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Impact of high temperature on the life history traits of the egg parasitoid *Trichogramma cacoeciae* Marchal (Hymenoptera: Trichogrammatidae)

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Abstract

The effect of high-temperature values (25, 30, 35 and 40 ± 1 °C) on the performance of the egg parasitoid *Trichogramma cacoeciae* Marchal (Hymenoptera: Trichogrammatidae), was assessed herein. Our results showed that the temperature of 30 °C was optimal for parasitism, with a mean number of parasitized eggs of about 29.00 ± 1.14. A significant decrease in parasitism and emergence was observed at 35 °C, while no progeny was produced at 40 °C. The developmental period and the longevity were inversely related to temperature. The possible implications of these results in biological control programs were discussed.

Keywords: Biological control, temperature, trichogrammatids, life table

Introduction

The egg-parasitoid species from the genus *Trichogramma* (Hymenoptera: Trichogrammatidae) are the most promising biological control agents used for inundative releases against lepidopteran pests worldwide [1, 2]. Thanks to their ubiquitous distribution, specificity and efficiency, these tiny hymenopterous wasps were involved in biological control programs for more than a century [3]. These parasitoids were already commercialized in over 30 countries [1, 3].

In Tunisia, the naturally occurring strain *T. cacoeciae* showed a great preference for key lepidopteran pests such as, *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) [4] and *Ectomyelois ceratoniae* Zeller (Lepidoptera: pyralidae) [5, 6]. Various factors including climatic conditions may hamper the biological control programs [7].

Temperature and relative humidity are thought to be the most important abiotic factors influencing insect biological performance [8]. Variations in temperature and/or humidity thus affect a variety of biological traits, most notably fecundity and adult survival [9, 10]. The majority of research has concentrated on temperature's effect on *Trichogramma* sp [9, 11]. In this context, the present study aimed to study the effects of high-temperature levels on the biological performances of the *T. cacoeciae* under laboratory conditions.

Materials and Methods

Insect rearing

A laboratory colony of *Trichogramma cacoeciae* parasitoids was obtained from a private company (ControlMed, Tunisia). The parasitoid was maintained in the laboratory under controlled conditions (25 ± 1 °C, 60 ± 10% RH and 16:18 L: D) using the eggs of the Mediterranean flour moth *E. kuehniella* reared on wheat flour mixed. UV-sterilized *E. kuehniella* eggs were glued on cardboards before being offered to the newly emerged parasitoids. Afterwards, the parasitized eggs were kept in (10×1.5 cm) glass tubes under the same conditions described above. Adults were (provided with) given a honey solution (10% dilution) as a source of food.

Effects of temperature on the performances of *T. Cacoeciae*

Trichogramma cacoeciae females were randomly chosen and incubated at four constant temperatures (25, 30, 35 and 40 ± 1 °C).

Twenty females were tested for each temperature. Each female was individualized in Eppendorf tubes with about 100 UV-sterilized *E. kuehniella* eggs. Each replicate was supplied with honey (10% dilution) as a source of food. Females were allowed to parasitize during 24 hours before they were removed and the parasitized eggs were incubated at the correspondent climatic chamber. Parasitism was based on the number of *E. kuehniella* eggs which turned black. When the parasitoids began to emerge, the emergence rate was calculated by counting the number of emergence holes. Moreover, the development time from egg to adult was calculated from the day when the females were removed. The sex ratio was not assessed as *T. cacoeciae* is a thelytokous species that does not produce males [12]. Twenty other females were randomly chosen to assess the female longevity separately at the four temperatures tested.

Statistical analyses

All analyses were performed using the software R version 3.5.2. In all tests, differences were considered significant at $P = 0.05$. Before analysing the data, assumptions of normality

of residuals (Shapiro-Wilk's test) and homogeneity of variance (Levene's test) were firstly checked. Parasitism and development time were then analysed using a one-way analysis of variance (ANOVA) followed by the Tukey honestly significant differences (HSD) *post hoc* test. Emergence rate and female longevity were analysed using a non-parametric test (Kruskal-Wallis H test) followed by the Dunn's *post hoc* test with Bonferroni correction.

Results

Our results indicated that a temperature of 30°C was the most suitable for parasitism (Figure 1a).

However, the emergence rate (Figure 1a), development time (Figure 2a) and longevity (Figure 2b) were all higher at 25 °C. At 40 °C, the parasitoid did not emerge from parasitized eggs (Figure 1a). Statistical analysis revealed a significant difference between tested temperature for parasitism ($F_{3,76} = 128.3$, $P < 0.001$), emergence rate ($H = 55.09$, $df = 3$, $P < 0.001$), development time ($F_{2,57} = 330.2$, $P < 0.001$) and longevity ($H = 77.88$, $df = 3$, $P < 0.001$).

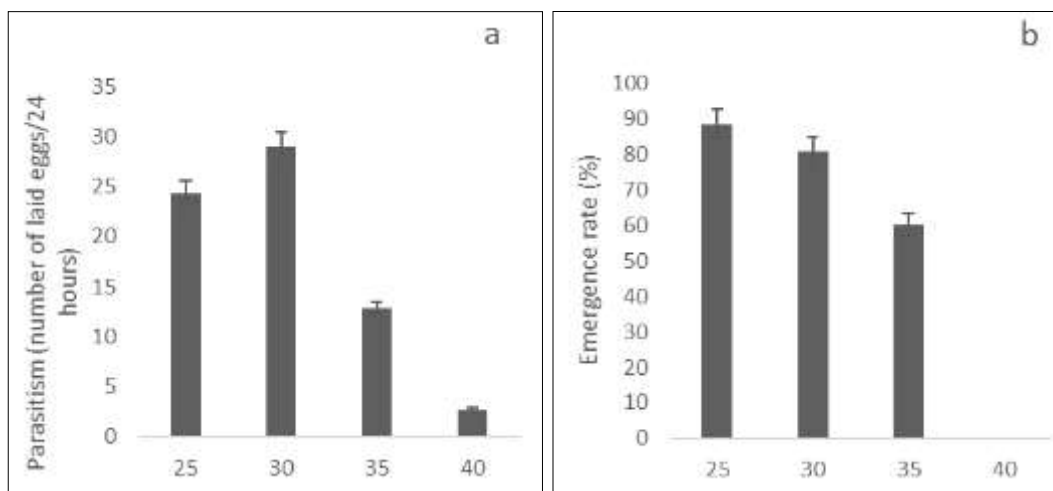


Fig 1: Parasitism (a) and emergence rate (b) of *T. cacoeciae* incubated at four constant temperatures (25, 30, 35 and 40 ± °C)

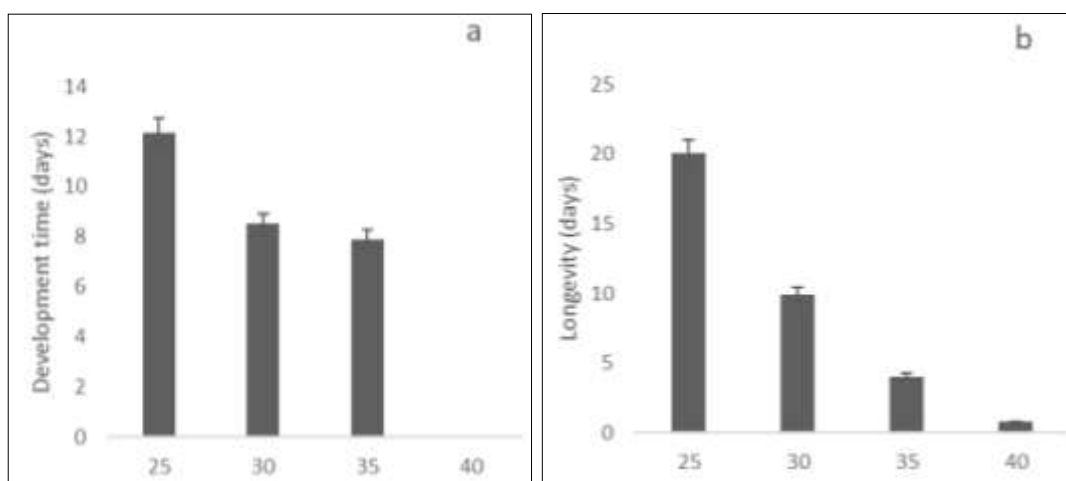


Fig 2: Development time (a) and female longevity (b) of *T. cacoeciae* incubated at four constant temperatures (25, 30, 35 and 40 ± °C)

Discussion

Our study revealed that the temperature significantly affected the biological traits of *T. cacoeciae*.

Other species might require high temperatures for oviposition, such as *T. nubilale* Ertle & Davis [13] and *T. chilonis* [14]. (Similarly, *T. pretiosum* parasitized a significantly higher

number of eggs at 30 °C (compared to 26 °C) [10]. Nadeem and Hamed (2008) [15] (did not report significant differences in the parasitism recorded at 25 and 30 °C for *T. chilonis* and *T. bactrae*. As written by Schöller and Hassan (2001) [12], *T. evanescens* and *T. cacoeciae* parasitized more eggs at 30 °C than at 26 °C during the first 24 hours following emergence.

Parasitism was reduced further at 35 °C and especially at 40 °C, consistent with previous research [12, 14, 16].

The emergence rates observed in our study were globally high, being above 60% at temperatures ranging from 25 to 35 °C. According to the results of Pizzol *et al.* (2010) [17]. The emergence of two strains of *T. cacoeciae* was very high at 25 and 3 °C, being above 90%.

Similarly, the emergence rate of *T. pretiosum* and *T. atopovirilia* was unaffected by temperatures ranging from 14 to 30 °C, because viability was greater than 90% [18]. Other *Trichogramma* species, such as *T. chilonis* and *T. bactrae* showed a viability reduction at 35 °C [15, 19].

At 40°C, there was no adult progeny, but the host eggs could turn to black colour without reaching the adult stages; this shows that at that temperature, the parasitoid is able to kill the host egg but is unable to survive and produce progeny. As reported by Nadeem *et al.* (2009) [19], no progeny of *T. chilonis* emerged when developed at 40 °C due to the mortality of parasitoids.

T. evanescens when developed at 36°C, did not produce adult progeny [16]. The effect of temperatures on parasitoid progeny production is then linked to the parasitoid/strain studied. Prior acclimatization to high temperature (> 35 °C) may improve the parasitoid's performance when released in extreme summer temperatures.

Development time and female longevity were inversely proportional to temperature; the egg-to-adult period and female longevity were longer at 25 °C than at higher temperatures. This was in agreement with different studies [10, 15, 16, 19, 20].

Conclusion

Our results showed that temperature significantly affected the biological performances of the egg-parasitoid *T. cacoeciae* under laboratory conditions. The optimal development of *T. cacoeciae* at 25-30 °C indicates that this temperature range is suitable for mass releases of this parasitoid under field conditions. However, as *T. cacoeciae* was able to parasitize and develop at 35 °C, releasing this parasitoid at weekly intervals under similar field conditions would be able to maximise the success of the biocontrol program.

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Disclosure statement

There is no conflict of interest.

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