Studies on Temperature Influence on Oviposition and Development of Immature Stages of the Yam Beetle *Dinoderus Porcellus* Lesne. Coleoptera: Bostrichidae on Dried Yam Species

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Abstract

Teneral adults of *Dinoderus porcellus* were raised in the laboratory and exposed to various temperature regimes 10^0, $15^{0,}$ 20^0, 30^0, 35^0 and 40^0 C respectively. Four dried yam species *Dioscorea rotundata, Dioscorea alata, Dioscorea dumetorum* and *Dioscorea cayenensis* were used, to determine the effect of temperature on oviposition and developmental stages of the insect. At 10^0C, there was no oviposition, at 15^0 C fewer eggs were laid. Oviposition increases with little variation as temperature increases from 20^0C 30^0C. There is reduction in the number of eggs laid at 35^0C , while zero oviposition was recorded at 40^0 C. Egg incubation ranges between 6 to 8 days and there were significance difference ($P<0.05$) in the developmental period of larva and no significance difference ($P<0.05$) at the pupal stage. However, developmental period was prolonged on *Dioscorea cayenensis as* temperature increases.

Keywords: Oviposition, Immature stages, Dried yam species, Temperature

1. Introduction

Preliminary investigation of insects collected in descending order of frequency in a survey of insect infestation on dried yams, *Dinoderus porcellus*. Lesne, *Araecerus fasciculatus DeGeer*, *Sitophilus zeamais*. Motsch and *Tribolium castaneum.* Herbst, *Dinoderus. porcellus* and *Rhizoperta dominica* Fab was observed as the most abundant in dried yams. (Adesuyi, 1967; Osuji, 1980). *Dinoderus porcellus* is mainly associated with dried yam and yam products and closely resembles the lesser grain borer *Rhizoperta. dominica* in general appearance, biology and habits (Osuji, 1985) *Araecerus fasciculatus* and. *Sitophilus zeamais* are reported to be generally associated with many stored products, most especially cereals and grains (Ofuya, T. I. & Lale N.E.S (2002); Zaidi & Singh, 2005; Stoll, 2000; Pedigo and Rice, 2006; Osunde, 2008; Osagie, 1992), *Dinoderus porcellus* is a major pest in dry yams (Adesuyi, 1997; Osuji, 1980; Oni, 1995).

Studies on temperature influence on biology of *Dinoderus porcellus* has not been given due attention as other stored product insects. The mean developmental period of *Dinoderus porcellus* on dried yam was reported to be 35.9 days at ambient temperature (Nwana, 1993). A temperature of 28^0 – 30^0C favours the development of *Rhizoperta. dominica* (Osuji 1980; 1985). At 20^0C, the Khapra beetles *Trogoderma granarium* were inactive and laid no eggs, while at 27^0C to 35^0C, eggs laid showed little variations as temperature increases (Odeyemi & Hassan, 1992). This study investigated temperature influence on oviposition and development of immature stages of the yam beetle, *Dinoderus porcellus* on dried yam species.

2. Materials and Methods

This study was conducted in Post-graduate research laboratory of the Department of Biology, Federal University of Technology, Akure, Ondo State, Nigeria.

2.1 Insect Culture

Adult *Dinoderus porcellus* were obtained from selected local dried yam markets in Akure, Nigeria. Insecticide-free and uninfested samples of dried yam from the same market was heat sterilized in an oven at 105^0C for 2hr to kill hidden insects, eggs and other contaminants. Insect colonies were raised by infesting the disinfected dried yam chips with 20 adults of *Dinoderus porcellus* of both sexes in a kilner jar. The kilner jars were kept in the laboratory at fluctuating temperature of 20 – 30^0C and a relative humidity of 75 ± 5%, subsequent teneral adults used for the study were raised from this culture for subsequent experiment (Adedire & Oni, 1998).

2.2 Preparation of dried yam species

Samples of four dried yam species used in this study were prepared from fresh tubers of *Dioscorea rotundata*, *Dioscorea alata*, *Dioscorea dumetorum* and *Dioscorea cayenensis* (Table 1). The fresh yam tubers were processed and each dried yam species were pulverized into fine yam flour using mortar and pestle and sieved with sieved No. 10 to obtain fine powder while large fibrous particles were removed and discarded (Coursey, 1996: Idoko & Adebayo, 2011) and used for subsequent assays.

2.3 Temperature and Oviposition

Five grams (5g) of each dried yam specie were weighed into petri-dishes. Five pairs of adult *Dinoderus porcellus* (1 -2 days old) were introduced into each Petri-dish, covered with muslin cloth held in place by a rubber band. This was to allow adequate aeration and prevent escape of insects. Sex of adults was determined using size and antennal characters according to Halstead (1963).

Oviposition was monitored over constant temperatures of 10, 15, 20, 25, 30, 35 and 40^0C in a cooled Gallenhamp incubator model 2C / 1525 and R216GA and the number of eggs laid and period of incubation was recorded.

2.4 Temperature and Developmental Stages

Developmental stages of *Dinoderus porcellus* were also determined. One day old larva collected from sets of incubated eggs was placed in a petri-dish containing 5.0g of dried yam flour and covered with muslin cloth held in place by a rubber band. All the four variants of yam species (flour) were used at each temperature ranges for incubation of eggs in Gallenhamp cooled incubator. Treatment was replicated four times at each temperature tested. Period of development of larva to pupa were observed and recorded until adult emergence on each dried yam species tested.

2.5 Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) and mean separation was carried out using New Duncan's Multiple Range Test (DUNCAN).

3. Results

3.1 Temperature effect on Oviposition

There was no oviposition at 10^0C, while at 15^0C few eggs were laid (Table 2). As the temperature increased from 20^0C to 30^0C, the number of eggs laid increased and showed little variation. There was a slight decrease in the number of eggs laid at 35^0C on all the dried yam species tested while at 40^0C there was no oviposition. All insects died second day after pairing them at 40^0C. Significantly, *Dioscerea alata* and *Dioscorea dumetorum*, than recorded on *Dioscorea cayenensis* at all temperature regimes tested (Table 2).

Statistically, the mean number of eggs laid in *Discorea rotundata* showed no significant difference at ($P < 0.05$) probability level between the temperature ranges of 20^0C, 25^0C and 30^0C while a significant difference occurred between mean numbers of eggs oviposited at 15^0C when compared to those exposed to higher temperatures. On D*ioscorea alata* and *Dioscorea dumetorum*, there was a significant difference ($P < 0.05$) in the number of eggs laid at 15^0C and 20^0C while no significant difference was established between 25^0C, 30^0C and 35^0C. However, on D*ioscorea cayenensis*, no significant difference was recorded between the temperature regimes tested ($P<0.05$).

3.2 Temperature Effect on Development of Immature Stages of Dinoderus porcellus

At 10^0C, no eggs were laid, so no further development was observed. Egg incubation period ranges between 4.5 to 8.75 days across the temperatures 20^0C to 35^0C. A prolonged incubation period of 8.75 days was recorded on *Dioscorea cayenensis* at 15^0C when compared with other temperature 20 - 35^0C (Table 3).

Development of larva terminated at the second instar stage with a delayed developmental period of 40 – 42 days on all the dried yam species and at this stage mortality of the larva occurred. Analysis of variance test showed that, there were significant difference in the developmental period of larva at 5% probability level between the temperature ranges 20^0C to 35^0C (Table 3 – 5) showed that there were no significant difference ($P<0.05$) on the pupal's period of development between the temperature regimes on *Dioscorea alata* and *Dioscorea dumetorum*. The pupal stage lasted 5.25 to 6.50 days. Further test using Duncan's multiple range test confirmed that there was no marked difference on the total development period on the four dried yam species.

4. Discussion

This study shows the temperature variation influence on oviposition and development of immature stages of *Dinoderus porcellus*. At 10^0C, the beetles were chilled and inactive, hence there was no oviposition, while at 15^0C, few eggs were laid. The increase in the number of eggs laid as temperature increased from 20^0C to 35^0C may be attributed to increased temperature and similar to observation on *Corcyra cephalonica* that oviposition increases as temperature increases (Rao, 1954). However at 40^0C, there was no oviposition and all the insect pairs died second day after pairing. This temperature regime was probably too high for the survival and further development of the beetles. Similar response was reported at 20^0C, as *Trogoderma granarium* become inactive and eggs were not laid, while little variation was reported in eggs laid at 27^0C and 35^0C (Odeyemi & Hassan, 1992).

Temperature parameter had a slight effect on different stages of *Dinoderus porcellus.* A longer period of incubation was recorded at 15^0C than obtained at 20^0C to 35^0C. At this temperature (15^0C) all the larva died after a delayed developmental period of 40 – 42 days. This may be attributed to a low temperature tolerance. This results confirmed reports of previous work by Bowley et al, 1987 on *Corcyra cephalonica* on wheat that at 15^0C and 70% R.H all the larva died young. In contrast to his observation Voelkel, (1974) observed development at 15^0c. No significant difference was recorded from larva to adult stage ($P<0.05$) across the temperature 20^0c to 35^0C.

5. Conclusion and Recommendation.

It was observed from the laboratory results of rearing *Dinoderus porcellus* at controlled temperatures and relative humidity 75 ± 5 %b that, the favourable temperature range for the development of *Dinoderus porcellus* was from 20^0C to 35^0C. At temperatures below this range, development was much slower as recorded at 15^0C. The significant delay in the developmental period of the dried yam beetle could be attributed to the presence of some anti-nutritional factors. Oni, 1995; Adedire & Oni, 1998 affirmed that, this may be attributed to low protein content of *Dioscorea cayenensis* and the presence of some anti-nutritional factors. In a similar vein, Kochlar 1986 was of the opinion that, low preference for *Dioscorea cayenensis* may be due to the presence of alkaloids present in some yam species.

From the view point of this study, the storage of dried yams at temperature below 20^0C and above 35^0C is suggested, since the insects are unable to develop outside this temperature range (20^0C to 35^0C) and a good recommendation for management of insect pests, since infestation is not likely to develop at these temperature ranges

Consequently, the economic significance *Dinoderus porcellus* on dried yam chips and on other stored products requires an urgent attention in country like Nigeria being 90-95% of yam's world producer (Osunde, 2008), and a major consumer of dried yam chips. In view of this, further studies require the identification of the chemical substance responsible for the significant delay in the development of the beetle on *Dioscorea cayenensis* is important. This chemical substance could serve as preservative to other yam species from the development of the beetle *Dinoderus porcellus* and other storage coleopterans on dried yam chips.

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Table 1. Yam Species used in this study

Yam species	**Common name**
Dioscorea rotundata	White yam
Dioscorea alata	Water yam
Dioscorea dumetorum	Wild yam
Dioscorea cayenensis	Yellow yam

Table 2. Mean egg (mean ± SD) oviposited by female *Dinoderus porcellus* on dried yam species at various temperature

Dried yam species	10^0c	15^0c	20^0c	25^0c	30^0c	35^0c	40^0c
Dioscorea. rotundata	-	21.5±1.19b	25± 1.03ab	33.5± 1.32a	35.0±0.41a	34.0±2.16a	-
Dioscorea alata	-	20.75±1.38c	26.75±0.85b	33.5+1.89a	32.75±1.89a	32.75±1.89a	-
Dioscorea dumetorum	-	19.75±0.63c	24.5± 0.65b	31.25±1.11a	32.25±2.01a	29.0±0.91b	-
Diocorea cayenensis	-	6.5 ± 1.19a	9.25± 0.85a	8.5±1.11a	9.25±1.11a	7.25±1.11a	-

* Each value is a mean of 4 replicates ± standard error of the mean. Means followed by same letter(s) are not significantly different (P<0.05) by New Duncan's multiple range test.

Table 3. Temperature variation on immature stages of *Dinoderus porcellus* on *Diocorea rotundata*

Temperature Period of development (days)

^0C	Egg incubation	Larva	Pupal	Total
15	7.25 ± 0.25a	-	-	-
20	4.50 ± 0.29a	25.75 ± 0.48a	6.25 ± 0.25a	36.75 ± 0.25a
25	5.75 ± 0.25b	23.25 ± 1.11a	5.5 ± 0.29a	34.25 ± 1.11a
30	5.25 ± 0.48bc	24.25 ± 0.48a	5.5 ± 0.29a	35.0 ± 0.71a
35	5.25 ± 0.25bc	24.75 ± 0.48a	5.5 ± 0.25a	35.25 ± 0.75a

- no development

Each value is a mean of 4 replicates ± standard error of the mean. Means followed by the same letter(s) are not significantly different (P<0.05) by Duncan's multiple range test.

Table 4. Temperature variation on the development immature stages of D*inoderus. porcellus on Dioscorea alata*

Temperature Period of development (days)

^0C	Egg incubation	Larva	Pupal	Total
15	6.50 ± 0.65a	-	-	-
20	5.00 ± 0.22b	25.0 ± 0.41a	4.25 ± 0.48a	35.75 ± 0.25a
25	5.25± 0.29a	24.25 ± 0.63a	5.75 ± 0.25a	35.0 ± 0.41a
30	5.0 ± 0.41b	24.75 ± 0.48a	5.5 ± 0.5a	35.0 ± 0.58a
35	5.75 ± 0.43ab	24.5 ± 2.04a	5.25 ± 0.25a	35.25 ± 0.48a

- no development

Each value is a mean of 4 replicates ± standard error of the mean

Means followed by the same letter(s) are not significantly different (P<0.05) by Duncan's multiple range test.

Table 5. Temperature variation on the development of immature stages *Dinoderus porcellus* on D*ioscorea. dumetorum*

Temperature	Period of development (days)			
^{0}C	**Egg incubation**	**Larva**	**Pupal**	**Total**
15	6.50 ± 0.50a	-	-	-
20	5.0 ± 0.22a	25.0 ± 0.41a	6.0 ± 0.41a	36.0 ± 0.41a
25	5.0 ± 0.22a	24.25 ± 0.48a	5.75 ±0.25a	35.0 ± 0.41a
30	4.75 ± 0.42b	25.5 ±0.29a	5.75 ± 0.25a	36.0 ± 0.25a
35	5.0 ± 0.22a	25.5 ±0.29a	5.75 ± 0.25a	36.0 ± 0.25a

- no development

Each value is a mean of 4 replicate ± standard error of the mean. Means followed by the same letter(s) are not significant different at ($P<0.05$) by Duncan's multiple range test.

Table 6. Temperature variation on the development of immature stages of *Dinoderus porcellus* on *Dioscorea cayenensis.*

Temperature	Period of development			
^{0}C	**Egg incubation**	**Larva**	**Pupal**	**Total**
15	8.75 ± 0.25a	-	-	-
20	5.75 ±0.42b	27.0 ± 0.58a	5.5 ± 0.29a	38.25 ± 0.25a
25	6.50 ±0.06a	26.5 ± 0.29a	5.75 ± 0.25a	38.75 ± 0.25a
30	6.50 ± 0.06b	25.5 ±0.29a	6.5 ± 0.29a	38.5 ± 0.29a
35	6.0 ± 0.42b	26.5 ± 0.48a	6.0 ± 0.41a	38.0 ± 0.65a

- no development

Each value is a mean of 4 replicates ± standard error of the mean. Means followed by the same letter(s) are not significantly different at ($P<0.05$) by Duncan's multiple range test.