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Temperature Tolerance in the Five Field Strains of *Trichogramma chilonis* from Northern Districts of Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The egg parasitoid, *Trichogramma chilonis* is a potential egg parasitoid in the agricultural ecosystem, reducing many lepidopteran pest incidences. The laboratory strains of *T. chilonis* was significantly inferior to the ecotypes collected from fields in their parasitisation potential and tolerance to temperature due to continuous exposure to temperature extremes in the field. Hence, a study was undertaken to evaluate the laboratory reared strain of *T. chilonis* with that of other ecotypes to identify a temperature tolerant ecotype for use in pest management programme. Five ecotypes of *T. chilonis* were collected from farmer's fields on sugarcane and citrus using sentinel egg technique by exposing egg cards of *Corcyra cephalonica*, mass reared on *C. cephalonica* for three successive generations and tested for their relative tolerance to temperature in comparison with the laboratory population. The emergence percentage of the parasitoid varied with the ecotypes tested and all the field collected ecotypes recorded increased emergence compared to the laboratory population. At 150 C, the emergence was significantly higher in Chitteri ecotype

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(83.44%) followed by Arungunam and Amirthapuram ecotype (78.65 and 75.57%). The performance of all the ecotypes were best at 200 C and Chitteri ecotype performed significantly better compared to other ecotypes and the laboratory population with an adult emergence of 95.66 per cent. It was followed by Arungunam ecotype (88.65%) at 200 C. While the laboratory population and other ecotypes failed to develop at 350 C, Chitteri and Arungunam ecotypes were able to develop with 9.66 and 7.25 per cent adult emergence from the parasitised eggs.

Keywords: Egg parasitoid; Trichogramma chilonis; ecotype; temperature tolerance.

1. INTRODUCTION

“Increasing global trade and change in climate have led to the introduction and establishment of many invasive insect pests to new geographic areas, producing substantial ecological and economic impacts. Several non-native lepidopteran pests have been established in many countries in recent years, and some native species have expanded their range within the continent. Besides, due to climate change, many moth pest species are changing their migration routes, invading new geographical areas where they can optimally reproduce and survive” [1]. “The lepidopteran pests in newly invaded areas have been predominantly managed by extensive application of broad-spectrum and persistent insecticides, which have often proved rapidly ineffective due to the development of resistance and a multitude of undesired side effects on non-target organisms. Many agricultural crops and forests pests were controlled worldwide by inundative biological control with egg parasitoids of the genus *Trichogramma* (Hymenoptera: Trichogrammatidae)” [2]. “These parasitoids can be inexpensively produced in large numbers and easily released in fields or greenhouses, reducing both egg hatching and subsequent crop damage caused by larval feeding and contributing to the conservation of environment and human health by restricting the application of pesticides” [3].

“The successful selection and introduction of *Trichogramma* wasps in biological control programs is determined by some important factors such as the potential development of the parasitoid species or strain in the target host, beside some abiotic and physical factors. Among these, temperature is the most important environmental factor that affects the distribution and abundance of *Trichogramma*, because it strongly determines biological parameters such as the development rate, survival, longevity, parasitism rate, viability, sex ratio, and emergence rate of the parasitoid wasps” [4]. “The egg parasitoid, *Trichogramma chilonis* is a potential egg parasitoid in the sugarcane, reducing early shoot borer and internode borer. The ecotypes collected from fields are always performing better compared to the laboratory strains of parasitoids. The ecotype of *T. chilonis* collected from cotton field in Palladam recorded maximum extent of parasitism and emergence” [5]. Hence, the present study was undertaken to evaluate the laboratory reared strain of *T. chilonis* with that of other ecotypes to identify a temperature tolerant ecotype for use in pest management in the present scenario of increasing temperature over years.

2. MATERIALS AND METHODS

2.1 Collection of *T. chilonis* ecotypes

Five ecotypes of *T. chilonis* were collected from farmer's fields on sugarcane and citrus using sentinel egg technique by exposing egg cards of *Corcyra cephalonica* (List 1). These were mass reared on *C. cephalonica* for three successive generations and then tested for their relative tolerance to temperature extremes in comparison with the laboratory strain.

List 1. Details of field collected trichogrammatids from Tamil Nadu

Sl. No.	Crop	Village	Latitude	Longitude	Disrict
1	Sugarcane	Chitteri	12.8752° N,	79.1193° E	Ranipet
2	Sugarcane	Rajapalayam	13.1231° N,	79.9120° E	Tiruvallur
3	Citrus	Amirthapuram	13.1231° N,	79.9120° E	Tiruvallur
4	Sugarcane	Padur	12.5107° N,	79.1268° E	Thiruvannamalai
5	Sugarcane	Arungunam	12.8185° N,	79.6947° E	Kancheepuram

2.2 Effect of Temperature on the Growth and Development of *T. chilonis*

To assess the temperature tolerance of the *T. chilonis* ecotypes, (eighty fresh, sterilized eggs of *C. cephalonica* were glued over a cardboard strip of 2.0 x 6.5 cm using diluted gum arabic, and placed in BOD incubator at different temperature viz., 15,20,25,30 and 35^0 C) A pair of female parasitoid from each ecotype was allowed to oviposit and the percentage of parasitism was worked out based on the blackening of eggs four days later. The adult emergence was recorded up to 10 days, sexed and the percentage emergence and sex ratio were worked out. The adult longevity was recorded by observing daily mortality up to 7 days. Each treatment was replicated five times.

3. RESULTS AND DISCUSSION

The emergence percentage of the parasitoid varied with the ecotypes tested and all the field collected ecotypes recorded increased emergence compared to the laboratory population. At 15^0 C, the emergence was significantly higher in Chitteri ecotype (83.44 %) followed by Arungunam, Amirthapuram and Rajapalayam ecotype (78.65, 75.57 and 74.87 % respectively). In Chitteri population more percentage of females (59.67) emerged at 15^0 C with a sex ratio of 1:1.47 (Table 1). At 20^0 C also, Chitteri ecotype performed significantly better compared to other ecotypes and the laboratory population with an adult emergence of 95.66 per cent. It was followed by Arungunam ecotype (88.65 %) (Table 2). An increase in the adult emergence at 20^0 C was observed uniformly in all the ecotypes as well as the laboratory population. How ever not much difference was observed in the sex ratio of the ecotypes developed at 15^0 C and 20^0 C.

The adult emergence of different ecotypes of *T. chilonis* at 25^0 C ranged from 94.62 per cent (Chitteri) to 84.14 per cent (Padur). The Chitteri, Arungunam and Amirthapuram ecotypes outperformed other ecotypes with increased percentage of female emergence (58.12, 57.46 and 56.58 %respectively) (Table 3). A decline in the adult emergence of all the ecotype tested was observed at 30^0 C. However, significantly more adults emerged in Chitteri ecotype (83.44 %) followed by Arungunam (78.64 %) as observed at 25^0 C (Table 4). Increased male emergence (42.68 %) was observed at 30^0 C with a sex ratio of 1:1.34 compared to 1.1.39 at 25^0 C. However more females were produced at the temperatures tested compared to the males. A female-biased sex ratio was also recorded in *T. achaeae* at all the temperatures tested between 15 – 30^0C [6].

Except, Chitteri and Arungunam ecotypes, other ecotypes and laboratory population failed to develop at 35^0 C (Table 5). Only 9.66 per cent emergence was observed from Chitteri ecotype and 7.25 per cent from Arungunam population with decline in female production (Sex ratio of 1.1.20 and 1.1.15 respectively). Ghosh et al. [7] found that *T. achaeae* was successfully able to develop and emerge at 36 °C in *C. cephalonica* eggs.

Temperature is considered the most significant abiotic factor directly influencing development rate, cumulative fertility, adult longevity, sex ratio and emergence rate of *Trichogramma* [8]. Results of the current study also clearly showed that temperature significantly affected the adult parasitoid emergence in all the ecotypes tested when temperature was increased from 15 °C to 30 °C. Similar observation was recorded in *Trichogramma achaeae* by del Pino [6] and by other authors on different *Trichogramma* species

Table 1. Growth and development of *Trichogramma chilonis* ecotypes at 15^0 C

Ecotype	Adult Emergence (%)	Male (%)	Female (%)	Sex ratio (♂:♀)
Chitteri	83.44 (78.44)[a]	40.33 (30.29)[e]	59.67 (49.29)[a]	1:1.47
Amirthapuram	75.57 (71.34)[c]	42.77 (33.19)[c]	57.23 (45.23)[c]	1:1.34
Rajapalayam	74.87 (69.86)[c]	43.38 (34.56)[c]	56.62 (44.78)[d]	1:1.30
Padur	71.34 (67.34)[d]	44.55 (35.29)[b]	55.45 (43.29)[e]	1:1.24
Arungunam	78.65 (75.29)[b]	41.58 (31.69)[d]	58.42 (47.85)[b]	1:1.40
Laboratory population	70.56 (65.29)[d]	46.35 (36.10)[a]	53.65 (41.89)[f]	1:1.16

Mean of five replications
Figures in parenthesis are Arcsine transformed values
Means followed by same letters within columns are not significantly different by Tukey's HSD test (P = 0.05)

Table 2. Growth and development of *Trichogramma chilonis* ecotypes at 20^0 C

Ecotype	Adult Emergence (%)	Male (%)	Female (%)	Sex ratio (♂:♀)
Chitteri	95.66 (82.45)^a	41.45 (32.30)^f	58.55 (49.23) ^{a}	1:1.41
Amirthapuram	85.78 (73.34)^c	44.16 (34.67)^d	55.84 (45.78)^c	1:1.26
Rajapalayam	84.78 (69.86)^d	44.56 (34.32)^c	55.44 (45.28)^d	1:1.24
Padur	82.34 (68.34)^e	45.49 (36.21)^b	54.51 (43.29)^e	1:1.20
Arungunam	88.65 (77.49)^b	42.78 (33.11)^e	57.22 (48.85)^b	1:1.34
Laboratory population	81.56 (66.33)^f	47.58 (38.69)^a	52.42 (41.89)^f	1:1.10

Mean of five replications
Figures in parenthesis are Arcsine transformed values
Means followed by same letters within columns are not significantly different by Tukey's HSD test (P = 0.05)

Table 3. Growth and development of *Trichogramma chilonis* ecotypes at 25^0 C

Ecotype	Adult Emergence (%)	Male (%)	Female (%)	Sex ratio (♂:♀)
Chitteri	94.62 (76.35)^a	41.88 (31.29)^f	58.12 (47.29)^a	1:1.39
Amirthapuram	87.18 (77.14)^c	43.42 (33.31)^d	56.58 (47.13)^b	1:1.30
Rajapalayam	85.17 (66.76)^d	45.63 (35.52)^b	54.37 (43.49)^c	1:1.19
Padur	84.14 (66.22)^d	45.46 (35.47)^c	54.54 (43.68)^c	1:1.14
Arungunam	89.12 (65.35)^b	42.54 (31.55)^e	57.46 (46.55)^b	1:1.35
Laboratory population	78.33 (63.29)^e	47.29 (36.52)^a	52.71 (42.49)^d	1:1.11

Mean of five replications
Figures in parenthesis are Arcsine transformed values
Means followed by same letters within columns are not significantly different by Tukey's HSD test (P = 0.05)

Table 4. Growth and development of *Trichogramma chilonis* ecotypes at 30^0 C

Ecotype	Adult Emergence (%)	Male (%)	Female (%)	Sex ratio (♂:♀)
Chitteri	83.44 (78.15)^a	42.68 (30.43)^e	57.32 (45.85)^a	1:1.34
Amirthapuram	73.71 (67.14)^c	43.33 (31.31)^d	56.67 (44.13)^c	1:1.30
Rajapalayam	72.47 (66.76)^c	44.63 (32.47)^c	55.37 (43.68)^d	1:1.24
Padur	71.71 (65.44)^d	46.63 (38.33)^b	53.37 (42.19)^e	1:1.14
Arungunam	78.64 (64.12)^b	43.27 (32.29)^f	56.73 (44.29)^b	1:1.31
Laboratory population	61.10 (63.29)^e	47.36 (39.33)^a	52.64(41.44)^f	1:1.11

Mean of five replications
Figures in parenthesis are Arcsine transformed values
Means followed by same letters within columns are not significantly different by Tukey's HSD test (P = 0.05)

Table 5. Growth and development of *Trichogramma chilonis* ecotypes at 35^0 C

Ecotype	Adult Emergence (%)	Male (%)	Female (%)	Sex ratio (♂:♀)
Chitteri	9.66 (17.45)^a	45.44 (41.25)^b	54.56 (46.25)^a	1:1.20
Amirthapuram	0.00 (6.25)^c	0.00 (6.25) ^{c}	0.00 (6.25) ^{c}	-
Rajapalayam	0.00 (6.25)^c	0.00 (6.25) ^{c}	0.00 (6.25) ^{c}	-
Padur	0.00 (6.25)^c	0.00 (6.25) ^{c}	0.00 (6.25) ^{c}	-
Arungunam	7.25 (16.25)^b	46.56 (42.32)^a	53.44 (48.89)^b	1:1.15
Laboratory population	0.00 (6.29)^c	0.00 (6.29) ^{c}	0.00 (6.29) ^{c}	-

Mean of five replications
Figures in parenthesis are Arcsine transformed values
Means followed by same letters within columns are not significantly different by Tukey's HSD test (P = 0.05)

[9-11]. Present studies indicated that *T. chilonis* developed successfully from egg to adult in the temperature range of 15 °C to 30 °C and the laboratory and three field collected ecotypes

failed to develop in at 35^0 C. Similar observation was recorded in *T. achaeae*, where the parasitized host eggs turned black at 35 °C, but many of them collapsed, dried, and no viable progeny emerged, showing a negative effect of high temperature, thus exceeding the upper threshold [6]. The high temperature preventing the adult emergence observed in our study agrees with previous works [12-14]. The current study showed that temperature significantly affected parasite emergence, and sex ratio of *T. chilonis*. Similar observations were recorded by several workers with different species of *Trichogramma* [15-17].

"Among the ecotypes tested, Chitteri and Arungunam ecotypes were able to perform well compared to other ecotypes and laboratory population with regards to the parasitisation potential. Earlier increased parasitisation in the *T.chilonis* Nilgris strain was reported compare to the laboratory and kodai strains" [7]. Similar observation was also recorded by earlier worker with different ecotypes of *T. chilonis* with regards to the parasitisation potential and pesticide tolerance [5, 18] and with "*Trichogramma euproctidis* in respect of parasitisation rate, survival rate, and progeny sex ratio with the greatest percentage of females" [19]. "The Arungunam ecotype was also reported to be tolerance to the pesticides" [20]. The reason for the increased temperature tolerance might be due to the adaptation of the parasitoid by continuous exposure to the increased temperature prevailing at Chitteri.

4. CONCLUSION

The study with the field collected ecotypes of egg parasitoid, *Trichogramma chilonis* showed variation in their tolerance to different temperature viz., 15, 20, 25 and 30^0 C. Significant effects of temperature on the percentage parasitism, adult emergence and Sex ratio and adult longevity was observed with best performance of the parasitoid at temperature 15 and 20^0 C. The Chitteri and Arungunam ecotypes was able to survive at 35^0 C suggesting that the parasitoid can be collected from the regions of high temperature to get optimum biocontrol at increasing temperature due to the present climate change.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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