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Laboratory studies on biology and ecology of *Eretmocerus debachi* Rose and Rosen (Hym., Aphelinidae) the parasitoid of *Parabemisia myricae* (Kuwana) (Hom., Aleyrodidae)

By Ç. ŞENGONCA, N. UYGUN, M. R. ULUSOY and U. KERSTING

Abstract

The effects of three constant temperatures (20, 25, 30 ± 1 °C) and two fluctating temperatures (25/35, 27/33 °C) on the preimaginal developmental time and the longevity of the parasitoid *Eretmocerus debachi* Rose and Rosen (Hym., Aphelinidae) that parasitized *Parabemisia myricae* (Kuwana) (Hom., Aleyrodidae) were studied in the laboratory. In addition, laboratory experiments were conducted to study the effects of different diets on the longevity of the parasitoid. The generation time and the number of generation in a year were evaluated in a semi-field experiment. The preimaginal developmental time decreased significantly with increase in temperature from 28.4 days at 20 °C to 12.0 days at 27/33 °C. Increasing temperature showed little effect on adult longevity, varying from 3.1 days at 20 °C to 3.7 days at 25 °C. Longevity was significantly shorter at the fluctuating temperatures (25/35 and 27/33 °C) compared to the constant temperatures. *E. debachi* held on 10 % saccharose solution lived significantly longer (3.4 days) than on any other five diets. Only slight differences were observed among honey dew, water or no diet, ranging from 1.2 to 1.6 days. In the semi-field experiment 13–14 generations in a year were observed. The shortest generation time valuing 14 days was observed during summer time at average daily temperatures between 25.1 and 28.9 °C. A generation time of 145 days occurred in winter (November–April) when the daily temperature averaged 10.8 °C. *E. debachi* hibernated in second *P. myricae* instars.

1 Introduction

The Japanese bayberry whitefly, *Parabemisia myricae* (Kuwana) is a most serious pest of citrus in the Mediterranean, especially in the eastern region (SWIRSKI et al. 1987; MICHELAKIS and ALEXANDRAKIS 1989; LONGO et al. 1990; UYGUN et al. 1990). In Turkey, this pest was discovered for the first time in the Çukurova in 1982, and has since spread through whole citrus growing area.

Eretmocerus debachi Rose and Rosen was imported from California to Turkey (UYGUN and ŞEKEROĞLU 1987) and, following a mass release, controlled the pest very successfully (UYGUN et al. 1990; ŞENGONCA et al. 1993). Previously, the parasitoid demonstrated its great impact in the biological control of *P. myricae* in California and Israel, and recently *E. debachi* was also imported to Italy (SWIRSKI et al. 1988a, b; ROSE and DEBACH 1992).

Although *E. debachi* is intensively used in biological control programs very little information on its biology and ecology is available in literature. However, the elucidation of the parasitoid biology may prove useful in improving biological control programs.

The purpose of this study was to determine the preimaginal developmental time and the longevity of *E. debachi* at various temperatures in the laboratory and ascertain the number of generation and the generation time of the parasitoid in field.

2 Material and methods

E. debachi was reared on second instars of *P. myricae* at 25 ± 2°C, 65 ± 10 % RH and a light regime of 8:16 dark/light in a climate chamber. Second immature stages of the whitefly host were produced by placing young *Citrus aurantium* L. seedlings into the mass culture of *P. myricae* for an oviposition period of 24 h (ŞENGONCA et al. 1993). The plants were then transferred into a climate chamber and kept for 1 week, until *P. myricae* reached the 2nd instar (UYGUN et al. 1993). Those plants were enclosed with *E. debachi* females for a 24 h parasitization period.

The preimaginal developmental time and longevity of *E. debachi* were determined by transferring a single female, maximum 2 hours old, into a Petri dish, with one citrus leaf bearing approximately 50 *P. myricae*-2nd-instars. Every 24 h the parasitoids were transferred into a new Petri dish until their death. The leaves were placed with the petiole in a water reservoir and observed daily for development of *E. debachi* under binocular microscope. During the trials, adult parasitoids were fed with 10 % saccharose solution. The experiments were carried out at three constant temperatures of 20 ± 1°C, 25 ± 1°C, and 30 ± 1°C. and two fluctuating temperatures 25/35 ± 1°C and 27/33 ± 1°C (12/12 h), 65 ± 10 % RH and 16 h of artificial light in a climate chamber.

To determine the effect of different diets on the longevity of *E. debachi*, females were isolated immediately after emergence with different diets: 10 % saccharose solution, 20 % honey solution, 1st instar of *P. myricae* on leaves, *P. myricae*-honey dew on leaves, water and as control the females were kept without food. Every 12 h the number of dead individuals was counted; the food was renewed every day. The females had no possibility for oviposition. These experiments were conducted at a constant temperature of 25 ± 1°C, 65 ± 10 % RH and a light regime of 8:16 dark/light in a climate chamber.

In a semi-field experiment the number of generations and the generation time of *E. debachi* per year in a citrus orchard in Balcali/Adana were determined. A caged, young citrus plant bearing some hundreds 2nd *P. myricae* instars were placed under the canopy of a citrus tree and 50 *E. debachi* released for an oviposition period of 24 h. The cage was checked daily for the emergence of adult parasitoids. After the first *E. debachi* hatched, about 50 females hatched the same day were transferred from the mass culture into a new cage and observed till the next generation was completed. This semi-field experiment was conducted for 1 year and the number of generations and the generation times of *E. debachi* were evaluated.

3 Results and discussion

3.1 Preimaginal development period

The development of *E. debachi* involves an egg, three larvae, a prepupa, and a pupal stage. Since *Eretmocerus* species deposit their eggs under the host and the host penetration occurs in the first or second larval stage (FOLTYN and GERLING 1985; GERLING et al. 1990), in this study only the developmental time from egg to adult was recorded. The preimaginal developmental time decreased significantly with the increase in temperature from 28.4 days at 20°C to 12.0 days at 27/33°C (table 1). Thus, *E. debachi* developed about two times faster from egg to adult than its whitefly host *P. myricae* from the second immature stage to adult (UYGUN et al. 1993). The second instar is the preferred host stage of *E. debachi* (ŞENGONCA et al. 1994). For the reason that the developmental time in *Eretmocerus* is dependent on the development of its host (POWELL and BELLOWS 1992), results on the length of the developmental period obtained with different *Eretmocerus* species, whitefly hosts, and host plants are difficult to compare. However, other researchers found longer developmental times for *Eretmocerus* spp., being as long as 35.8 days at 20°C and 18.3 days at 29°C for parasitoids attacking *Bemisia tabaci* (Genn.) (SHARAF and BATTA 1985; POWELL and BELLOWS 1992). For *Eretmocerus mundus* Merc. parasitizing *Trialeurodes vaporariorum* (Westw.) preimaginal developmental times between 28 days at 21.5°C and up to 56 days at 17°C are reported (GERLING 1965; VET and VAN LENTEREN 1981). In this study, *E. debachi* showed the shortest developmental time of all *Eretmocerus* reported literature.

3.2 Longevity

E. debachi held on *P. myricae*-2nd-instars and 10 % saccharose solution displayed a very short longevity at all five temperatures tested, varying from 3.1 days at 20°C to 2.1 days at

Table 1. **Mean preimaginal developmental time and longevity of *Eretmocerus debachi* at different temperatures**

Temperature °C	n	Preimaginal developmental time (days)		n	Longevity (days)	
		Mean ± SE	min–max		Mean ± SE	min–max
20 ± 1	27	28.4 ± 0.41 a	22–31	11	3.1 ± 0.51 a	1.0–7.5
25 ± 1	31	17.0 ± 0.20 b	14–19	10	3.7 ± 0.41 a	1.5–6.0
30 ± 1	24	13.5 ± 0.21 c	12–15	10	2.8 ± 0.33 a	1.5–4.5
25/35 ± 1	27	13.7 ± 0.19 c	12–15	16	2.1 ± 0.32 b	1.0–4.5
27/33 ± 1	23	12.0 ± 0.13 d	11–13	13	2.2 ± 0.22 b	1.0–3.0

Means in column followed by the same letter are not significantly different at the 5 % level (Tukey's HSD Multiple Range Test).

25/35 °C. *E. debachi* that lived longest (7.5 days) were two individuals kept at 20 °C. No significant reduction in longevity was observed as result of increasing constant temperatures (20–30 °C). *E. debachi*, however, lived significant shorter at the two fluctuating temperatures of 25/35 °C and 27/33 °C compared to the three constant temperatures (table 1). Most data cited in literature for the longevity of other *Eretmocerus* species reported longer life-spans compared to the results obtained here. Depending on host plant, whitefly host and temperature, the longevity varied from 7.6 days at 18 °C for *E. mundus* parasitizing *B. tabaci* on cotton to 14.8 days at 14 °C and 9.6 days at 25 °C on tomato (TAWFIK et al. 1978; SHARAF and BATTA 1985). For the same parasitoid species a longevity between 7.6 days at 19–21 °C and 34.6 days at 21–25 °C on cotton was observed in field experiments in Sudan (GAMEEL 1969).

POWELL and BELLOW (1992) studied the development of two populations of *Eretmocerus* species (Hawaii and Indio) attacking *B. tabaci* on cotton and cucumber. They observed a statistically significant reduction in longevity with increasing temperatures, ranging between 11.6 days at 20 °C and 5.4 days at 29 °C for the Indio population and 13.7 days at 20 °C and 8.4 days at 29 °C for the Hawaiian population. The life-span was slightly shorter if cucumber instead of cotton was chosen as a host plant for the whitefly. *Eretmocerus* sp. parasitizing *T. vaporariorum* on cotton displayed a longevity of 5.1 days at 17 °C (GERLING 1965).

The longevity of *E. debachi* held on different diets at 25 °C is given in table 2. The statistically longest life-span was recorded for the 10 % saccharose solution, averaging 3.4 days. This longevity was comparable to the longevity of adult parasitoids that were offered 2nd stage *P. myricae* for parasitization and saccharose solution as diet in the experiments on longevity (table 1). Individuals kept without food lived on average 1.2 days, which differed insignificantly from those experiments where first stage *P. myricae*, or honeydew was offered as diet. These results clearly indicate that *E. debachi* does not depend on host feeding or honeydew to increase life-span. At least one carbohydrate source is necessary to increase the longevity compared with parasitoids kept without food or water. Why honey and honeydew did not increase the life-span of *E. debachi* as saccharose in our experiments is unknown. However, it is difficult to judge the influence of the different diets on the life-span of *E. debachi*, since the longevity of this species was very short. VAN LENTEREN et al. (1987) reported that honey was a better diet for *Encarsia formosa* Gahan than other food sources, including host substances and/or honeydew. Laboratory studies and field experiments of ROSE and DEBACH (1992) and ŞENGONCA et al. (1994) showed that host feeding on and/or mutilation of second-stage *P. myricae* by *E. debachi* is a common phenomenon and was responsible for the very high overall mortality rate. In our experiments it was observed that eggs are present at the moment of emergence and the *E. debachi* starts oviposition directly after hatching. For this reasons host feeding might not be necessary to

Table 2. **Mean longevity of *Eretmocerus debachi* on six different diets at 25 ± 1°C**

Diet	n	Longevity (days) Mean ± SE	min–max
Saccharose (10 %)	19	3.4 ± 0.32 a	1.5–6.0
Honey (20 %)	10	2.8 ± 0.17 b	1.0–3.0
Honey dew	29	1.6 ± 0.09 c	1.0–2.0
P. myricae- 1st larva stage	10	1.6 ± 0.08 c	1.5–2.0
Water	10	2.5 ± 0.29 b	1.0–3.5
Without food	20	1.2 ± 0.09 c	0.5–2.0

Means in column followed by the same letter are not significantly different at the 5 % level (Tukey's HSD Multiple Range Test).

obtain nitrogenous compounds to develop oocytes (BELL and BOHM 1975), but to maintain oviposition behavior as it is reported for several hymenopterous parasitoids (FLANDERS 1953; LEIUS 1961; VAN LENTEREN et al. 1987). However, in the present experiments no behavioral observations were made on parasitization and host feeding of *E. debachi*, which could prove this.

3.3 Generation time

Between 13 and 14 generations of *E. debachi* were obtained in the semi-field experiment in 1 year (table 3). The shortest generation time was 14 days in summer, the longest 145 days during November to April. These results corresponded well with those obtained in the laboratory studies. Average daily temperatures of 23 °C and higher resulted in generation times between 14 and 15 days; in the laboratory this period was found to last between 12 and 17 days for comparable temperature regimes. *E. debachi* hibernated in second stage *P. myricae*. If third stage *P. myricae* were parasitized in late autumn, the parasitoid emerged and did not hibernate. It was observed that *E. debachi* completed its development in spring

Table 3. **Generation times and number of generations per year of *Eretmocerus debachi* in a semi-field experiment in Balcali/Adana**

Start of exposition	Hatching date of females	Daily average temperature during exposition period (°C) Mean	min–max	Generation time (days)	Number of generation
25.06.1991	09.07.1991	27.1	26.0–27.7	14	1
09.07.1991	24.07.1991	28.4	27.5–29.6	15	2
24.07.1991	07.08.1991	28.4	27.4–29.0	14	3
07.08.1991	21.08.1991	28.9	28.4–30.4	14	4
21.08.1991	05.09.1991	27.6	26.1–29.5	15	5
05.09.1991	20.09.1991	26.9	24.2–29.9	15	6
20.09.1991	11.10.1991	25.2	21.6–28.4	21	7
11.10.1991	07.11.1991	20.7	14.5–25.2	27	8
07.11.1991	31.03.1992	10.8	5.2–18.2	145	9
31.03.1992	26.04.1992	16.7	13.9–23.1	26	10
26.04.1992	20.05.1992	19.8	16.0–25.5	24	11
20.05.1992	04.06.1992	23.2	19.4–27.8	15	12
04.06.1992	19.06.1992	24.4	21.8–26.8	15	13
19.06.1992	03.07.1992	25.1	23.8–26.2	14	14

2 weeks later than its whitefly host *P. myricae*. This means that the first generation of the parasitoid will already find suitable host stages in the field after overwintering in March and April.

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