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Effect of Temperature and Photoperiod on the Biological Characters of *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae)

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Abstract: Effect of temperature (20, 25 and 30°C) and photoperiod (12:12, 14:10 and 16:8 h L:D) were studied separately on *Trichogramma chilonis* Ishii. As the temperature increased from 20 to 30°C, fecundity increased but longevity decreased. The maximum fecundity (12.73±1.01 eggs/female/day) and adult emergence was observed at 30°C. However, the least longevity of females (6.73±0.53 days) was observed also at 30°C and the maximum (10.08±1.21) was at 20°C, which was significantly higher compared with that at 25 and 30°C. Similarly, at 14:10 h L:D fecundity (9.92±0.13 eggs/female/day) and adult emergence was significantly higher compared with 12:12 and 16:8 h L:D photoperiod regimes. There was no significant differences among different photoperiod regimes tested with respect to longevity, though it was higher at 16:8 h L:D.

Key words: Temperature, photoperiod, *Trichogramma chilonis*, fecundity, longevity

INTRODUCTION

Trichogramma species are used as inundative biological control agents in more than 30 countries around the world, covering over 32 million ha of agriculture and forestry land (Li, 1994). In India, about 26 species have been reported among which *Trichogramma chilonis* Ishii is considered more important with regard to its distribution (Nagarkatti and Nagaraja, 1979; Ramesh and Baskaran 1996; Singh *et al.*, 2002). Despite the accepted practice of inundative release of *Trichogramma* against certain pests, the degree of success obtained often varies (Ramesh and Baskaran, 1996; Prasad *et al.*, 1999).

Rearing conditions such as food, temperature, light etc. may affect the performance of a colony being mass produced in confined situations (Hoffmann *et al.*, 2001). Among abiotic elements, temperature and photoperiod have proved to affect biological characteristics of *Trichogramma* (Prasad *et al.*, 1999; Gunie and Lauge 1997; Miura and Kobayashi, 1993; Smith and Hubbes, 1986; Harrison *et al.*, 1985; Rounbehler and Ellington, 1973; Calvin *et al.*, 1984).

In general, the effect of temperature on most species of *Trichogramma* within a defined range (9 to 30°C) is positively related to fecundity and adult emergence but inversely related to longevity (Harrison *et al.*, 1985; Consoli and Parra, 1995; Resende and Ciociolla, 1996; Carriere and Boivin, 1997). However, there are some reports indicating that lower temperatures are preferred by some species of *Trichogramma* (Attaran, 2002; Miura and Kobayashi, 1993). Pak and Oatman (1982) studied *T. brevicapillum* and *T. pretiosum* at various temperatures to find an answer to their differences in natural distribution and found that the former would be successful under high temperatures and the latter under intermediate temperatures. Forsse *et al.* (1992) observed that under laboratory conditions lower temperatures resulted in lower level of parasitism. Haile *et al.* (2002) found differences among four species of *Trichogramma* including *T. chilonis* regarding their developmental time, fertility, rate of emergence and sex ratio reared at different temperatures. Pratissoli *et al.* (2004) demonstrated improvements in fertility life table parameters of *T. pretiosum* and *T. acacioi* from 15 to 30°C and 15 to 25°C, respectively.

Very few studies are available on the effect of photoperiod on *Trichogramma* and the results indicate a direct positive relationship of photoperiod with longevity and fecundity (Rounbehler and Ellington, 1973; Calvin *et al.*, 1984; Zaslavski and Quy, 1982). One of the accessible old information on the effect of photoperiod is the studies done by Rounbehler and Ellington (1973). They found that longevity of *T. semifumatum* increased as the photoperiod elevated from 10 to 14 h in one strain but in another strain, maximum longevity happened at 10:14 h L:D. Zaslavski and Quy (1982) demonstrated that *T. chilonis* and *T. evanescens* had the greatest fecundity at 16:8 h L:D. Calvin *et al.* (1984) observed that developmental time increased in *T. pretiosum* under 12 and 16 h photophase, female longevity decreased significantly under 12 h photophase and fecundity was not affected by photoperiod. Garcia *et al.* (2000) reported that developmental time had an inverse relationship with increase in temperature and photophase in *T. cordubensis*.

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As it has frequently been observed that different experimental conditions (temperature and photoperiod) are used by researchers to study various aspects of similar *Trichogramma* species, the obtained results may not be comparable or may even be controversial. From the other hand, if the experimental conditions are not uniform in studying given species of insects, then the genetical and geographical differences may not be revealed vividly. Consequently, this study was undertaken to investigate the effect of temperature and photoperiod on quality and performance of *T. chilonis* and to find out if some basic biological parameters of this species is related to these environmental conditions.

MATERIALS AND METHODS

The study was conducted in Department of Entomology, College of Agriculture, University of Agricultural Sciences, Bangalore, India, during 2002-2004.

Parasitoid rearing: *Trichogramma chilonis* Ishii culture was established by taking more than 5000 parasitized eggs of *Corcyra cephalonica* (Stainton) from Biological Control Research Laboratories (BCRL), Bangalore. The culture was maintained on eggs of *Corcyra* at 25±1°C, 65±10% RH and 16:8 h L:D.

Temperature experiment: Temperature regimes used were 20±1, 25±1 and 30±1°C. Three incubators were set at either of the said temperatures. A number (>12) of newly emerged (0-24 h old) and mated females of *T. chilonis* were confined in homeopathic vials. Eighty to 100 fresh eggs of *Corcyra* were stuck on a strip of white paper (0.5×4 cm) and assigned a number, treatment code and date. Wasps were provided individually with said egg cards daily till they died. The whole set was maintained at required temperature treatment but all at 65±10% RH and 16:8 h L:D. A streak of honey was also provided inside the vials for adult feeding. Parasitized eggs were kept at the corresponding temperature and photoperiod regimes related to their treatments. After parasitized eggs turned black, blackened eggs were counted for each wasp and recorded as daily fecundity. After emergence, the number of female, male and unemerged progeny was recorded for all the treatments.

Photoperiod experiments: Photoperiod regimes were 12:12, 14:10 and 16:8 h L:D. Three incubators were set at either photoperiod regime but all at 25±1 °C and 65±10% RH. For each photoperiod treatment a number of females were prepared as explained in temperature experiment and exposed to egg cards daily. Parasitized eggs were incubated in the same corresponding conditions (incubator). After 5 days, the parasitized eggs which turned black, were counted and recorded as daily fecundity for each wasp in each treatment. After emergence, female, male and unemerged progeny were noted down for all wasps in all treatments separately.

Statistical analysis: Data were subjected to GLM (Proc GLM, SAS, 1986) and means were separated by Least Significant Difference method (LSD).

RESULTS

Temperature experiments: The fecundity of *T. chilonis* significantly increased with increase in temperature from 20-30°C (Table 1 and Fig 1a-c). Female progeny also had a positive relationship with the temperature. There was almost 3-fold increase in female progeny with an increase in temperature from 20 to 30°C. Male progeny and the number of unemerged were also significantly higher at 30°C compared to that at 20 and 25°C. In contrast to adult emergence and fecundity, longevity decreased with an increase in temperature from 20 to 30°C. The female longevity was significantly the highest (10.08±1.21 days) at 20°C and the lowest at 30°C. From these studies it is seen that 30°C appears to be the optimum temperature for rearing *T. chilonis*.

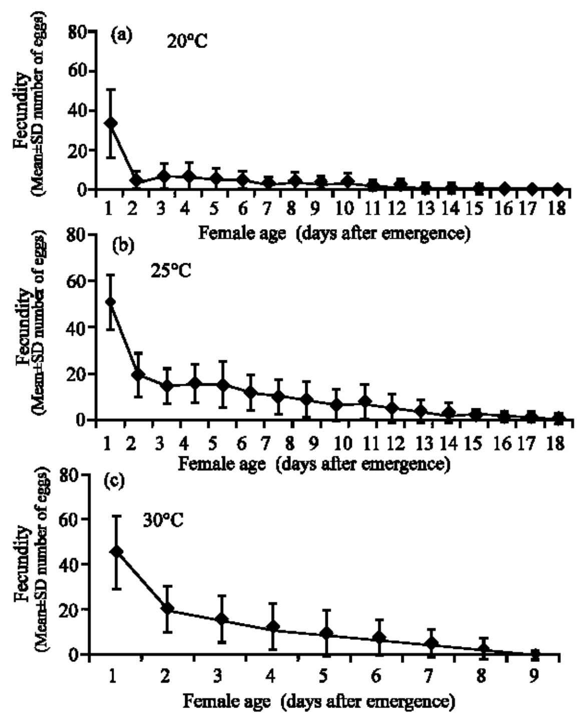

Fig. 1: Age specific fecundity (Mean±SD number of eggs) of *Trichogramma chilonis* Ishii females on eggs of *Corcyra cephalonica* (Stainton) at 20, 25 and 30°C

Table 1: Influence of rearing temperature on fecundity and adult emergence of *Trichogramma chilonis* Ishii females at 65±10% RH and 16:8 h L:D

	Biological characters (Mean±E)[§]				
Temperature (°C)	Fecundity/day	Female/day	Male/day	Unemerged/day	Longevity
20	4.27±0.41c	2.20±0.27c	1.39±0.13c	0.69±0.06b	10.08±1.21a
25	6.69±0.72b	3.22±0.40b	2.19±0.24b	1.28±0.14b	9.25±1.03ab
30	12.73±1.01a	5.90±0.60a	4.62±0.34a	2.22±0.21a	6.73±0.56b
LSD (5%)	1.4791	0.8896	0.4917	0.2854	2.3406

[§]Means with similar letter in a column are not significantly different at $p<0.05$

Table 2: Influence of photoperiod on fecundity, emergence, and longevity of *Trichogramma chilonis* Ishii females at 25±1°C and 65±10% RH

Photoperiod Regime	Biological characters (Mean±SE)[§]				
(L:D h)	Fecundity/day	Female/day	Male/day	Unemerged/day	Longevity/day
12:12	5.16±0.50b	2.78±0.31b	1.85±0.19b	0.54±0.06b	6.07±0.80a
14:10	9.92±0.31a	5.30±0.74a	3.29±0.42a	1.34±0.17a	6.69±0.83a
16:8	6.50±0.70b	3.15±0.40b	2.11±0.23b	1.24±0.14a	8.75±1.18a
LSD (5%)	1.5820	0.9608	0.5868	0.2346	2.7524

[§]Means with the same letter in one column are not significantly different at $p<0.05$

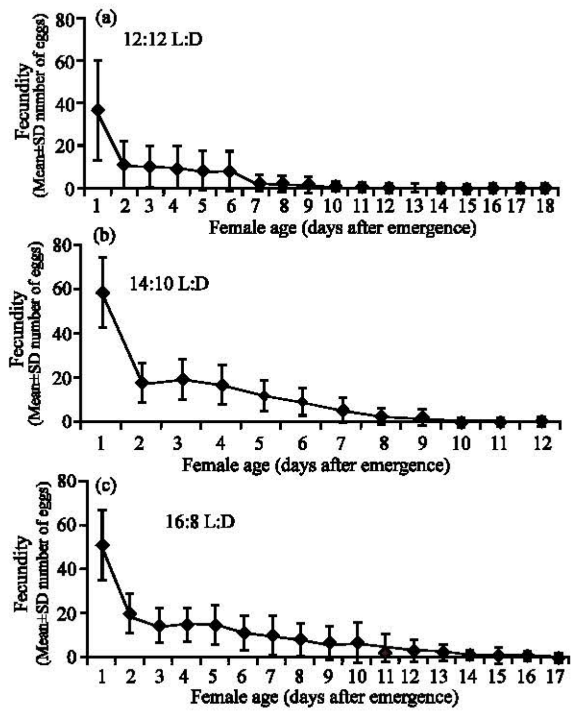

Fig. 2: Age specific fecundity (Mean±SD number of eggs) of *Trichogramma chilonis* Ishii females on eggs of *Corcyra cephalonica* (Stainton) at 12:12, 14:10 and 16:8 h L:D

Photoperiod experiment: *T. chilonis* reared at regime of 14:10 h L:D had significantly higher fecundity/day (9.92±0.31 eggs/day) compared to 12:12 or 16:8 h L:D regimes, which were on par with each other (Table 2 and Fig 2a-c). The number of female progeny produced was also significantly higher at 14:10 h L:D regime (5.30±0.74) compared to the other two regimes. Similarly, the number of males produced were also the highest at 14:10 h L:D compared to other regimes. The photoperiod regime of 12:12 h L:D recorded the least number of unemerged/day compared to other two regimes. However, all three regimes tested did not have any influence on adult female longevity of *T. chilonis* (Table 2).

DISCUSSION

Temperature directly affected the developmental period of *T. chilonis*. Almost in all organisms there is a positive acceleration in the biological parameters when temperature increases within a thermal range (Cossins and Bowler, 1987). The effect of temperature on *T. chilonis* is also at par with most of earlier studies (Miura and Kobayashi, 1993; Harrison *et al*., 1985; Smith and Hubbes, 1986; Ramesh and Baskaran, 1996). *T. chilonis* has shown a kind of thermophilic behaviour in other studies. Some strains of *T. chilonis* could tolerate up to 37±1°C (Singh *et al*., 2002). Calvin *et al.* (1984) introduced 30°C as the normal temperature for the optimum development of all stages of *T. pretiosum.* However, Miura and Kobayashi (1993) demonstrated that 28°C was the optimum temperature for *T. chilonis* developing on eggs of diamondback moth which may reveal the differences in geographical strains of *T. chilonis* on their sensitivity toward temperature. Moreover, Haile *et al.* (2002) concluded that *T. chilonis* from India could complete its development even at 34°C, however, the fertility decreased as the temperature increased from 25 to 34°C. All these findings are in general in agreement with the findings of the present study on the significantly better performance of *T. chilonis* at 30°C. Recently it was proved by Pratissoli *et al.* (2004) that *T. pretiosum* had the maximum ($r_m = 0.47$) and doubling time ($\lambda = 1.61$) at 30°C but those of *T. acacioci* occurred at 25°C. Therefore, with the observation recorded during this investigation, the studied strain of *T. chilonis* had significantly higher fecundity (≥85 eggs/female/life time) at 30°C, although longevity decreased compared with that at 25°C, which gave rise to lower fecundity (≤60 eggs/female/life time) despite of longer life span.

The photoperiod significantly affected all the biological parameters studied in *T. chilonis*. However, there are very few studies available on the effect of photoperiod on life histories of *Trichogramma*. Most reports on this aspect emphasize on the effect of photoperiod on diapause initiation in *Trichogramma* (Bennemaison, 1972; Zaslavski and Umarova, 1990) and on the emergence rhythm (Zinovjeva *et al.*, 1996). Zaslavski and Quy (1982) reported that fecundity of *T. chilonis* and *T. evanescens* increases in long day photoperiod regimes. It was proved by the present study that a 14:10 h L:D resulted in increased fecundity and adult emergence in *T. chilonis*, although, longevity increased with the increase in light duration (16 h) but it was not significantly different with 14 or 12 h light regime. This is not in conformity with the findings of Zaslavski and Quy (1982) mentioned before. However, even in their studies, long day did not evoke increase in fecundity of a third species named *T. euproctidis*. According to the results of Calvin *et al.* (1984) the developmental rate (mean±SE) of *T. pretiosum* increased at 12:12 (10.53±0.26) and 16:8 (9.15±0.10) h L:D but decreased at 14:10 (7.80±0.23) h L:D and fecundity was not affected by photoperiod. All these interesting findings prove that effectiveness of this environmental parameter on different species of *Trichogramma* differs greatly.

It can be concluded that as *T. chilonis* strain studied was taken from BCRL, Bangalore, reared in condition near to local natural environment with respect to day length and temperature, had experienced almost a 14:10 h day and night length, it may have been adopted for shorter day than 16 h light and higher temperatures. Therefore, using 25°C selected based on previous recommendations for evaluating photoperiod effects even in this investigation caused differences in measured parameters. However, it can be suggested that *T. chilonis* preferred 30°C and 14:10 h L:D which can be used in lab studies as well as mass rearing conditions. Compiling more information on the matter can lead to standardizing conditions in studying this wasp and making mass rearing systems more economic by saving time and money (shortening egg to adult duration and increasing adult products) as well as guarantying the quality and performance.

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