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Effect of temperature at fixed relative humidity in fecundity and development of *Tribolium castaneum* (Herbst)

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Abstract
The present study was carried out to determine fecundity and development of red flour beetle *Tribolium castaneum* (Herbst) over a series of constant temperatures. Larval and pupal forms of *T. castaneum* were kept at four different temperatures 20, 25, 30 and 35 °C at fixed relative humidity (60±5%) RH. The larval duration was minimum and per cent pupation was maximum at 30 °C. Similarly minimum pupation period and maximum adult emergence was also recorded at 30 °C. At 20 °C developmental activities of larvae and pupa both ceased and at 35 °C, it retarded significantly.

Keywords: Temperature, humidity, *Tribolium castaneum*, development, fecundity, larval stage, Pupal stage.

1. Introduction
Several species of stored grain insect pests were reported attacking granaries and other food structures since time immemorial. According to an estimate, the overall damage caused by stored-grain insect pests account for 10-40% of loss worldwide annually [1]. These stored-grain insect pests have been damaging our economy by infesting agriculture stored products [2, 3, 4, 5, 6, 7, 8, 9]. Storage of stored-grain started with the beginning of agriculture as a safeguard against poor harvest and famines simultaneously insects are one of the major causes of grain losses during storage.

Among important stored product insect pests, the red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) is one of the common pests belonging to secondary stored-grain insect pests, found in indoor food storage facilities feed on great variety of products including all kinds of grains, flour, cereals, meal, crackers, beans, spices, pasta, dried pet food, dried flowers, chocolate, nuts and even dried museum specimens [10]. Red flour beetles are not able for stinging and biting but they have chewing mouthparts. These beetles may produce allergic responses but do not spread disease [11]. Infestations of *T. castaneum* cause significant losses due to the consumption of grains and they also result in elevated temperature and moisture conditions which lead to an accelerated growth of molds, including toxigenic species [12]. They infest stored products with their larva layers and excrements and consequently lower the quality of stored products greatly. Adult insects and larva also feed on broken up grains [13].

The continuous increasing pressure of expanding human population has created a critical problem of food scarcity. This pest has been reported to attack the germ part of the grain. Their presence in stored foods directly affects both quality and quantity of commodity [14]. The progeny production rate of *T. castaneum* is so high. The fourth instars larvae are highly active in rainy season and cause very high infestation. The adult beetles are very active. They live 2 years or more in adult stage, during which period the female may produce nearly 1000 eggs [15]. The purpose of this work was to know, how the temperature at fixed humidity effect the development of larval and pupal stage of *T. castaneum.*

Materials and Methods
Insect Rearing – Red flour beetle *T. castaneum* was first reared on wheat (*Triticum aestivum* L.) flour and grains in laboratory at room temperature and fixed humidity at a photoperiod 10-14 (L:D) hour in Entomological Laboratory, D.D.U. Gorakhpur University, Gorakhpur in an incubator without exposure to any insecticides. *T. castaneum* adults were reared on wheat

grain (*Triticum aestivum* L.) and flour at 12–13% moisture content. It was maintain as research stock for experimental works. The development of larval and pupal stage was studied at 4 different temperature ranges from 20, 25, 30 and 35 °C.

Larval Stage – The newly larvae were kept in plastic box (10cm. height x 10cm diameter) along with 20 gm of wheat flour and grains, incubated at 20, 25, 30 and 35 °C temperature at fix relative humidity (60±5% RH) in four different incubators. The duration of larvae period and the percentage of pupae formation were recorded. Six replicate where taken and in each replicate 20 larvae were used.

Pupal Stage – The effect of four different temperatures 20, 25, 30 and 35 °C was studied on the newly formed pupae. 20 pupae were taken in plastic box (10 cm. height x 10 cm diameter) and incubated at different temperature at fix relative humidity (60±5 RH) in four different incubators. The duration of pupae period and percentage of adult emergence were examined daily after the first and last day of period. The number of individual and duration of development (days) were noted.

Data Analysis – All the value obtained during observation were represented as mean ± SD. Chi-square test Sokal and Rholf [16] was performs to test the effect of temperature on different larval and pupal stages.

Result – At 20 °C no larva was change into pupa. At 25 °C 65% larva developed into pupa in 17 days. At 30 °C the development of larva to pupa increased to 75% in 15 days. At 35 °C the development of larva decrease to 60% and developmental period was 25 days.

In case of pupa at 20 °C 75% of pupa emerge into adult at 15 days, and at 25 °C number of adult emergence increased to 83% while the days of emergence decrease to 8 days. At 30 °C the development of pupa into adult was recorded in 6 days. At 35 °C number of pupa emergence was decreased due to high temperature simultaneously the time required for development of pupa to adults in comparision to 30 °C was increased 9 days.

The results showed that 30 °C was most suitable for developmental period of larva transfer into pupa and pupa emerge into adults of red flour beetle *T. castaneum*.

Discussion- Temperature is the major environmental factor that influences the rate of larval and pupal period of insect. In the present study the different temperature range were studied for the larval period and pupal period and the data showed that temperature range between 25 to 30 °C is suitable for the development of larva and pupa of *T. castaneum.* This range of temperature was suitable for development of *Tribolium* species was supported previous study of Willis and Roth [17].

Hastrum and Milliken [18] analyzed the influence of temperature, moisture and diet on the life cycle of many coleopterons species of stored products. The author demonstrated that effect of temperature was the most important factor in the fecundity and developmental time followed by moisture and diet. However, near each species optimal temperature of development changes in moisture and diet seemed to influence the developmental time more than changes in temperature. Several researchers studied the development of *Ulomoides dermestoides* and reported 30 °C was the most suitable termperature for development of coleopteran species [19, 20, 12]. They also observed that at high temperature, some species (*T. confusum*, Jacquenline Du Val, flrrugineus Stephens) increased the developmental time at low moisture.

Table 1: Mean temperatures and fixed relative humidity maintained in the three incubators used in experiment.

Incubator Number	Temperature °C		Fixed Relative humidity
	Mean ± PE	S.D	
Incubator-1	20.06 ± 0.05	0.72	60±5 RH
Incubator-2	25.03 ± 0.04	0.69	60±5 RH
Incubator-3	29.98 ± 0.05	0.56	60±5 RH
Incubator-4	35.02 ± 0.02	0.76	60±5 RH

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