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Some Biological Attributes of *Trichogrammatoidea bactrae*, Hymenoptera: Trichogrammatidae, at High Temperatures in Pink Bollworm (*Pectinophora gossypiella*, Lepidoptera: Gelechiidae) Eggs

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Abstract: The peed of development, (Egg to adult emergence) of *Trichogrammatoidea bactrae* ranged from 7.273 to 6.532 days between temperatures 30 to 40 °C. Immature mortality was maximum (71.88 %) at 40 °C and minimum (39.77 %) at 30 °C. More females than males were found at all tested temperatures. Fecundity was 31 per female at 30 °C and 19 per female at 40 °C. Females lived longer than males at all tested temperatures. The net reproductive rate (*Ro*), intrinsic rate of increase (*rm*) and finite rate of increase (*λ*) (16.98, 0.30 and 1.43 respectively) were maximum at 30 °C. From these results, 30 °C is the best temperature for rearing *T. bactrae* in the laboratory with 45% RH and 14/10 photoperiod. At 30 °C parasitoid can produced about 33 generations in a year. Upper threshold temperature for *T. bactrae* looks around 45°C.

Key words: *T. bactrae*, parasitoid, mortality, fecundity, speed of development, net reproductive rate, intrinsic rate of increase, finite rate of increase, Balochistan, Pakistan

Introduction

Parasitic Hymenoptera are very effective and environmentally safe for the control of agricultural pests (Bhatty *et al.*, 2000). Pink bollworm (PBW) is a key pest of cotton. Due to the absence of native biological agents the pest has got a level of economic importance (Anonymous, 1978). Egg is the first stage in the life cycle of PBW . By using an egg parasitoid it may be possible to biologically control PBW (Hutchison *et al.*, 1990). *T. bactrae*, Hymenoptera, Trichogrammatidae is an egg parasitoid of PBW. *T. bactrae* is widely distributed in the orient. It is adapted to hot and humid habitats and is known to attack various pests of cotton, sugarcane, fruits and vegetables (Nagaraja, 1978). There is a need to understand its life history and behavior in detail at high temperature and low humidity. Nagaraja (1978) first described *T. bactrae* from the specimen collected from India. Hutchison *et al.* (1990) reported that *T. bactrae* completes it's immature stages within the host (*Pectinophora gossypiella*) egg. *T. bactrae* may prove to be a good parasitoid for PBW in hot and semi humid climatic conditions. It could be used in an IPM program for PBW control in cotton growing areas of Balochistan, Pakistan which are hot and semi humid like New Mexico State, USA. So to determine different biological attributes, like speed of development, mortality, sex ratio, fecundity, net reproductive rate (*Ro*), intrinsic rate of increase (*rm*) and finite rate of increase (*λ*), of *T. bactrae* at hot and semi humid conditions in PBW eggs in the laboratory, the project was assigned.

Materials and Methods

To determine different biotic parameters like speed of development, immature mortality, sex ratio, fecundity, net reproductive rate (*Ro*), intrinsic rate of increase (*rm*) and finite rate of increase (*λ*) of *T. bactrae* at four different temperatures (30, 35, 40 & 45 °C), with constant 45% relative humidity (RH) and 14/10 photoperiod, an experiment was conducted in the Post Graduate's Laboratory, Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, USA. Environmental chambers (Atmar & Ellington, 1972) were used for control conditions. PBW eggs and *T. bactrae* were obtained from the colonies maintained locally in the department.

Development, Immature Mortality and Sex Ratio: To determine development, immature mortality and sex ratio, two hundred PBW eggs were placed in an air tight petri dish (50 x 9 mm) with ten pairs of *T. bactrae* adults and diet (100% natural honey) at 23 °C, 55% RH and 11/13 photoperiod (Malik, 2000). After parasitization, eggs were placed in another air tight petri dish (50 x 9m^2) at the same temperature for emergence. Soon after emergence, ten males and ten females *T. bactrae* adults were placed in an air tight petri dish (50 x 9m^2). Development was noted twice a day. Because egg and larval stages could not be distinguish therefore these two stages were combined for data collection (Malik, 2000). Blackening of the vitelline membrane of the host egg occurs at the onset of the pre-pupal stage (Hutchison *et al.*, 1990). Therefore, the time from adult release to blackening was considered to be the egg/larval stage while blackening of host egg to emergence of the parasitoid was considered to be the pupal stage. After the emergence of all adults the speed of development of males and females, immature mortality and sex ratio were counted.

Fecundity: To determine the fecundity of female *T. bactrae*, two male and female *T. bactrae* with diet and about 100 PBW host eggs were placed in an air tight petri dish (50 x 9 m^2) at 23°C, 55°C RH and 11/13 photoperiod. PBW eggs were replaced every eight hours until the death of the last female. After the death of all the females, the total number of parasitized eggs were counted in each replication.

Life Table Parameters: A computer program Life48: (Abou-Setta, 1986) was used to calculate life table parameters like net reproductive rate (*Ro*), intrinsic rate of increase (*rm*) and finite rate of increase (*λ*) of the parasitoid, *T. bactrae*.

Statistical Analysis: Each temperature regime was considered a treatment and each small air tight petri dish a replication. Egg/larval and pupal development, male/female longevity, egg/larval and pupal mortalities, fecundity, reproductive rate (*Ro*), intrinsic rate of increase (*rm*) and finite rate of increase (*λ*) of the parasitoid were the different variables in this experiment. Treatments were replicated eight times for four generations in a split plot design. Data were analyzed by Statistical Analysis System (SAS) Statistical Procedures Program (SAS Institute, 1990). ANOVA was used to test for

Table 1: *1Mean Egg/Larval, Pupal Speed Of Development and Percent Immature Mortality, of *T. bactrae* at Different Temperatures.

Temp. °C	EGG/Larval Stage (Days)	Pupal Stage (Days)	*2Total Time From Egg To Emergence, (Days)	Egg/Larval Mortality (%ag)	Pupal Mortality (%ag)	*3Total Immature Mortality (%ag)
30	4.731a*4	2.542 a	7.273a	22.34 c	17.43 c	39.77 c
35	4.512 b	2.421 a	6.933 b	31.76 b	19.67 b	51.43 b
40	4.324 c	2.208 b	6.532 c	41.89 a	29.99 a	71.88 a

*1Means are from eight replications. *2Total time from egg to adult emergence is the sum of egg/larval and pupal stages. *3Total Immature Mortality is the sum of Egg/Larval and Pupal Mortalities. *4Lower case letters indicate significant difference down the column using the LSD test. LSD for egg/larval stage 0.155, pupal stage 0.132, total immature stage 0.187, egg/larval mortality 0.345, pupal mortality 0.592, total immature mortality 0.468 at significance level of 0.05.

Table 2: *1Mean Male, Female Longevity, Sex Ratio, and Fecundity of *T. bactrae* at Different Temperatures.

Temperature °C	Male Longevity (Days)	Female Longevity (Days)	Female/Male Ratio	Fecundity/Female (No.)
30	1.52 a	5.22 a	62/38a*2	31a
35	1.31 a	5.14 a	55/45b	29b
40	1.20 a	4.23 b	55/45b	19c

*1Means are from eight replications. *2 Lower case letters indicate significant difference down the column using the LSD test. LSD for male Longevity 0.232, female longevity 0.22, female/male ratio 0.537 and fecundity/female 0.413 at significance level of 0.05.

Table 3: Life Table Parameters of *T. bactrae* at Different Temperatures.

Temperature °C	Net Reproductive Rate (Ro)	Intrinsic Rate of Increase (rm)	Finite Rate of Increase (λ)	Total Generation Time (T) (Days)
30	16.98 a*1	0.30 a	1.430 a	11.95 a
35	15.11 b	0.29 b	1.321 b	10.55 b
40	8.97 c	0.09 c	1.001 c	10.07 c

*1 Lower case letters indicate significant difference down the column using the LSD test. LSD values for *Ro*, *rm*, *λ* and *T* were 0.564, 0.005, 0.007 and 0.863 respectively at significance level of 0.05.

significant differences between variables. LSD test was used for means separation.

Results and Discussion

Development, Immature Mortality and Male/Female Longevity: Temperature had a significant effect on immature mortality as observed by Sharma & Chaudhary (1988) in *Heliothis armigera* and Marco *et al.* (1997) in *Aubeonymus mariaefranciscae*. More morality observed in egg/larval stage than pupal stage (Table 1). Same is reported by Shipp & Houten (1997) in the study of *Amblyseius cucumeris*. Total immature mortality was maximum at 45 °C (>95%). Thus was not considered in further analysis. This indicates that the upper threshold temperatures for *T. bactrae* might be around 45 °C. As temperatures went towards upper threshold level the mortality increased as reported by Sharma & Chaudhary (1988). The lowest percent mortality occurred at 30 °C (39.77%) (Table 1). Temperature also had an inverse relation with the mean development time of the parasitoid (Sharma & Chaudhary 1988, Phoofolo *et al.* 1995, Marco *et al.* 1997). It took *T. bactrae* a minimum 6.532 days from eggs to emergence at 40 °C and a maximum of 7.273 days at 30°C. Pupal stage respond less to the temperature than the egg/larval stage. Based on these results, the speed of development of *T. bactrae*, from sting to adult death, was 7.273 days at 30 °C (Table 1) which is about the same as reported Naranjo (1993) 7.3 days at 29.5 °C. Immature mortality was 39.77 to 71.88% at 30 & 40 °C respectively (Table 1). Hutchison *et al.* (1990) reported 34.3% at 27.5 °C and Naranjo (1993) observed 38% at 29.5 °C. Females at any temperature lived longer than males. Both male and female longevity decreased as temperature increased (Table 2). Same response was observed by Hutchison *et al.* (1990) and Naranjo (1993).

Sex Ratio and Fecundity: *T. bactrae* female/male ratio ranged from 62/38 to 55/45 between 30 & 40 °C temperatures (Table 2).

Hutchison *et al.* (1990) got 64/36 at 27.5 °C. A maximum of 31 eggs/female at 30 °C were obtained (Table 2). Hutchison *et al.* (1990) got 19 and Naranjo (1993) got 34 eggs/female at 27.5 °C. These differences might be due to differences in diet, temperature, relative humidity and density of parasitoid. Hutchison *et al.* (1990) and Naranjo (1993) used 10% honey solution while 100% pure natural honey was used in this study. Diluted honey was not used because it reduces the osmotic concentration and allows mold growth (Malik, 2000). Relative humidities were also different in this study from the studies of Hutchison *et al.* (1990) and Naranjo (1993). Hutchison *et al.* (1990) and Naranjo (1993) used high relative humidity (75%) for hot and humid areas like Sindh and Punjab (Pakistan), Arizona and California (USA). In this study high temperatures of 30 to 45 °C with constant low relative humidity (45%) was used like cotton areas of Balochistan (Pakistan) and New Mexico State (USA). Hutchison *et al.* (1990) used 1:10 and Naranjo (1993) 1:25 female/host eggs while in this study the ratio was 1:50.

Life Table Parameters: To compare biotic potential under the conditions of the experiment (Table 3), net reproductive rates (*Ro*) at 30 °C was 16.98 while Naranjo (1993) got 16.23 at 27.5 °C., intrinsic rate of increase (*rm*), was 0.30 at 30 °C while Naranjo (1993) got 0.31 at 27.5 °C. finite rate of increase (*λ*), 1.43 was maximum at 30 °C and minimum total time for a generation (*T*), 10.07 at 40 °C.

From these results, 30 °C is the best temperature for rearing

T. bactrae in the laboratory at 45% RH and 14/10 photoperiod. At 30 °C about 33 generations of *T. bactrae* can be produced in a year. The result indicated that the above said combination of environmental conditions suits *T. bactrae* to establish in the cotton growing areas of Balochistan, Pakistan and New Mexico State, USA.

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