THE EFFECT OF TEMPERATURE ON DEVELOPMENT OF THE LEGUME POD- BORER *MARUCA TESTULALIS* GEYER (LEPIDOPTERA: PYRALIDAE) REARED ON ARTIFICIAL DIET

Georgina S. Mwansat
International Institute of Tropical Agriculture Ibadan, Oyo State, Nigeria.*

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Abstract

Six temperatures (19°C, 22°C, 25°C, 28°C, 31°C and 34°C; S.D = 0.5°C) were tested for their effect on larval development, pupation and adult emergence of Maruca testulalis Geyer (Lepidoptera: Pyralidae) in laboratory experiments. Percival® growth chambers (constant temperature cabinets) were used. Cohorts of first instar larvae were infested on an artificial diet, immediately upon hatching. Temperature had pronounced effects on all parameters studied namely larval and pupal periods, percentage pupation and emergence, pupal weight, total development time, growth index and number of eggs laid per female. The optimum temperature for larval development, percentage population, adult emergence and fecundity for M. testulalis was found to be 25 ±0.5°C. Prolonged larval development, noticed at lower temperatures, was accompanied by the production of a low number of eggs laid per female. The results suggest that the temperature range suitable for larval development, mating and oviposition of M. testulalis is between 22°C and 34°C.

Running Title: Effect of temperature on the legume pod-borer.

* Present Address: Department of Zoology, University of Jos, Nigeria.

INTRODUCTION

The legume pod-borer *Marca testulalis* Geyer (Lepidoptera: Pyralidae) is a major pest of cowpea and other grain legumes wherever they are grown (Taylor, 1967, 1978). In Nigeria that produces about 40% (0.85million tons) of cowpea of total world production (Singh, Singh, Jackai and Ntare, 1983), *M testulalis* occurs in all cowpea growing areas and more in the second growing season of September –December.

The pod-borer infests the cowpeas plant during the flowering stage, feeding on the flower buds, flowers and green pods, resulting in 100% yield loss during heavy infestation (Singh *et al.*, 1983). Laboratory studies of *M. testulalis* have hitherto been conducted at room temperature. Breeding experiments carried out under fluctuating temperatures of between 25°C and 29°C generated larval development periods varying from 8 to 13 days, with an average pupal period of 7 days (Taylor, 1967). Ochieng, Okeya- Owuor and Dabrowski (1981) reared *M. testulalis* on a natural diet at morning temperatures of 18°C 21°C and evening temperatures of 26°C- 36°C, but the effect of this fluctuating temperatures was not documented. However, rearing the pod-borer on artificial diet at room temperatures ranging from 25°C-30°C, (Ochieng and Bungu, 1983) got a complete life cycle of 23 days, that is 13.35 days larval period and 6.67 days pupal period. Under controlled temperatures of 25°C – 27°C, *M. testulalis* completed its entire life cycle at different durations depending on the types of artificial rearing diets. For example the larval period of male *M testulalis* were 12.40days, 13.65days, 16.37days, and 13.98 days when reared on soyflour wheatgerm, cowpea casein, cowpea yeast and corn soya milk artificial diets respectively (Jackai and Raulston, 1982).

Although the pest status of *M testulalis* has long been established, not much has been done on the physiology of the insect, particularly the role of environmental factors, such a temperature, on its development and oviposition. In actively flying insects such as *M testulalis*, mating is often proceeded and / or followed by special flights and if these are denied, mating and / or oviposition fail to occur (Kaufmann, 1983).

This paper, therefore examines the effects of temperature on the development, oviposition and fecundity of *M. testulalis* reared on wheatgerm-based diet at 6 different temperatures 19°C, 22°C, 28°C, 31°C and 34°C (SD = 0.5°C), temperatures obtainable in the field (13°C- 35°C in 1978) in major cowpea growing locations (IITA, 1978).

MATERIALS AND METHODS

The study was conducted in the Entomology Research Laboratories at the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria.

Experiment 1:

About 2,400 first instar larvae of *M. testulalis* used in the study were obtained from culture maintained on a modified cowpea wheatgerm diet of Jackai and Raulston (1982). Method of diet preparation, larval infestation, rearing in Percival® growth chambers and data collection were as described by Jackai and Raulston (1982). Each temperature regime was replicated four times with 100 insects per replicate. Data recorded include larval period, number of pupae, pupal period and number of emerging adults. Average relative humility (RH) in growth chamber for all treatments was 75±5% with 12hour-

photophase. From the data collected, the Growth Index (G.I) of *M. testulalis* was calculated using the formula;

$$G.I. = \frac{\% \text{ Emergene}}{\text{Total development time}}$$

Experiment 2

Cohorts of *M. testulalis* adults used here were obtained from experiment 1. Immediately after emergence, 50 pairs of male and female *M. testulalis* were set for mating on emergence cages measuring $30cm^3$ in the adult oviposition room, with a mean temperature of 23^0C and RH of 76%. Cages were made of wire mesh on all sides, except the steel-made bottom and a side fitted with a cloth sleeve through which access into the cage was made. The insects were held in the mating cages for five nights after which individual mated adult females were introduced into thunderbird cup along with a feeder (a small strip of paper towel soaked in 5% sugar solution). Individual adult female was transferred into a new container each day and the eggs laid counted. Data were analysed using the analysis of variance package and the 5% level of significance. Confidence limits and means were separated by the duncan multiple range test (Duncan, 1955).

RESULTS

Temperatures showed a profound effect on larval development of *M. testulalis* (Fig. 1). Overall larval period for all treatments was 11 days to13 days after infestation. At 22^0C, all surviving larvae pupated between 19 days and 31 days with the majority of pupation occurring 23 to 24 days after infestation. Range of pupation was considerably less at 25^0C taking only about 6 days (i.e between 13 days and 19 days after infestation)

For 25^0C, 28^0C and 31^0C, highest number of pupae harvested per day occurred 14 days after infestation. It was quite evident ($P<0.05$) that larval development was greatly prolonged at 22^0C (Fig. 2). Beyond this temperature it appeared that temperature had no effect on larval development as indicated by the lack of significant differences in larval period at 25^0C, 28^0C and 31^0C ($P>0.05$). They were, however, significantly different from the larval period at 34^0C ($P<0.05$).

Temperature had a significant effect on pupation of *M. testulalis* but not on percentage pupation at 22^0C, 26^0C, 28^0C and 31^0C ($P<0.05$). At 19^0C, none of the larvae pupated. The data indicated an optimum temperature of 25^0C, below and above which percentage pupation of the pod-borer decreased.

Pupal period and percentage emergence of *M. testulalis* reared on artificial diets were significantly affected by temperature (Figs. 2 and 3). Significant differences in percentage emergence were observed between 20^0C and 28^0C, and between 22^0C and 31^0C ($p < 0.05$). An optimum temperature of 25^0C favoured *M. testulalis* adult emergence below and above which the number of adults emerging decreased. Zero emergence was observed at 19^0C and 34^0C, representing the lowest and highest temperature levels used in this study. Pupal period was relatively prolonged at 22^0C to 10.8 ± 0.18 days. The total development period (i.e larva to adult) was affected by temperature (Fig. 2). While there were zero values for treatments 19^0C and 34^0C, a mean total development time of 34.96 ± 0.87 days recorded for *M. testulalis* reared at 22^0C was significantly different from the 22.30 ± 0.09 days for those reared at 25^0C ($P<0.05$). However there was no significant difference between 20.67 ± 0.09 days and 19.66 ± 0.22 days recorded for 28^0C and 31^0C respectively ($P>0.05$). The relationship between temperature and the Growth Index (G. I) of *M. testulalis* was similar to that between percentage pupation and percentage emergence. The highest (G.I) of $2.98 \pm 0.24\%$ day recorded for *M. testulalis* larvae reared at 25^0C was significantly different from $1.33 + 0.14\%$ days recorded for those reared at 28^0C. For those reared at 22^0C and 31^0C, there was no significant temperature effect ($P>0.05$).

Oviposition started five days after adult emergence and continued until death at ages ranging between 8 days and 14 days old. Most adult insects that never ovipositted were from the cohort reared at 31^0C. Temperature had significant effect ($P<0.05$) on the oviposition of females reared at 25^0C (Mean = 157.7 ± 13.13eggs) when compared to 131.7 ± 4.71 eggs laid by a single female reared at 28^0C. The number of eggs laid correlated positively with pupal weight (Fig. 4).

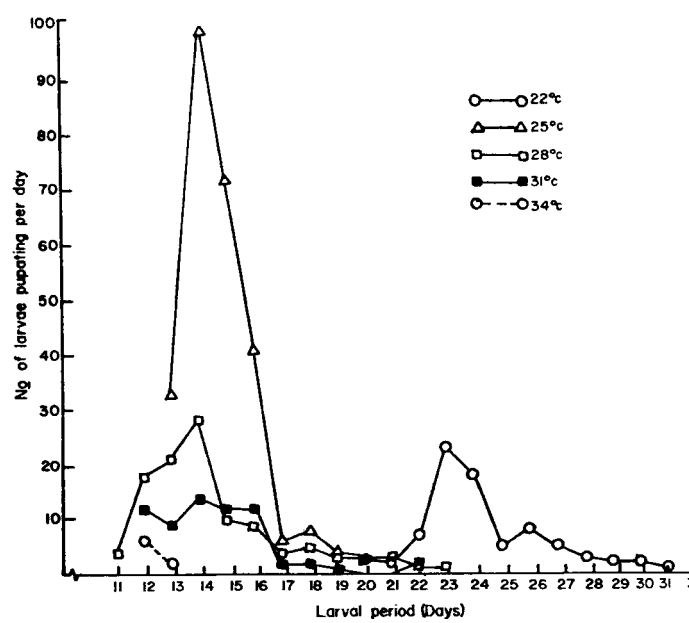

Fig. 1: Frequency distribution larval period as affected by temperature.

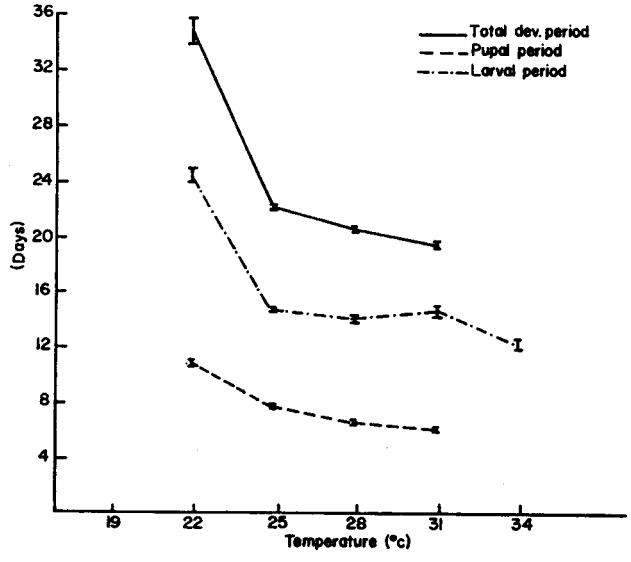

Fig. 2: Total development, larval and pupal periods of *Maruca testulalis* at six temperature regimes.

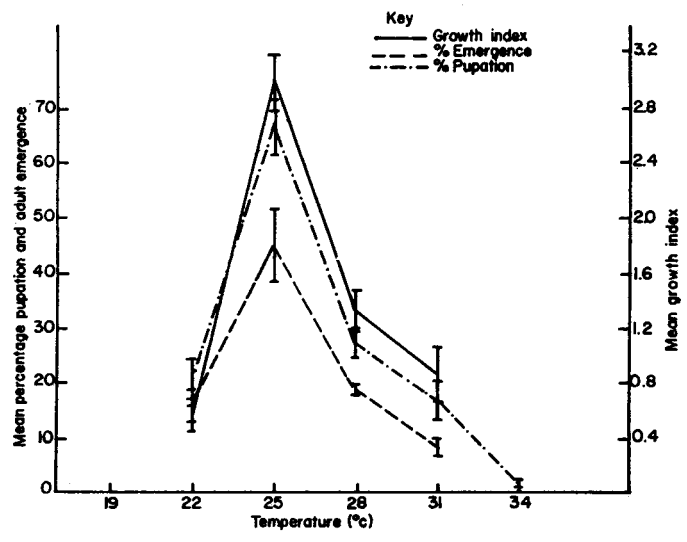

Fig. 3: Mean growth index, pupation and emergence of *M. testulalis* at six temperature regimes.

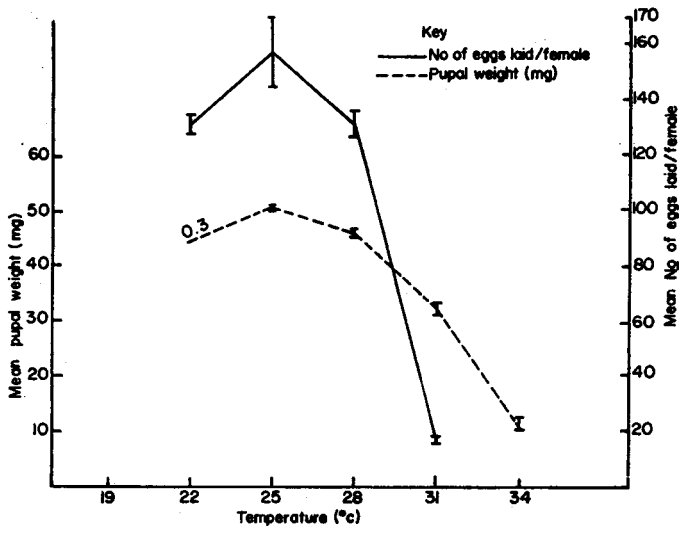

Fig. 4: Graphs of pupal weight (mg) and No of eggs laid/female *M. testulalis* at six temperature regimes.

DISCUSSION

The two most important environment factors that influence the physiology of insects are temperature and humidity (Wigglesworth, 1974). *M. testulalis,* a poikilotherm and nocturnal insect responds to changes in environmental conditions by positively conforming to the prevailing photophase and temperature, respectively. The results of the present study showed that *M. testulalis* were very active and fed at night, and that the lower and upper temperature limits were 19^{0}C and 34^{0}C, respectively. This range is small compared to those of some multicellular ectotherms found where temperature extremes are within 0-45^{0}C range. Synchonous pupation of *M. testulalis* was affected by changes in rearing temperature. The wide range in pupation period observed at 22^{0}C might be due to prolonged insect feeding in small doses with low assimilation rate, thus delaying larval development, since growth in insects is directly proportional to food intake (Krebs, 1972). Differences in percentage pupation (or larval moralities) could be explained by reduced growth rate and hence death of some larvae at low temperatures, water loss from diet at higher temperatures and hence inability of larvae to adequately feed on the dried-up diet, contamination of diet during preparation, and contamination of diet by infested larvae. Larval period of 14.7±0.12 days at the optimum temperature of 25±0.5^{0}C identified in this study was in close agreement with 8-12 days reported by Taylor (1967), 12.40-16.37 days reported by Jackai and

Raulston (1982) and 13.35 days reported by Ochieng and Bungu (1983). The same trend was observed in the pupal and total development periods.

Temperature seemed to have relatively little effect on pupal weight of *M. testulalis* reared at lower temperature as compared to its effects at higher regimes. At 22^{0}C, *M. testulalis* larvae took longer time to mature suggesting the ingestion and assimilation of a greater overall amount of food. Pupae here were therefore expected to be heavier than those at other temperature levels (compare Fig. 2 and 4). Low pupal weights at higher temperatures might be attributed to high energy expenditure due to larval restlessness prior to pupation.

Adults emerging from heavy pupae (25+0.5^{0}C) laid the highest number of eggs suggesting insect nutritional adequacy expressed in pupal weights as one of the factors influencing reproductive ability (Wigglesworth, 1974). Adult females reared at the optimum temperature of 25^{0}C laid the highest number of eggs (157.7 + 13.13 eggs), but this figure is low compare to the 257.1 eggs per female by *M. testulalis* reared at laboratory room temperature (Ochieng and Bungu, 1983). The difference is attributed to the effect of constant environmental temperature used in this study (S. D. +0.5^{0}C) whereas Ochieng and Bungu (1983) worked under fluctuating room conditions. Contamination of insect diet may have also affected egg production by the females. Slightly lower number of eggs recorded at 22^{0}C may be due to delay in mating of the sluggish and less active females while small number of eggs recorded at higher temperature especially at 31^{0}C might be due to delay in mating and short adult longevity.

In conclusion, this study ascertained that the optimum temperature for *M. testulalis* for several of its biological activities such as larval growth index, pupal weight, adult emergence and fecundity was 25 $\pm$0.5^{0}C. Pupal weights had noticeable influence on the numbers of eggs laid per female. Laboratory experiments concerning the control of *M. testulalis* could be done between the temperature regimes of 22^{0}C and 31^{0}C to ensure optimal parameters provided the crop can grow well at these temperatures.

REFERENCES

Duncan, D. B., (1955). Multiple range and multiple f-tests. *Biometrics.* Academic Press, London and New York. 270 pp.

IITA, (1978). *Weather Bulletin for 1978.* International Institute of Tropical Agriculture Ibadan, Nigeria.

Jackai, L.E.N. and Raulston, J. R. (1982). Rearing two maize stem borers and a legume pod-borer on artificial diet. International Institute of Tropical Agriculture. *Research Briefs 3* (1): 1-6.

Kaufamann, K. (1983), Behaviour and development of gonads in *Maruca testulalis* (Geyer) (Lepideptera: Pyralidae) in captivity: *Journal of Ghanian Entomological Society, 1((1):* 93-103.

Krebs, C. J. (1972). Ecology: the experimental analysis of distribution and abundance. New York. Harper and Row, 1972.

Ochieng, R. S. and Bungu, D. O. (1983), Studies on the legume pod-borer *Maruca tesulalis* (Geyer)- IV. A model for mass rearing. Rearing on artificial diet. *Insect Science and its Application: 4(1-2):* 83-88.

Ochieng, R. S. Okeya –Owuor, J. B., and Dabrowski, Z. T. (1981). Studies on the legume pod-borer, *Maruca testulalis* (Geyer) – 11: Mass –rearing on Natural food. *Insect Science and its Application 1* (3): 269-272.

Singh, S. R. Singh, B.B; Jackai L. E. N. and Ntare, B. R. (1983). Cowpea Research at IITA. *International Institute of Tropical Agriculture. Information Series* No. 14, 20 pp.

Taylor, T. A. (1967). The bionomics of *Maruca testulalis* Gey. (Lepidoptera: Pyralidae) a major pest of cowpeas in Nigeria. *Journal of West African Science Association. 12* 111-129.

Taylor, T. A. (1978). *Maruca testulalis* an important pest of Tropical Grain legumes. *In pest of Grain Legumes: Ecology and Control.* Eds. S.R. Singh, H.F. Van Emden and Taylor 454pp. Academic Press, London and New York, T. A.

Wiggeslesworth, V. B. (1974). Insectphysiology. 7th ed. London. Chapman and Hall: New York. Halsted Press Division. Wiley, 1974.