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Effect of Temperature on the Development, Survival, Fecundity and Longevity of Stored Grain Pest, *Trogoderma granarium*

Tanzeela Riaz,* Farah Rauf Shakoori and Syed Shahid Ali
Department of Zoology, University of the Punjab, Lahore-54590, Pakistan

Abstract.- Effect of different temperatures ranging from 15 to 45°C at 60±5% R.H have been studied on the survival, fecundity, egg hatching duration, length of larval and pupil periods and mortality of eggs, larvae and pupae of a stored grain pest *Trogoderma granarium*. The adult female survived for 19.62±2.18 days at 25°C, but when temperature increased its longevity decreased. The male, on other hand, survived for 13.84±2.15 days at 20°C and its longevity also decreased with increase in temperature. Maximum egg laying occurred at 30 and 35°C and declined at 20 and 40°C. Hatching period of eggs, development of larvae into pupa and emergence of adult was minimum at 35°C but the developmental periods were prolonged at 25 and 30°C. Larvae did not pupate at 20 and 40°C. Eggs hatched after 7.15±1.92 days at 35°C while it was delayed to 13.19±1.38 days at 25°C. The larval and pupal periods were considerably reduced at 35°C. The total developmental period was 60.46, 41.48 and 36.53 days at 25, 30 and 35°C, respectively. So it can be concluded from this study that *T. granarium* could not develop or complete its development at 20 and 40°C. The optimum temperature for development of *T. granarium* was 35°C.

Key words: *Trogoderma granarium*, stored grain pest

INTRODUCTION

Trogoderma granarium, Everts (Khapra beetle) is the native beetle of subcontinent and is the most serious pest of stored products throughout the world including Pakistan due to its high infestation potential (Ramzan and Chahal, 1986; Campbell and Arbogast, 2004; Neethirajana *et al*., 2007; Ahmedani *et al.*, 2009). It has been considered as one of the 100 most aggressive pests in the world (Lowe *et al.*, 2000). To overcome the problem of pest development, several techniques are being used to keep the pest population below the economic loss level which includes use of natural method of control by plant material (Dwivedi and Garg, 2003; Prakash and Rao, 2006; Kestenholz *et al*., 2007), chemical control by pesticides, fumigation with phosphine, methyl bromide (Atkinson *et al*., 2004; Walter, 2006; Wang *et al*., 2006). Indiscriminate and unplanned use of pesticides and fumigation has resulted in wide spread resistance in pests against these chemical pesticides (Irshad and Iqbal, 1994; Saleem and Shakoori, 1989, 1990; Assie, 2007; Daglish, 2008).

Development rates and survival of *T. granarium*, significantly depends on temperature, light, moisture, season, and host species (Ramzan and Chahal, 1986) so, by controlling these physical parameters long term control of pest can also be achieved. The current report deals with the role of temperature on survival, fecundity, egg hatching duration and length of larval and pupil periods of *T. granarium*. It may provide some alternate methods of control of *T. granarium* infestation by controlling the temperature of storage facilities.

MATERIALS AND METHODS

Rearing and maintenance of beetles

The master culture of *T. granarium* were collected from gowdowns of Lahore, Punjab and maintained in temperature and humidity controlled room at 30±1 ºC and 60±5 R.H. The culture was fed on broken wheat in 300ml glass jars covered with muslin cloth to prevent the escape of newly emerged beetles. The culture was reared to obtain homogeneous stock of 2nd, 4th, 6th larval instar, pupa and adult in separate jars. The homogeneous stock was maintained for further experiments. Male and female was identified on the basis of size and color. Male was smaller and dark brown in color compared with its female.

* Corresponding author: missbiochem@gmail.com
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Effect of temperature on survival and fecundity

In this study, 15 newly emerged male and 15 female beetles were released in seven petri plates, each for temperature 15-45°C, in triplicates without any food. Petri dishes were covered with muslin cloth, rubber band and kept in six different incubators set at specific constant temperature of 20, 25, 30, 35, 40 and 45°C at 60±5% R.H. The temperature of 15°C was maintained in culture room by using thermostat heater in winter. The beetles were allowed to mate under conditions of starvation. Eggs laying occurred within 4-5 days of mating. On 6th day the adult beetles were separated from eggs and were placed in separate petri dishes. Number of eggs laid in each petri dish was counted by using magnifying lense and camel hair brush. Number of days of male and female longevity at each temperature was also recorded.

Effect of temperature on duration of egg hatching, and lengths of larval and pupil periods

Petri dishes in triplicates containing eggs, without food, were incubated at 20, 25, 30, 35,40°C at 60±5% R.H. When eggs hatched into 1st instar larvae, the number of days for hatching and the number of 1st instar larvae were recorded. These 1st instar larvae later transferred to 300ml glass jars containing flour and crushed wheat to 1/3rd portion of jar, in triplicates, were placed in different incubators at 20, 25, 30, 35 and 40°C at 60±5% R.H. as described above. The culture was examined daily until pupae appeared. The number of days required for pupation and the total pupae formed were recorded. Pupae were later placed in jars without food and incubated at 25, 30 and 35°C at 60±5% R.H. as described above. Length of pupil period and number of adults emerged were recorded.

Student 't' test was applied to analyze the data for significance.

RESULTS

Effect of temperature on survival and fecundity

The survival of adult female was maximum (19.62±2.18 days) at 25°C, but when temperature increased to 30, 35, 40 and 45°C at 60±5% R.H., the adult female longevity decreased to 18.29±1.52, 15.17±2.45, 12.40±2.92 and 9.12±1.96 days respectively. Female beetle longevity was also decreased to 16.35±1.37 and 10.20±0.81 days at 20 and 15°C, respectively. The survival of male was maximum (13.84±2.15 days) at 20°C which decreased to 11.49±2.94, 9.36±3.11, 6.17±2.73, 5.19±1.94 and 5.06±0.96 days at 25, 30, 35, 40 and 45°C, respectively (Fig. 1).

The results showed that no eggs were laid at 15 and 45°C but maximum eggs (80.24±1.31) were found at 30°C which declined at 20, 25, 35 and 40°C (Fig. 2). Above and below 30°C, a decline in egg laying potential was observed.

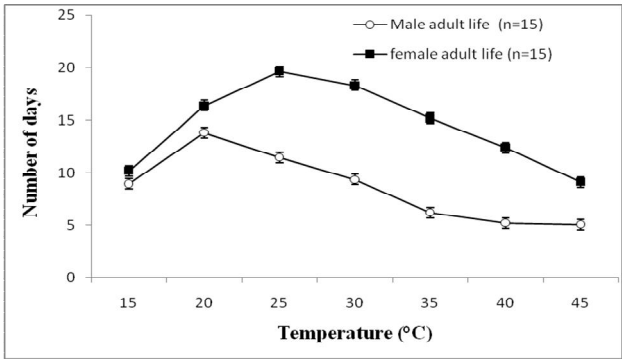

Fig. 1. Effect of temperature on the longevity (in days) of the male and female beetles of *Trogoderma granarium.*

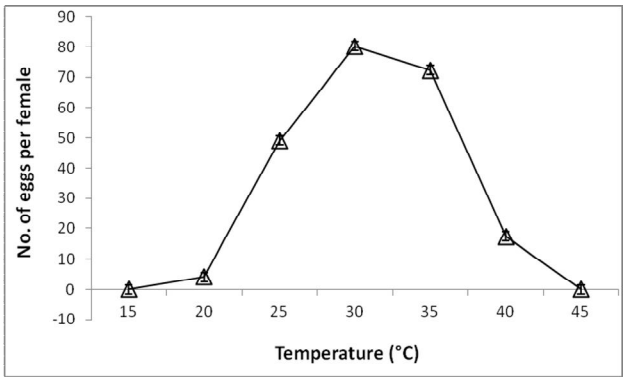

Fig. 2. Effect of temperature on the fecundity (number eggs laid per female) of *Trogoderma granarium.*

Effect of temperature on duration of egg hatching and duration of larval and pupil periods

Minimum hatching period of 7.15±1.92 days recorded at 35°C. It increased to 8.23±2.31 days at

30°C, 13.19±1.38 days at 25°C and 25.13±1.23 days at 20°C. At 40°C, the hatching period increased to 30.63±2.11 days. The larval period at 35°C was 24.27±1.19 days which increased to 27.42±1.96 and 35.12±1.14 days at 30 and 25°C, respectively.

The maximum pupation period of 12.35±1.41 days was recorded at 25°C. This period decreased to 6.29±1.17 and 5.21±0.19 days at 30 and 35°C, respectively. Hatching of eggs, pupation and emergence of adult beetle were generally prolonged above and below 35°C. Larvae went into diapause at 20 and 40°C (Table I).

Table I.- Effect of temperature on duration of egg hatching, larval period and pupil period.

Temp. (°C)	Eggs incubation period (days)	Larval period (days)	Pupal period (days)	Total develop-mental period (days)
15	-	-	-	-
20	25.13±1.23	A	A	B
25	13.19±1.38	35.12±1.14	12.35±1.41	60.66±3.39
30	8.23±2.31	27.42±1.96	6.29±1.17	41±5.44
35	7.15±1.92	24.27±1.19	5.21±0.19	36±3.30
40	30.63±2.11	A	A	B
45	-	-	-	-

A, Not pupated; B, In diapause

Effect of temperature on mortality of eggs, larvae and pupae

Maximum number of eggs (1203.6) was laid at 30°C of which 1155 (96%) eggs hatched into larvae at 30°C (Table II); only 4.0 % eggs did not hatch. The minimum mortality recorded was 4.03% at 30°C. Egg mortality increased to 48.22 and 32.48% at 20 and 40°C (Table III).

At 35°C 928 pupae emerged from 1003 larvae (Table II) and only 7.47% larvae did not pupate at 35°C (Table III). At 20 and 40°C larvae entered into diapause and did not pupate. At 25 and 30°C mortality increased to 21.74 and 11.94%, respectively (Table III).

At 35°C maximum pupae are molted into adults and the rate of percent mortality was less compared to that of 25 and 30°C (Table III).

It took 36±3.30 days to complete the developmental period at 35°C whereas at 30 and 25°C it took 41±5.44 and 60.66±3.39 days, respectively (Table I).

Table II.- Effect of temperature on egg hatching, development of larvae into pupae and molying of pupae into adult (n=15).

Temp. (°C)	No. of eggs laid	No. of eggs hatched into larvae	No. of pupae	No. of adult
15	-	-	-	-
20	61.8	32	Not pupated	-
25	737.1	699	547	501
30	1203.6	1155	1017	987
35	1084.65	1003	928	914
40	259.2	175	Not pupated	-
45	-		-	-

Table III-. Effect of temperature on mortality of egg, larvae and pupae.

Temperature °C	% mortality of eggs	% mortality of larvae	% mortality of pupae
15	-	-	
20	48.22	In diapause	-
25	5.17	21.74	-
30	4.03	11.94	8.41
35	7.53	7.47	2.94
40	32.48	In diapause	1.50
45	-	-	-

DISCUSSION

T. granarium is a serious pest of grains and stored products all over the world especially in tropics and subtropics including Pakistan. The present results show the effect of temperature on survival, fecundity, egg hatching duration and length of larval and pupil period of *T. granarium* at 15, 20, 25, 30, 35, 40 and 45°C. Little variation was observed in number of eggs laid, eggs incubation period, length of larval and pupil development at 30 and 35°C but there was significant decrease in number of eggs laid at 20, 25 and 40°C. There was significant increase in eggs incubation period, length of larval and pupil period at 25°C and larvae entered into diapause at 20 and 40°C. At 15 and 45°C no eggs were laid. The present results at

lower temperature range are in well accordance with the results of Shulov (1955), Hadaway (1956), Burges (1957) Odeyemi and Hassan (1993). Hadaway (1956) recorded a mean of 43 eggs per female and a mean larval plus pupil developmental period of 51.5 days at 25°C. In this study a female laid 49.14±0.19 eggs and mean developmental period was 60.66±3.39 days at 25°C, but different observations were recorded by many workers on the lower temperature threshold of development of *T. granarium*. Hadaway (1956) and Burges (1963) reported that no development occurred below 25°C but in this study 4.12±3.18 eggs per female were laid at 20°C but larvae entered in diapause, as also reported by Odeyemi and Hassan (1993). In this study no oviposition occurred at 15°C in favor of the results obtained by Burges (2008) who reported no development below 20°C but this study showed results in contrast to Lindgren and Vincent (1959), Burges and Cammell (1964) who observed development even below 15°C. In the present study larvae entered in diapauses at lower temperature which are in well accordance with the results of other workers (Burges, 1963; Nair and Desai, 1972; Odeyemi and Hassan, 1993; Bell, 1994). Nair and Desai (1972) reported that there was a genetic trait involved in the capability of *T. granarium* to enter in diapauses. In current research maximum number of eggs and minimum larval to pupil developmental period was observed at 30 and 35°C which are in accordance to the results of Burges and Cammell (1964) who reported that maximum development occurred between 35 and 37.5°C. In this study, at temperature above 35°C the larvae did not pupate and entered into diapauses. In this study it was observed that at higher and lower temperature ranges, breeding did not occur to reach the pest status. The developmental period *T. granarium* of was very short from 30-35°C, so temperature above or below this range (30-35°C) was not most suitable for its development.

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