Influence of Temperature, Humidity and Photoperiod on Oviposition and Larval Development in *Trogoderma granarium* Everts (Coleoptera: Dermestidae)

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Newly emerged adults and first instar larvae of *Trogoderma granarium* Everts were exposed to various temperature-humidity and temperature-photoperiod combinations to determine their effects on oviposition and developmental period. There was a significant difference ($p<0.05$) in the number of eggs laid at different temperature-humidity combinations. As temperature increased from 27°C to 35°C, the number of eggs oviposited showed little variation. The developmental period of larvae was prolonged at lower humidities. Oviposition was influenced by photoperiods at some temperature. At 35°C and 27°C, oviposition occurred at all photoperiods. Fecondity increased as the temperature-photoperiod regimens increased. The developmental period of larvae was prolonged as the photoperiod decreased at 20°C and 27°C. At 35°C, there was no effect of the photoperiod on the developmental period.

*Key words:* temperature, humidity, photoperiod, *Trogoderma granarium*

INTRODUCTION

The khapra beetle, *Trogoderma granarium* Everts, a cosmopolitan pest of stored products, is known in Nigeria for causing severe damage and losses in decorticated groundnut scientific name (Howe, 1952; Prevette, 1964; Mbat, 1987; Odeyemi, 1989). Several authors have reported on the effects of temperature and relative humidity on the biology of the khapra beetle. HADAWAY (1956) observed that optimum temperature for development ranged from 30°C to 35°C when the life cycle from egg to adult was completed in 24 days. BURGES (1957) noted that the temperature range for the completion of life cycle was 20°C to 40°C. LINGREN and VINCENT (1959) reported that egg production at 0% RH and 30°C ranged from 31 to 88 eggs per female, while VOELKEL (1924) observed development of larvae at 15°C.

The influence of the photoperiod on the biology of the khapra beetle has not been studied extensively. LINGREN et al. (1955) reported that the day length had no effect on the developmental time of larvae at 30°C to 35°C. HAMMACK and BURKHOLDER (1981) observed that regardless of day length, a stable phase relationship was maintained between daily calling maxima and photophase mid-points during the mating activities of the beetles. However, further work is required on the effect of the photoperiod on the biology of the beetle.

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This paper reports on the results of experiments on the influence of temperature, humidity and photoperiod combinations on the oviposition and larval development in _T. granarium_.

**MATERIALS AND METHODS**

A stock culture of the khapra beetle was reared in the laboratory at 28±2°C as previously described (Odeyemi, 1990). Sex of adults was determined using size and antennal characters as described by Halstead (1963). Newly emerged adults (0–24 h old) used for subsequent experiments were collected from the culture.

*Temperature—humidity combinations (TH combinations)*. Oviposition and larval development were measured at all combinations of three constant temperatures of 20°, 27° and 35°C, and five constant humidities of 20, 40, 60, 80 and 100% RH under a 12L:12D photoperiodic condition. Humidity was controlled with an appropriate sodium hydroxide (Madge, 1961) in distilled water at the bottom of a Scheibler knob glass desiccator (150 mm dia.). Distilled water alone was used to obtain the highest humidity.

To investigate the response of females to TH combinations, adult male and female beetles (0–2 h old) were placed in glass vials (4×2 cm) in the ratio of two males to one female. Clean, whole groundnut seeds (2 g) were used as substrate for oviposition. A set of glass vials was exposed to each TH combination. The total number of eggs laid per female over a period of five days was determined.

The response of the larval stage to TH combinations was tested by introducing a set of 20 glass vials (4×2 cm), each containing a first instar larva (0–24 h old), to each TH combination. Each larva was fed with 2 g of powdered groundnut per glass vial. The time interval from the first instar larvae to adult emergence was recorded for each combination tested.

All data were statistically analyzed using the analysis of variance test. Further grouping was done using Duncan's (1955) multiple range test.

*Temperature—photoperiod combinations (TP combinations)*. Oviposition and development of larvae were measured at photoperiods of 0:24, 6:18, 12:12, 18:6 and 24:0 (L:D) and temperatures of 20°, 27° and 30°C. Temperature and photoperiod were maintained as described by Odeyemi (1989).

To determine the response of females to TP, male and female adults were exposed to various combinations. One female and two male adults (0–24 h old) were placed into a glass vial (4×2 cm) and provided with 2 g of powdered groundnut. The number of adult females tested for oviposition at each TP combination was 10. The total number of eggs laid per female over a period of five days was determined for each combination tested.

To determine the effect of TP on the development of the larvae, first instar larvae (0–24 h old) were exposed to various TP combinations. Sets of 20 larvae, each set contained in a glass vial (4×2 cm) and fed on 2 g of powdered groundnut, were exposed to each TP combination. The larvae were observed until adult emergence.

Confidence limits for percentage of adults ovipositing at each TP combination were determined (Steel and Torrie, 1960).
RESULTS

Effect of temperature—humidity combinations

Table 1 shows a significant decrease \( p<0.05 \) in the number of eggs laid at 20\% RH and 100\% RH but not in the range from 40\% RH to 80\% RH. At 20\°C, the beetles were inactive and no eggs were laid at any humidity level. As the temperature increased from 27\°C to 35\°C, the number of eggs showed little variation.

Table 2 shows a significant difference \( p<0.05 \) in the developmental period of larvae at the various humidity levels. At 20\°C and 27\°C, larval development was delayed at lower humidities of 20 and 40\% RH in comparison with the higher humidities of 60, 80 and 100\% RH.

Effect of temperature—photoperiod combinations

The temperature—photoperiod combinations influenced the rate of ovipositing females of *T. granarium* (Fig. 1). At 35\°C, a high percentage of females oviposited at each photoperiod. At 27\°C, more than 50\% of females oviposited at photoperiods of 18 h and 24 h, whereas at 20\°C no oviposition occurred at photoperiods below 18 h. The rate of ovipositing females increased with increased day length at every temperature condition.

<table>
<thead>
<tr>
<th>Temperature, Humidity and Photoperiod Effect on <em>T. granarium</em></th>
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Table 1. Mean number of eggs (mean±SD) deposited per female *T. granarium* at various temperature and humidity combinations under a 12L–12D photoperiodic condition.

<table>
<thead>
<tr>
<th>Relative humidity (%)</th>
<th>Temp. (°C)</th>
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<tbody>
<tr>
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Means followed by the same letter in the column are not significantly different at 5\% levels by DUNCAN’s multiple range test.

* At 20\°C no eggs were laid at any humidity level.

Table 2. Mean development period in days (mean±SD) of *T. granarium* larvae at various temperature and humidity conditions under a 12L–12D photoperiodic condition.

<table>
<thead>
<tr>
<th>Relative humidity (%)</th>
<th>Temp. (°C)</th>
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<tbody>
<tr>
<td></td>
<td>20°</td>
</tr>
<tr>
<td>20</td>
<td>32.20±2.18 a</td>
</tr>
<tr>
<td>40</td>
<td>33.48±1.33 a</td>
</tr>
<tr>
<td>60</td>
<td>27.28±3.98 b</td>
</tr>
<tr>
<td>80</td>
<td>24.64±2.88 b</td>
</tr>
<tr>
<td>100</td>
<td>23.94±2.73 b</td>
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</tbody>
</table>

Means followed by the same letter in the column are not significantly different at 5\% level by DUNCAN’s multiple range test.
The total number of eggs per ovipositing female laid over a period of five days varied according to photoperiod (Fig. 2). At 20°C, all oviposition ceased at photoperiods shorter than 18 h (Fig. 2A). At 27°C, oviposition occurred at all photoperiods but only a few eggs were found at 0: 24 and 6: 18 (L: D) (Fig. 2B). At 27°C and 35°C, oviposition increased as the photoperiods increased except at 24: 0 (L: D) (Figs. 2B, C). As the temperature increased, more eggs were laid even at shorter day lengths.

The TP combinations also influenced the developmental period of the larval stage (Fig. 3). At 20° and 27°C, there was delayed development in the larvae at shorter daylengths (Fig. 3A, B). At 35°C, the number of days required for larval development did not vary greatly in all the photoperiod regimens (Fig. 3C).
DISCUSSION

This study shows the effect of temperature-humidity and temperature-photoperiod on oviposition and development of larvae in *T. granarium*. While little variation was observed in the number of eggs laid at temperatures of 27° and 35°C, there were significant differences in the number of eggs laid at different humidities. Similar observations were made by Hadaway (1956) and Burges (1957). The effect of the photoperiod on oviposition was greater at 27°C and 35°C than at the lower temperature. At 20°C, no oviposition occurred at photoperiods of less than 18 h day length, whereas at 35°C oviposition occurred at all photoperiods studied. This type of oviposition response in insects was described by Beck (1980). In this study, the inability of ovipositing females to lay eggs at 20°C under a 12L–12D photoperiodic condition at different humidities and photoperiods below 18 h at 20°C showed that daylength had an effect on oviposition.

At 20° and 27°C, the period of larval development tended to decrease from 20% to 100% RH. Likewise, the developmental periods decreased at a temperature of 35°C at all levels of humidity. Similarly, at 20° and 27°C, there was a decrease in the
developmental period of larvae with increasing photoperiods, and at 35°C, no effect of the photoperiods on the developmental period was observed. Lindgren et al. (1955) reported that the daylength had no effect on the developmental period of larvae of the khapra beetle at 30°C and 35°C.

There were different views on the lower temperature threshold of development for T. granarium. Hadaway (1956) and Burgess (1963) did not observe any development below 25°C, since all the larvae under study entered diapause at this temperature, whereas Voelkel (1924) and Lindgren and Vincent (1959) had observed development even at 15°C. Nair and Desai (1972) observed that there was a genetic trait
involved in the ability of some strains of *T. granarium* to enter diapause, which may explain this discrepancy. He further expressed the possibility of selection of a genetic strain capable of completing its cycle at lower temperatures.

**REFERENCES**


