may represent strains or biotypes of a single species. This research considers adult longevity and fertility, preimaginal developmental time and superparasitism of the two populations. Both parasitoids parasitize three economically important cosmopolitan species of whiteflies, *B. argentifolii*, *B. tabaci* and *Trialeurodes vaporariorum* Westwood and thus an elucidation of their biology may be useful in considering potential biological control and IPM programs.

MATERIALS AND METHODS

Experiments were conducted in temperature controlled cabinets at 24 ± 1ºC and 30 ± 1ºC, 65% ± 5RH, 16 : 8 (L : D) photoperiod, and light intensity was set at about 15,000 lux, with source of fluorescent. The plants used in the experiments were *L.camara* and *C.arvensis*. The insect used was *B. argentifolii* taken from a stock culture that originated from Isfahan province. Cultures of *E.mundus* were maintained on *B.argentifolii* fed on *L. camara* under a 16 : 8(L : D) photoperiod at 24 ± 1ºC. All the experiments were conducted at the randomized completely designs and analysis of variance (ANOVA) was accomplished by SAS (1994).

The longevity and daily fertility of both populations were studied by placing newly emerged (< 12 h) females (and males for the "M" population) in leaf cages similar to those described by MacGillivary and Anderson (1957) on *L. camara* and *C. arvensis* leaves in either the 24 ± 1 or 30 ± 1ºC. The leaves were infested with 20 - 30 sessile first instar through fourth instar whitefly nymphs, with at least one nymph of each instar. Every 24 h, parasitoid adults were transferred by an aspirator to another whitefly infested leaf until the female parasitoids died. If a male parasitoid died, another was added to the cage. Parasitized whiteflies were reared until the parasitoids emerged. Occasionally the leaves became desiccated before all parasitoids emerged. To compensate for the adverse effect of leaf desiccation on parasitoid emergence, fourth instar of whitefly nymphs from which neither a whitefly nor a parasitoid had emerged were examined to determine if they were parasitized. If the whitefly was

parasitized, the developmental stage of the parasitoid was noted. If the parasitoid had pupated, an attempt to determine its sex was made by examining its antennae, and it was counted as having emerged. Differences in the number of progeny produced between the different populations, plant types, and temperatures were examined by analysis of variance (ANOVA).

In the fertility experiments in which parasitoids were presented with new whiteflies to parasitize daily, the length of time for the eggs that were laid to mature into adults was noted. This provided an estimate of the parasitoid developmental period from egg to adult for eggs laid on first through fourth instar whiteflies. Differences in developmental periods of the parasitoids between populations, plant types, and temperatures were examined by analysis of variance.

In the superparasitism experiments, third nymphal instar of *B. argentifolii*, which is the most suitable for parasitism (Ghahari and Ostovan, 2002), were taken from the host plants into the plexy glass cages with 30 cm height and 22 cm diameter. The number of nymphal stage on each plant were 30, and 15 parasitoid females (and 5 males for the "M" population) which were released in each cage for 48 h. This experiment was conducted in randomized completely design with 8 treatments including, populations, host plants, and temperatures at 5 replications. After sixth – days, dissection of host nymphal stages was made under stereomicroscope, and the number of parasitoid larvae in the hosts was counted. Since *E. mundus* is not a polyembrionic reproducer (Tawfic *et al.*, 1978), therefore observing more than one larva in the host body, indicated superparasitism and/or self–superparasitism. At last, differences in effect of different populations, plant types, and temperatures on superparasitism were analyzed by ANOVA.

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences in longevity as a result of temperature, but not of populations or host plants, although mean longevities of the "I" population were greater than "M" in all treatments (Table 1). There were no significant interactions between temperature, population and host plant. Mean longevities varied from 13.33 at 24 ± 1ºC for the "I" population on *L. camara* to 6.6 days at 30 ± 1ºC for the "M"population on *L. camara*. The parasitoids that lived the longest (53 days) were 4 parasitoids of "M" population confined on *C. arvensis* leaves at 30 ± 1ºC. Of the "I" population, the greatest longevity (26 days) was for 2

parasitoids confined on *L. camara* leaves at 24 ± 1ºC (Table 1). The mean number of progeny (fertility) varied from 19.8 for "M" population confined on *L. camara* leaves at 30 ± 1ºC to 48.5 per female for "I" population confined on *C. arvensis* leaves at 30 ± 1ºC. The greatest number of progeny produced by a single female was 126 (Table 1). A few parasitoids produced no offspring and were considered in the analysis.

Table 1. Longevity and fertility of two populations of *Eretmocerus mundus* parasitizing *Bemisia argentifolii* on *Lantana camara* and *Convolvulus arvensis* at two temperatures.

Population	Host plant	Temp. ºC	n	Longevity		Progeny		
				Range	X ± SD	Range	X ± SD	Daily mean
I	*L.camara*	24 ± 1	26	9 - 26	13.33 ± 7.4a	12-51	24.2 ± 15.6a	2.11
		30 ± 1	17	6 - 21	9.6 ± 6.65b	13-126	41 ± 38.4b	4.59
	C.arvensis	24 ± 1	21	8 - 17	11.94 ± 3.7a	15-92	43.4 ± 33.2b	4.23
		30 ± 1	32	3 - 14	8.26 ± 4.2bc	6-87	48.5 ± 34.3a	7.14
M	*L.camara*	24 ± 1	24	5 - 25	12.4 ± 8.1a	11-82	32.6 ± 28.7d	2.85
		30 ± 1	18	4 - 10	6.6 ± 2.42a	5-37	19.8 ± 12.19f	3.37
	C.arvensis	24 ± 1	28	6 - 16	11.1 ± 3.5ab	9-44	27 ± 13.2e	3.96
		30 ± 1	23	2 - 53	6.8 ± 2.94c	19-73	36 ± 20.2c	6.21

An analysis of variance was conducted to examine differences in mean total fertility of parasitoid populations, the plant on which the whitefly was reared, and temperature. There were no significant differences ($F = 3.21$; $P < 0.05$) in any of these main effects. An ANOVA was also conducted to examine differences in the mean daily fertility. Significant differences were detected between *C. arvensis* and *L. camara* and between 24 ± 1 and 30 ± 1ºC, with higher daily fertility on *C.arvensis* leaves and at 30 ± 1ºC. "M" parasitoid progeny produced from *L. camara* leaves at 24 ± 1 and 30 ± 1ºC were 65.2 and 37.2 % female, respectively. On *C. arvensis* leaves, the percentages were 41.3 and 61.6 %. All progeny produced by the "I" populations were females.

The shortest developmental period at 30 ± 1ºC was 13d for 3 females "M" parasitoids, and the longest was 27d for 2 females "I" parasitoids, both emerged from hosts on *L. camara*. At 24 ± 1ºC the shortest developmental period was 27 d for 3 females "M" parasitoids reared from hosts on *L. camera* and the longest was 48 d for

one male and one female "M" parasitoid emerged from hosts of *L. camara* and one female "I" parasitoid emerged from hosts on *C. arvensis* (Table 2).

Analysis of variance indicated significant differences in mean developmental times at the two temperatures for both populations, with development occurring about twice as fast at 30 ± 1 as at 24 ± 1 °C. When females and males of each population were examined separately for differences in developmental periods by ANOVA, all sources of variation- plant, temperature, and plant X temperature interaction proved to be significant.

Table 2. Preimaginal developmental period "M" and "I" populations of *Eretmocerus mundus* reared from *Bemisia argentifolii* on *Lantana camara* and *Convolvulus arvensis* at two temperatures.

Population	Host plant	Temp. °C	Sex	n	Range d	X±SD
M	*L.camara*	24 ± 1	Female	73	28 - 48	33.61± 2.92a
		30 ± 1	Female	51	15 - 26	19.73 ± 3.14b
	C.arvensis	24 ± 1	Female	64	30 - 46	34.89 ± 3.45a
		30 ± 1	Female	45	13 - 24	17.37 ± 1.66b
	L.camara	24 ± 1	Male	39	33 - 48	33.28 ± 3.88a
		30 ± 1	Male	86	16 - 25	18.50 ± 2.34b
	C.arvensis	24 ± 1	Male	91	31 - 40	34.21 ± 4.19a
		30 ± 1	Male	28	14 - 22	16.41 ± 1.72b
I	*L.camara*	24 ± 1	Female	70	27 - 45	31.78 ± 3.81a
		30 ± 1	Female	42	15 - 27	19.08 ±2.11b
	C.arvensis	24 ± 1	Female	54	29 - 48	32.89 ± 1.66a
		30 ± 1	Female	63	16 - 24	17.15 ± 2.07b

An interaction plot revealed that in each case the developmental period was longer on *C. arvensis* than *L. camara* at 24 ± 1 °C, but the developmental period was longer on *L. camara* than *C. arvensis* at 30 ± 1 °C. This is consistent with the fact that developmental period in *E. mundus* is dependent on the development of the host, and *B. argentifolii* develops faster on *L. camara* than on *C. arvensis* at 24 ± 1°C but faster on *C. arvensis* than on *L. camara* at 30 ± 1°C.

Dissection of parasitized and non-parasitized nymphs indicated that "I" parasitoids completely avoid superparasitism and self - superparasitism at the two temperatures and on the two host plants. In "M" population, superparasitism and self-superparasitism was observed in all cases. ANOVA indicated significant differences in

the number of progeny in the host nymphs at the two temperatures and the two plants. The greatest superparasitism or self - superparasitism was obtained on *C.arvensis* at 30 ± 1 °C and the least rate on *L. camara* at 24 ± 1 °C (Table 3).

Table 3. superparasitism and self - superparasitism of "I" and "M" populations of *Eretmocerus mundus* obtained from parasitized and non-parasitized *Bemisia argentifolii* reared on *Lantana camara* and *Convolvulus arvensis* at two temperatures.

Population	Host plant	Temp. °C	N	No. of progeny in one host	
				Range	X ± SD
M	*L.camara*	24 ± 1	36	1-2	1.6 ± 0.54a
		30 ± 1	27	1-3	2.1 ± 0.83ab
	C.arvensis	24 ± 1	29	1-4	2.4 ± 1.14ab
		30 ± 1	48	3-4	3.6 ± 0.79a
I	*L.camara*	24 ± 1	44	1	1b
		30 ± 1	25	1	1b
	C.arvensis	24 ± 1	32	0-1	0.8 ± 0.44b
		30 ± 1	39	1	1b

There have been very few studies on *E. mundus* in Iran (Al-e-Mansoor, 1992 and Ghahari and Ostovan, 2002). The results of this study can be compared to others (Gerling, 1965; Vet and Van Lenteren, 1981 and Powell and Bellows, 1992). In all other studies except Ghahari and Ostovan (2002), *B. argentifolii* was not selected as the host, and other whiteflies, *B. tabaci* and *T. vaporariorum* were employed as the hosts (Powell and Bellows, 1992 and Ghahari, 2000) . Except for the study of Vet and Van Lenteren (1981) and Al-e-Mansoor (1992), most repots of *E. mundus* longevity were similar to the results of this research. Females in the current study lived significantly longer when confined on *L. camara* or *C. arvensis* leaves bearing *B. argentifolii* than when placed in vials with or without honey or other diets (Ghahari and Ostovan, 2002). This may result from a nutritional requirement by the host feeding of the parasitoid (Hatami and Ghahari, 2001) or honeydew secreted by the whiteflies living on the *L. camara* and *C. arvensis* leaves (Powell and Bellows, 1992). Sharaf and Batta (1985) reported negative correlation between longevity and increasing temperature (14.8 d at 14 °C and 9.6d at 25 °C), similar to the results of this study.

Fertility was scored in this study as the number of progeny produced, not the number of eggs laid, by rearing parasitoids to the adult stage. This is in contrast to some articles in which eggs were counted. In discussing other studies in which only

eggs were counted in an experiment, the term "eggs" is used here. When parasitoids were reared to the adult stage, the term "progeny" is used. Possible mortality between the egg stage and adult emergence would lead to fewer adult progeny than the actual number of eggs laid. Thus, if the egg stage was utilized as a measure of reproductive potential without taking into account nymphal mortality, an over representation of reproductive potential would occur (Powell and Bellows, 1992).

Fertility has been reported in *E. mundus* to vary from 12 to 150 mean eggs per female (Tawfic, *et al.* 1978). These results are similar to those reported for other aphelinids, which range from 5 to 140 eggs per female (Viggiani, 1984). Values for progeny produced reported here (19.8 - 48.5) fall well within this range .Number of progeny produced was generally greater at higher temperatures, greater on *C. arvensis* than *L. camara* and the "I" population generally produced more progeny than the "M" one, although these differences were not statistically significant, the parasitoid produced a mean of 2.11 to 7.14 progeny per day, which is comparable with that reported by other workers (Table 4). The maximum number of eggs laid per day in the experiments of Gerling (1965), Vet and Van Lenteren (1981) and Powell and Bellows (1992) were 12, 35 and 25, respectively. The maximum number of progeny produced per day in this study was 28.

The analysis of variance in the present study indicated significant differences in mean daily fertility between parasitoids confined on *L. camara* and those confined on *C. arvensis* leaves and between the temperatures with a greater daily fertility on *C. arvensis* leaves and at higher temperatures. This could account for the greater total fertility of the parasitoids on C. *arvensis* leaves versus *L. camara* leaves. The greater daily fertility at higher temperatures in conjunction with a significantly shorter mean longevity at higher temperatures may have combined to yield the nonsignificant difference in the total mean fertility between the temperatures (Powell and Bellows, 1992).

There was little difference in mean developmental periods of immature parasitoids at the two temperatures between the populations or sexes. There was a significant difference between mean developmental periods at the two temperatures. The interactions indicated that the relationship between temperature, populations and sexes was a complicated one, but differences involved were very small compared with the differences caused by temperature. Developmental period of males and females were similar. The mean developmental period for female parasitoids varied from 31.78

to 34.89 at 24 ± 1 ºC and from 17.15 to 19.73 at 30 ± 1 ºC. They parasitized sessile first through fourth instar whitefly nymphs. Other researches found similar developmental times for *E. mundus* and *Eretmocerus* sp. parasitizing sweetpotato and the greenhouse whiteflies (Al-e-Mansoor, 1992; Powell and Bellows, 1992 and Ghahari, 2000). Differences among the results of the current study and the other ones are originated from variation in the biotype or race of parasitoid, the species of whiteflies as the hosts, the temperature and other environmental conditions, and host plants.

Comparison among strains and their performance in a common environment shows variations in acceptance of hosts, developmental time, fecundity, host range, insecticide resistance, mortality, search (handling and search time, and parasitism), sex ratio, suitability of hosts, and temperature tolerance (Ruberson *et al.*, 1989). Although genetic studies were not conducted in this research, but we must consider this highly effective factor in the study of strains or biotypes of parasitoids and hosts.

Avoidance of parasitoids from superparasitism is only possible when a parasitized host can be recognized. This recognition is generally based on a marking substance placed in and/or on the host during oviposition. Such a mark provides not only the marking individual but also other females with the information that host are parasitized. Parasitoids face two problems that do not exist for predators: A parasitoid may reencounter a host it has already parasitized, and a parasitized host can be attacked by competing parasitoids. This may result in self-superparasitism or conspecific superparasitism (Van Alphen and Visser, 1990).

In this research superparasitism and self-superparasitism were not separated, and both considered as superparasitism. Since the superparasitism is a destructive behavior in parasitoids, therefore "I" population without any superparasitism is more successful biocontrol agent than "M" population. The results indicate that biological control of *Bemisia argentifolii* would probably be better obtained by parasitoids from Asfahan at higher temperature.

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دراسات بيولوجية على سلالتين بيولوجيتين لطفيل أريتموسيروس مندز والمتطفل على ذبابة القطن و الطماطم البيضاء فى إيران

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تـم فـى هـذا البحـث عمل بعض الدراسات البيولوجية على السلالات البيولوجية لطفيل أريتموسيروس مندز و هو من الطفيليات الفعالة فى مكافحة ذبابة القطن و الطماطم البيضاء.

وقد تمت الدراسةعلى سلالاتين بيولوجيتين من اصفهان و مازاندران فى إيران على نباتى اللانـتانا كمارا والعليق تحت درجات حرارة ٢٤±١ ، ٣٠±١ و قد أتضح من النتائج أن فترة حياة الحشـرة الكاملـة للطفـيل كانت طويلة عند درجة الحرارة الأقل. وأن فترة الحياة تراوحت ما بين ١٣,٣٣ و ٦,٦ يوم عند درجتى حرارة ٢٤±١ ، ٣٠±١ على الترتيب و أن كمية البيض الموضوع علـى نبات العليق اكثر من الموضوع على نبات اللانتانا كمارا. أما النسبة الجنسية لهاتين السلالاتين فقد أتضح أن السلالة التى من اصفهان أن كل النسل الناتج إناث بينما السلالة التى من مازاندران أعـتمد تعدادها على نوع العائل النباتى و كذلك درجة الحرارة. أما بالنسبة لظاهرة تعدد التطفل فقد أثبتـت النـتائج أن السـلالة الـتى مـن اصفهان تجنبت تماما هذه ا لظاهرة بينما السلالة التى من مازاندران ظهرت بها ظاهرة تعدد التطفل.