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Effects of Temperature on the Egg Hatching and Adult Emergence in *Callosobruchus chinensis* L. (Chrysomelidae: Coleoptera)

Talapala Sai Kumar [a*], Sake Manideep [a], B. Tulasi [a], Thrisha K.S [a] and Yamini R [a]

[a] *Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu), India.*

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

This study investigated the impact of constant temperatures (-15°C, 7°C, 28°C, and 35°C) on *Callosobruchus chinensis* L. (Chrysomelidae: Coleoptera). The results indicated that temperatures outside the control temperature of 28°C i.e. (-15°, 7°, and 35°C) significantly affected the biological parameters of *C. chinensis*. Specifically, adult emergence and egg hatching rates were most favourable at 28°C compared to the other temperatures tested. These findings emphasize the temperature sensitivity of *C. chinensis* and highlight 28°C as optimal for its developmental processes.

**Corresponding author: E-mail: talapalasaikumar@gmail.com;*

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Keywords: C. chinensis; temperature; adult emergence; egg hatching.

1. INTRODUCTION

"Pulses play an important role as an energy supplier for human beings with a significant amount of carbohydrates and fats. They hold a significant position in global agriculture and food systems, ranking as the second most crucial group of food crops alongside cereal crops in various ways" [1]. "They also play an important role in sustaining soil fertility. Chickpea, Black gram and Green gram are highly nutritious pulses cultivated throughout the world. However, stored grain pests pose a serious threat to pulses during storage, leading to both quantitative and qualitative losses" [2]. Various pests like pulse beetles (*Callosobruchus* spp.), lesser grain borers, and khapra beetles are known to infest stored pulses, degrading their quality and causing economic losses [3,4]. These pests have high multiplication rates and can destroy a significant portion of stored grains, emphasizing the importance of effective pest management strategies [3]. "But in many developing countries the pulses suffer to heavy qualitative and quantitative losses from the attack of pulse beetle, i.e., *C. chinensis.* Larval feeding causes leguminous seeds to lose some of their nutritional value in addition to decreasing their ability to germinate. For farmers and traders, the biggest financial concern is the loss of leguminous seeds while they are being stored" [5]. "The pulse beetle is one of the most destructive pests of stored products, particularly chickpea, black gram and green gram" [6]

Integrated pest management schemes are being developed to reduce reliance on synthetic pesticides, which can have negative impacts on grain quality, the environment, and natural enemies of pests [7]. "Temperature is a crucial environmental factor that influences the development and growth of insects. Heat treatment has received increased interest in recent years as a means to disinfest storage commodities and this approach is expected to continue to continue with the impending removal of restrictions on Methyl bromide usage" [8,9].

"However, the expense of maintaining a storage temperature above 40°C or below 14°C is significant and not a cost-effective means of pest control. At high temperatures the metabolism rate is increased and at low temperature, insect development is slow and fecundity is reduced" [10]. "Also, temperatures below 14°C resulted in death for certain insect pests, particularly immature stages" [11]. "It has long been established that exposure to extreme temperatures can protect stored products by killing insect pests. Heat can affect the physiology of insects in many ways and ability of individual insects to survive and ability to reproduce" [6].

Therefore, the present study aims to evaluate the effect of 4 selected ranges of temperature on adult emergence and to develop a strategy for managing *C. chinensis.*

2. MATERIALS AND METHODS

2.1 Insect Cultures

The beetles of *C. chinensis* used in the experiment were obtained from the laboratory of the seed centre that is present adjacent to the college of TNAU and RI. 10 pairs of *C. chinensis* adults about one day old were introduced into the plastic jar each containing 500 g green gram seeds. The jars were then covered with fine mesh cloth fastened with rubber bands to prevent the escape of insects and allowed to mate. The present culture was available with seeds containing eggs left until the emergence of new adults, which were later used in the current experiment. The effect of different temperatures on the adult emergence of 2 pairs of *C. chinensis* adults i.e., male and female selected of 24h old age adults from insectary cultures. The selected ones are inoculated with green gram seeds of quantity 50 g in each small Petri dish covered with muslin cloth and left aside to allow them to mate inside the Petri dishes on green gram seeds.

After a few days *i.e*.,5to7 days the adults lay eggs and die. The dead adults are removed. In this manner, we have taken 3 replications for each treatment. For each replication of the treatment adults are released as mentioned in the above manner.

Now the petri dishes of each treatment are kept under different temperature set-ups like -15°C and 7°C are kept under the refrigerator that is available in the laboratory. Other two treatment temperatures i.e., 28°C and 35°C we managed to keep 28°C replications under room temperature conditions where as for 35°C the replications were kept under sunlight for 3hrs duration during bright sunshine hours. To facilitate observation, we have taken the observation every 4 days in cases of -15°C and

7°C, whereas for 28°C and 35°C the observation is taken every 2 days.

2.2 Statistical Analysis

Rate of Adult emergence and Post-hoc comparisons (Tukey's HSD)

$$Rate\ of\ Adult\ Emergence\ (\%) = \left(\frac{No\ of\ Adults\ emerged}{Total\ number\ of\ Individuals}\right) \times 100$$

3. RESULTS

At -15°C:

At this range of temperature, the hatching of eggs and the emergence of adults were not observed at all.

At 7°C:

The result is similar as in this case of temperature. No hatching of eggs and emergence of adults is observed.

At 28°C:

At this temperature, the rate of hatching and emergence is higher when compared to the above temperatures. This confirms that at temperature 28°C is the most suitable temperature for the completion of its life cycle.

At 35°C:

At this temperature the results are different there is no kind of hatching and emergence at this temperature.

Table 1. Rate of Adult emergence

Temperature (°C)	Rate of Adult emergence (%) at 15 to 21days
-15	0
7	0
28	High (Hypothetically 80 to 90 %)
35	0

Post-hoc comparisons (Tukey's HSD):

1) 28°C vs -15 °C : p< 0.005 (Significant difference)
2) 28°C vs 7 °C : p< 0.005 (Significant difference)
3) 28°C vs 35°C : p< 0.005 (Significant difference)

These results indicate that 28°C significantly promotes adult emergence compared to -15, 7, and 35°C, where no emergence was observed.

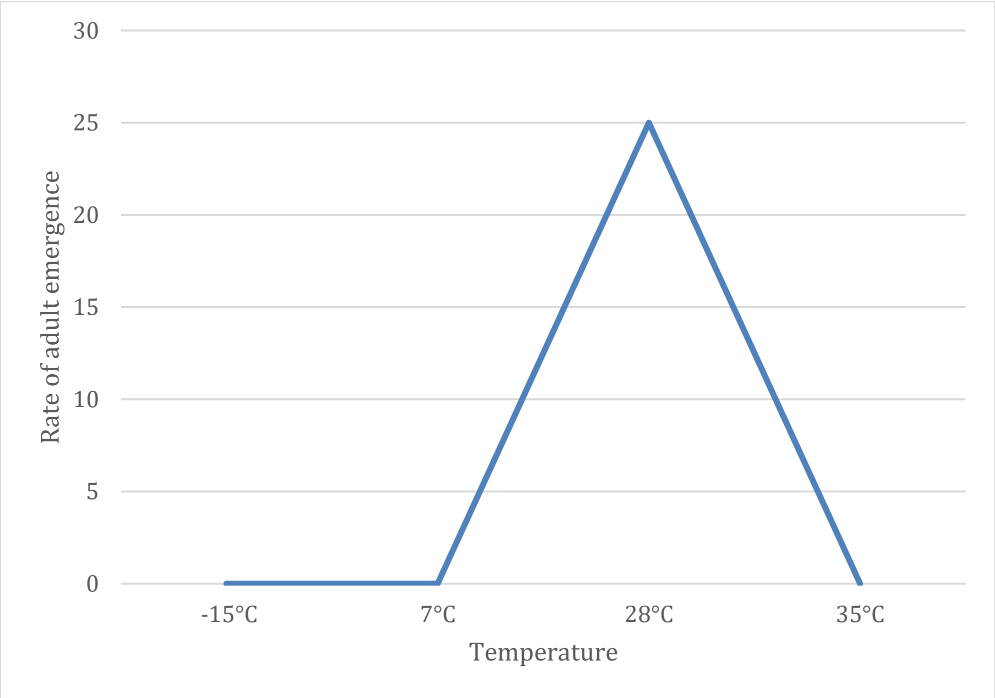

Fig. 1. Rate of adult emergence from different temperatures at 15 -21 days

4. DISCUSSION

From the above experiment, we came to know there are specific reasons for *C. chinensis* disturbing the life cycle. However, the survival and development of insects are greatly influenced by temperature variation, duration of exposure, species, stage of development, acclimation, relative humidity, and moisture content of the food [12,13].

Extreme temperatures can affect the enzymatic mechanism and can inactivate enzymes blocking cell cycle development, making the temperature range for embryonic development in insects much narrower than the range of thermal tolerance in adults [14]. Gu *et al*. [15] found that temperature treatment induced the synthesis of more Juvenile hormone (JH) and Heat shock proteins(hsp). Additional production and function of JH and hsp would consume more energy and result in slower insect development.

The effect of low temperature on insects is apparent in reduced metabolism and respiration leading to the loss of more ATP and insect development, and neural functions are greatly influenced during prolonged cold exposure [16,17]. Some of the findings suggest that mating duration is also dependent on temperature, and therefore temperature should influence sperm transfer and female remating frequency [18,19].

5. CONCLUSION

From the above experimental study, we concluded that -15**,** 7 and 35°C temperatures can be used for managing the *C. chinensis* effectively. Survival, development, and reproductive behaviours of *Callosobruchus chinensis* are intricately linked to temperature variations, highlighting the critical role of temperature in insect life cycles and population dynamics. Extreme temperatures, whether high or low, pose significant challenges to physiological and behavioural changes impacting their biological processes and survival strategies in natural and agricultural ecosystems.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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