VOL. 12, NO. 4, APRIL 2017 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

DEVELOPMENT OF *Lasioderma serricorne* (F.)(COLEOPTERA: ANOBIIDAE)ON DRIED ROOT AND TUBER CHIPS

Bernard Agyeman Boateng[1], William Azalekor[2], Eric Amoafo Boamah[1] and Edith Nonye Nwankwo[3]
[1]Department of Crop Science, College of Basic and Applied Sciences, University of Ghana, Legon, Accra, Ghana
[2]Quality Control Company, Ghana Cocoa Board, Tema, Ghana
[3]Department of Parasitology and Entomology, Nnamdi Azikiwe University, Awka, Nigeria
E-Mail: bboateng@ug.edu.gh

ABSTRACT

The cigarette beetle (*Lasioderma serricorne*) successfully develops on a wide range of stored products. This study was conducted to determine the development of the cigarette beetle on some roots and tubers namely; cassava, yam, cocoyam and sweet potato chips at laboratory conditions. The developmental period of the insect, consisting of the egg incubation period, larval, pupal and adult period, was recorded. The adult body weight, adult longevity and the amount of frass produced were also determined. The cigarette beetle was able to complete it lifecycle from the egg stage to the adult stage on all the different root and tuber chips. Sweet potato chips produced significantly better in all the variables evaluated, whereas cocoyam chips consistently served as a poor substrate for the development of the cigarette beetle. The result of the study has implication for long term post harvest storage of these roots and tuber crops as chips.

Keywords: lasioderma serricorne, cigarette beetle, roots and tubers, life cycle, development, sweet potato, cocoyam, dried chips.

INTRODUCTION

Cigarette beetle, *Lasioderma serricorne* Fabricius (Coleoptera: Anobiidae) is a cosmopolitan stored product insect pest (Rees, 2004). The beetle is one of the most common insects that damage stored products such as dried and processed materials of animal origin, nuts, herbs, spices, grains and grain products, etc. They usually feed heavily at the larval stage (Cabrera, 2007). The insect is also found to associate with or develop on root and tuber crops such as cassava, yam, and cocoyam mostly in the dried or processed state for storage (Osuji, 1980; Allotey and Unanaowo, 1993; Obadofin *et al.,* 2013). The female beetles are foundtodepositabout100eggsloosely on stored tobacco, grain-based products, and spices which hatch between 6-10 days (Allotey, 1988; Cabrera, 2007; Mahroof and Phillips, 2008). The beetles that emerge as adult are capable of flight but do not feed as adult but create holes in the substrates to locate a suitable ovi-position sites (Papadopoulou, 2006). The shortest development period from egg to adult stage is 26 days at 30°C and 70 % relative humidity on these commodities (Rees, 2004). The rate of development of the cigarette beetle is dependent on the food source and environmental factors such as temperature and relative humidity (Rees, 2004). The longest developmental stage is usually recorded at the larval stage where most feeding is done; the longevity of the adult insect is usually dependent on the type and quantity of food consumed during the larval stage (Papadopoulou, 2006; Mahroof and Phillips, 2008).

Root and tuber crops such as yam, cassava, cocoyam, and sweet potato are major staple crops in large parts of the humid and sub-humid tropics. According to IITA (2009) sub-saharan Africa produces over 50% of cassava and over 90% of the yam in the world. These are mostly produced on farms usually managed by small holders who rely on traditional, labour-intensive practices that do not allow for optimal exploitation of the crop productive potential. Although the severity of production and postharvest constraints differ with agro-ecology and specific crops, all the crops suffer severe yield losses due to a wide range of pest and disease infestation (IITA, 2009).

The biology and development history of L. *serricorne* have been investigated under various temperature and relative humidity (RH.) conditions, generally using tobacco, yeast, wheat or spices as food sources for several years (Jones, 1913; Powell, 1931; Howe, 1957; Lefkovitch and Currie, 1967; Mahroof and Phillips, 2008). These different food sources have been shown to influence the insect's life history parameters. However, there is paucity of data on using roots and tuber crops as food sources. There is therefore, the need to understand the developmental behaviour of storage insects on root and tuber crops in other to enhance their storage potential to ensure food security in the developing world where these are used as staple foods. The objective of the study was to determine the effect of yam, cassava, cocoyam and sweet potato chips on the development of *Lasioderma serricorne* (Cigarette beetle)

MATERIALS AND METHODS

A culture of *Lasioderma serricorne* was raised on groundnuts in the entomology laboratory of the Research Department of Quality Control (QCC) at Tema, Ghana. In the culturing process, four Kilner jars were washed and sterilized in an oven at 65°C overnight. Groundnuts obtained from the Research Department were also sterilized at the same temperature for three hours. This was done to rid the materials of unwanted organisms that could contaminate the culture. Both the jars and groundnuts were removed from the oven and allowed to cool before the 500 g of groundnuts were transferred into each jar.

Fifty newly emerged adult *L. serricorne* were added to each jar after which the jars were placed on glass stands in trays containing industrial oil to prevent contamination by other insects and mites. The set up was left undisturbed at the laboratory (22.7-28.5°C, 30.6 - 78%. RH, 10:14 L: D period). After 8 days, the adult insects were sieved off and the jars were left for further twenty days without disturbance. Daily observations were thereafter made until new insect progeny emerged which was used for subsequent experiments.

PREPARATION OF CHIPS

Root and tubers of cassava, cocoyam, yam, and sweet potato were purchased from the local market at Madina, a suburb of Accra, Ghana. They were further processed into chips by cutting the min to smaller sizes, about 1.5 x 1 x 0.5 cm in dimension. They were then oven-dried at the Entomology Laboratory at the Department of Crop Science, University of Ghana, Legon, Accra, Ghana, to reduce the moisture content to the minimum. The drying was done at 70°C for six hours daily for four days to constant weights, to obtain uniformly dried chips. All dried chips were packaged, sealed in different heavy duty plastic bags and stored at 5°C in the cold room until needed. The moisture content of all powdered materials used at the beginning of the study varied from 9% to 11% on a dry weight basis.

Development of *L. serricorne* on food chips

Sixteen Kilner jars were sterilized in an oven at a temperature of 60°C for six hours and allowed to cool. Each bottle was then filled with 200g of the different food chips, forty 4-day old *L. serricorne* adults were introduced into each bottle. The jars were covered with muslin cloth which was tightly held in place with rubber bands. The jars were then placed in a plastic tray containing industrial oil and kept in the laboratory at 22.7-28.5°C and relative humidity of 30.6 - 78%. After two days, the content of each bottle was emptied into a large glass trough and twenty chips were randomly sampled, carefully brushed, broken and examined for the opaque white eggs (Kucerová and Stejskal, 2010). Number of chips with eggs were recorded and the duration of each egg development (incubation period) was also recorded. Later the adult insects were sieved off and all chips, dust and egg turned to the jars. During the observation process, the developmental period of the insect which involves the egg incubation period, larval, pupal and adult period were recorded (Kucerová and Stejskal, 2010).

Larval and pupal developmental periods

The larval development period was counted from the day of emergence of the first in star, to the day on which the larvae constructed the pupal case to initiate pupation. The larvae that had emerged were constantly viewed daily, under a stereomicroscope (Leica® M80, Leica Microsystems, Germany) for detailed morphological features. Afterward, the pupal developmental period was recorded from the time the larvae constructed the pupal case or when detectable changes occurred in the larval to pupal morphology to the emergence of the adult. This was repeated for all four treatments and the mean developmental periods for the stages were calculated. The total egg-adult developmental period is the summation of egg, larval and pupal developmental periods.

Adult weight and longevity

After eclosion, ten adults were randomly selected from every experimental unit, placed in Petri dishes and weighed. To determine the longevity, freshly emerged adult cigarette beetles were left on the various root and tuber chips and observed daily until all died. Dead insects were removed from the chips daily until all insects died.

Frass weight

The amount of frass produced by the cigarette beetle was determined after the insect had completed development on various chips. This was done by removing all the insects from each jar as the chips were poured onto trays together with the frass that was produced during the feeding of the insect. The chips were carefully brushed to remove the powder from the infested chips. The frass collected was weighed. This was done for all the four treatments.

Data analysis

Prior to data analyses, the incubation period, larval, pupal, and total developmental period, and adult longevity data were transformed to a $\log_{10}$ (x) scale to satisfy the assumption of normality and homogeneity of variances (Zar, 1984). Number of chips with eggs data were converted into percentage and these percentage values were compared among different root and tuber chips. The data were transformed to arcsine $X^{0.5}$ (Zar, 1984) prior to analysis. All data collected were subjected to analysis of variance (ANOVA) at 5% significance level using GENSTAT software, version 12.1 to determine the significant differences among treatments. Least significant difference (LSD) was used for separating treatment means. Actual means and SEM are presented in the tables.

RESULTS

Proportion of chips used for oviposition

The proportion of chips used for oviposition of *L. serricorne* varied significantly among the treatments. The beetles distributed significantly higher percentage of eggs on sweet potato chips (72.5%), it however distributed eggs on fewer cocoyam chips (45%), compared to cassava (67.5%) and yam (52.5%) chips. No significant differences ($p > 0.05$) were observed between the percent oviposition on chips of cassava and sweet potato chips, as well as between yam and cocoyam chips.

Table-1. Development characteristics of egg and other immature life stages of *L. serricorne* reared on chips prepared from four roots and tuber crops.

Treatment	Proportion of chips with eggs (%)	Egg incubation period (days)	Larvae development (days)	Pupa development (days)
Potato	67.5 ± 1.2b	4.5 ± 0.3a	40.7 ± 0.5a	7.0 ± 0.4a
Yam	52.5 ± 0.7a	5.3 ± 0.3a	50.0 ± 0.4c	11.0 ± 0.4c
Cocoyam	45.0 ± 0.9a	5.5 ± 0.5a	52.8 ± 0.5d	14.3 ± 0.5d
Cassava	72.5 ± 1.3b	5.0 ± 0.4a	47.3 ± 0.5b	9.0 ± 0.4b

Means follow by same letter in a column are not significantly different by LSD (α=0.05)
*Mean of four replicates ± SEM.

Table-2. Performance indicators of adults of *L. serricorne* reared on chips prepared from four roots and tuber crops.

Treatment	Egg-Adult developmental period (days)	Adult body weight (mg)	Adult longevity (days)	Weight of frass (g)
Potato	52.2 ± 0.6a	5.8 ± 0.1d	16.8 ± 0.3d	10.4 ± 0.2d
Yam	66.5 ± 0.6c	5.3 ± 0.0b	10.3 ± 0.3b	4.3 ± 0.1b
Cocoyam	72.0 ± 1.2d	5.0 ± 0.0a	8.3 ± 0.3a	1.3 ± 0.1a
Cassava	61.3 ± 0.9b	5.5 ± 0.0c	13.8 ± 0.3c	6.4 ± 0.2c

Means follow by same letter in a column are not significantly different (α=0.05)
*Mean of four replicates ± SEM.

Incubation period

The incubation period of the eggs laid on the chips of the various treatments did not vary significantly ($p>0.05$) (Table-1). Eggs on sweet potato chips recorded the shortest incubation period of 4.5 days, it was then followed by eggs on cassava which took5.0 days to hatch, compared with those on yam chips, 5.3 days. Eggs laid on cocoyam chips recorded the longest incubation period of 5.5 days.

Larval and pupal developmental periods

The larval development period of *L. serricorne* varied significantly ($p<0.05$) among the various root and tuber treatments (Table-1). Larvae developed quickest on sweet potato chips (40.8 days) compared with the developmental period on cocoyam chips (52.3 days) which was longest among all treatments evaluated. The pupa development period among the various root and tubers treatments ranged from 7 to 14.3 days. Similarly, pupation period was shortest on sweet potato chips and longest on cocoyam chips. Significant differences ($p<0.05$) were observed among the mean pupal development times recorded on the chips from different crops.

Total developmental period

The total egg-adult developmental period for *L. serricorne*, on the various root and tuber hosts ranged from 52.3 days to 72 days (Table-2). *L. serricorne* experienced a significantly shorter developmental time (52.3 days) when it fed on sweet potato chips ($p < 0.05$). The longest development time was obtained when the insects were fed with cocoyam chips. The insects on cassava chips recorded 61.3 days and adult insects on yam chips recorded a total development time of 66 days (Table 2).

Adult body weight

The adult body weight of *L. serricorne* varied significantly among the root and tuber treatments (Table-2). The adult insects that were reared on sweet potato and cassava chips were observed to be heavier. Adult insects emerged from sweet potato chips experienced the heaviest body weight (5.75 mg) where as those reared on cocoyam chips had the lightest body weight (5.02 mg). Insects developed on cassava chips also recorded an adult body weight of 5.45 mg and insects reared on yam chips recorded a body weight of 5.22 mg. Significant differences ($p<0.05$) were however observed among the mean body weight of the insects reared on the various the root and tuber chips (Table-2).

Adult longevity

The mean adult longevity of *L. serricorne* varied significantly ($p < 0.05$) among the various chips which ranged from 8.3 days to 16.3 days (Table-2). Adults fed on cocoyam chips lived shortest whereas those fed with sweet potato chips lived longest. Insects reared on cassava chips however lived longer (13.75) than those exposed to yam chips.

Frass weight

The mean weight of frass produced by *L. serricorne* varied significantly ($p < 0.05$) among root and tuber treatments. From the Table-2, it could be observed that insects reared on sweet potato chips produced the greatest amount of frass, whereas the lowest amount of

frass was recorded on cocoyam chips. Cassava chips however produced a frass weight of 6.43 mg, and yam produced 4.3 g of frass during the entire developmental period of *L. serricorne* on the root and tuber chips. There were significant differences ($p < 0.05$) observed among the mean frass weight of the various root and tuber chips (Table-2).

DISCUSSIONS

In this study, the average number of eggs deposited by female *L. serricorne* varied (Mahroof and Phillips, 2008) among the root and tuber treatments. This means that *L. serricorne* was able to discriminate among the food sources provided for oviposition. Cassava chips were the most suitable medium while cocoyam was the least preferred for oviposition. Quantitative and qualitative differences in the chemical constituents of the various root and tuber treatments might have directly influence the oviposition behaviour of *L. serricorne* (Fletcher and long, 1971). Kohno and Ohnishi 1986 also reported that not only the chemical stimulus, but also the physical texture of the substance is a limiting factor for ovipositional response.

The incubation period of *L. serricorne* did not vary among the root and tuber substrate. This means the eggs ability to hatch does not depend on the food source but favourable environmental conditions (Mahroof and Phillips, 2008). It is known incubation period of insect eggs are greatly influenced by temperature. Powell (1931) and Rees (2004) reported that *L. serricorne* eggs do not hatch if eggs are kept in low relative humidity or temperatures below 17.5^{o}C during incubation (Mahroof and Phillips, 2008). The larval stage is the longest stage of development of the insect where most feeding is done to conserve nutrients for adult stage, since the adult does not feed (Minor, 1979). There was however a considerable variation during the larval development period in the various root and tuber treatment, where sweet potato chips recorded the shortest larval developmental time among the treatment. This means that sweet potato as a food source facilitated the development of *L. serricorne* as compared to cocoyam which recorded the longest larvae developmental time. The discrimination among food source might be due to the composition of the various root and tuber chips which facilitates the feeding response of the insects as reported by Papadopoulou (2006). Similar observation was made with the pupal period, adult body weight and adult longevity.

The total development period also varied significantly among food sources. On sweet potato chips recorded the shortest adult development time which means, of all the four root and tuber treatments that served as growth medium, sweet potato chips emerged as the best medium for *Lasioderma* development, even- though the insects were able to live or survive from the egg stage to adult stage on all root and tuber treatments. Cocoyam chips, however recorded the longest developmental time and hence emerged as poor medium for *Lasioderma* growth and development. Cocoyam plant parts are known to contain high concentration of acrid principles (Sakai and Hanson, 1974). These chemical irritants on the surface of raphides it contains (Tang and Sakai, 1983; Nixon, 1987) which limit the use of fresh corms and leaves by humans and animals (Pauli *et al.,* 1999). Cocoyam also contains phytic acid and sap which play a defensive role against damage by insects (Adebayor, 2002). These may have contributed to the low preference of cocoyam chips as a suitable substrate for growth and development of *L. serricorne.* Nutritional composition, like carbohydrates content (Papadopoulou, 2006), sugar content (Rhineand Stapples, 1968) and the total quality of food available to the larvae play a vital role and can influence adult body size and longevity (Ashworth, 1993). Insects' body weight positively correlated with their longevity. Adults that emerged from sweet potato chips were heaviest in body weight and lived longest. This means that they fed better on such chips as developing larvae, producing a lot of frass as a result.

The physical texture of the various root and tuber chips (Kohno and Ohnishi, 1986) also influenced the feeding behaviour of developing *L. serricorne* larvae on the various root and tuber substrates. *Lasioderma serricorne* fed higher on root and tuber chips that had relatively softer texture, such as sweet potato chips, producing a considering the amount of frass.

CONCLUSIONS

The cigarette beetle was able to complete it life cycle from the egg stage to the adult stage on all the different root and tuber chips. Sweet potato chips served as the most suitable substrate in all the developmental parameters evaluated whereas cocoyam chips consistently served as a poor substrate in all the developmental parameters of the cigarette beetle during the experiment. Cassava and yam chips however ranked in-between. Sweet potato chips were regarded as very susceptible to the development of the cigarette beetle.

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