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First Report of Infestation of Stored Plantain Chips by *Trogoderma granarium* Everts (Coleoptera: Dermestidae) in Southwestern Nigeria

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ABSTRACT

Plantain (*Musa paradisiaca*) chips were infested with varying levels (4, 8 and 12 adults) of *Trogoderma granarium* Everts (sex ratio 1:1) per 20 g chips. Uninfested plantain chips served as control. Data on chips weight loss due to *T. granarium* feeding and number of F1 larvae were taken at 3 and 6 months after infestation (MAI). Initial insect level significantly affected plantain chips weight loss and number of *T. granarium* larvae. At 3 MAI, chips that were infested with 12 adults suffered 9.5% weight loss and 63.0 larvae. These values were significantly ($P < 0.05$) higher than values (1.3% weight loss and 6.0 larvae) obtained when chips were infested with 4 adults. At 6 MAI, 66.0 larvae obtained in chips infested with 12 adults were significantly higher than values obtained when chips were infested with fewer *T. granarium* adults. Percentage weight loss was also highest when chips were infested with 12 *T. granarium* adults. The results indicate that *T. granarium* is a storage pest of plantain chips which fed on and utilized it for its reproductive biology.

Keywords: Khapra beetle, *Musa parasidiaca*, progeny development, storage pest, weight loss

INTRODUCTION

Trogoderma granarium (Khapra beetle) is an outstanding cosmopolitan pest of stored products with all potentials associated with the success of the class Insecta such as small size, colour, and tolerance to wide variations in climate, environmental parameters and ability of the larval stage to survive long starvation period. Its larval stage is primarily responsible for the damage done to products since adults rarely feed (Adedire 2001). Virgin female *T. granarium* produce an assembling pheromone which acts both as a male attractant and a female aggregant (Haines 1991). Female lays between 50-100 eggs lonely in stored produce over a period of 3-12 days subject to temperature variations (NRI 1996). The eggs develop into larvae which have long and conspicuous bristles. The larval stage takes about 3 weeks under optimum conditions and there are 4-5 instars. The rate of development of larvae varies from 14 days to several months, a year or even more because the larvae could diapause if conditions are unfavourable. The pupal stage lasts for 3-5 days. At optimum condition, it takes about 4-6 weeks for egg to develop into an adult beetle. The species is a very serious pest on account of the difficulty associated with its control. Larvae are often difficult to control possibly because the long bristles on their bodies prevent contact of pesticides; hence increase the tendency of emergence of resistant strains.

Plantains are vital crops for many tropical countries, as they are one of the cheapest sources of starch which can be produced. They are the subject of a traditional trade that is crucial for supplying the major urban centres in Africa (Skinner 1987). With the tendency of over production and post harvest spoilage, local farmers in some parts of southwestern Nigeria do peel and slice unripe plantains into different sizes, drying them for some days. Plantain and banana flour is currently on sale in these areas, which is a strong indication that farmers and plantain processors are beginning to adopt processing options as a means of market diversification and consequently curtailing glut (Adeniji *et al.* 2007). When fully dried, it can then be ground and used as substitute for yam flour to make "amala" paste. This has been high rated for its nutritional value for diabetic patients. Some even prefer its paste to that of yam and cassava flour when they want to change taste. As well, it is currently being exploited in baking and contemporary weaning food in Nigeria according to the recommendation of Ihekoronye and Ngoddy (1985). However, information is required on possible biological threats to the supply of this product, especially the impacts of the class Insecta.

Cockroach (*Periplaneta americana*) and ants have been found to be associated with fresh (unprocessed) plantains (*Musa paradisiaca*) in kitchens and stores in Ogbomoso metropolis of Nigeria. Perhaps, because plantain chips are not being produced in high quantities as tuberous crops in Nigeria, efforts have not been geared toward studying its storage pests. This dearth of knowledge worth special attention for the benefits of farmers, traders and consumers of plantain chips in the tropics and subtropics. Therefore, the objective of this study was to evaluate the effect of *T. granarium* on quantitative deterioration of stored plantain chips and to evaluate the effects of stored chips on fecundity of *T. granarium.* This is a preliminary study to establish its pest status against *Musa* species.

MATERIALS AND METHODS

Procurement of plantain and chips preparation

Bunches of matured but unripe plantain were purchased at Araada Market in Ogbomoso, Nigeria. The plantain was peeled and transversely sliced into chips form. It was later sun-dried for some days to attain about 4 mm thickness till moisture content of 9% was reached. Moisture content determination was done by AOAC (1990) method.

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Original Research Paper

T. granarium culture

T. granarium was obtained from the Storage Entomology Unit of Agronomy Laboratory, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso. Adults were cultured in 1-L jars with groundnut as described by Babarinde and Daramola (2006). The insect was cultured under laboratory condition of 64 ± 5% relative humidity and 30 ± 2°C. The experiment was carried out under similar conditions. Newly emerged adults (1- to 3-days old) were used for the experiment.

Entomological procedures

20 g of plantain chips were weighed with a sensitive balance (Gibertini TM 1600®) Italy, into 24 × 150 ml glass jars. The glass jars were divided into two batches of 12 jars each. Varying amounts (4, 8, 12 insects; sex ratio 1:1) were introduced into the glass jars. Sexing was done according to Haines (1991). A glass jar without any insect served as control. The jars were covered with muslin cloth to allow for aeration and to prevent other pests from entering. The experiment was set up in triplicates. The first batch of 12 jars was left for 3 months after which the chips were carefully removed and sieved to remove adherent plantain powder from the chips. The intact chips were then reweighed. Weight loss was estimated as the difference between original weight and final weight of chips. The number of larvae present was then recorded. At 6 months after infestation (MAI), chips were also removed from the second batch of 12 jars and the procedures followed were similar to what was done for the first experiment of 3-month storage.

Experimental design and data analysis

The experiment was set up in a spilt plot design with initial insect level as the main plot and storage period as the subplot. Data on weight loss and larval count were subjected to analysis of variance (ANOVA) and significant means were separated with least significant difference (LSD) at $P < 0.05$. Data analysis was done with the aid of SAS software package (SAS Institute 2001).

RESULTS

T. granarium larvae were observed in the infested plantain chips, having characteristic brownish colour due to the body hairs (**Fig. 1**). The adults were basically of two sizes which confirm sexual dimorphism in *T. granarium* (male being smaller in size than female) (**Fig. 2**).

The mean number of *T. granarium* larvae was significantly affected by the initial level of adults. When 4 insects were introduced, storing plantain chips for 3 months gave 6 larvae, while 8 and 12 adults gave 21.3 and 63.0 larvae, respectively. When plantain chips were stored for 6 months, 4 adults gave 16.7 larvae, while 8 and 12 adult gave 45.0 and 66.0 larvae, respectively. Storage period had a significant impact because when plantain chips were stored for 3 months, the mean number of *T. granarium* larvae was 30.1 whereas in 6-month storage of plantain chips, the mean number of larvae was 42.5 (**Fig. 3**).

Percentage weight loss of stored plantain chips due to *T. granarium* feeding was significantly ($P < 0.05$) affected by initial level of adult *T. granarium*. When stored for 3 months, 1.3% weight loss due to 4 initial insects was significantly lower than 9.5% weight loss due to 12 initial adults. When stored for 6 months 4.1% weight loss due to 4 initial insects was significantly lower than 11.2% weight loss due to 12 initial *T. granarium* adults. Storage period was also significant. At 8 initial adults, 8.2% weight loss due to 6-month storage was significantly higher than 4.0% due to 3-month storage (**Fig. 4**).

DISCUSSION

Pest problems in the tropical storage environment appear to be greater than what obtain in the temperate climates (Hill and Waller 1990), presumably because of optimal conditions of temperature and relative humidity for pest development found in the former (De Lima 1987). Several authors (Hill and Waller 1990; Haines 1991; Adedire 2001; Lale 2002) have listed agricultural produce attacked by *T. granarium.* Incidentally, plantain chip has not been recognized as a substrate of the insect species. Recently, Babarinde *et al.* (2010a) reported that *Tribolium castaneum*, a secondary storage insect pest, fed on plantain chip causing significant weight loss, but the chip did not support its reproduction.

In this study, susceptibility of plantain chips to *T. granarium* was studied on the basis of reproductive biology of the insect species and weight loss of plantain chips due to insect infestation of stored chips. Percentage weight loss of stored plantain chips due to *T. granarium* feeding was significantly affected by level of infestation and storage period. Initial infestation level also affected F1 progeny development. Poplawska *et al.* (2001) reported that the development of *T. granarium* larvae on barley grain and malt was longer than on wheat grain. They also reported that it showed greater feeding preference towards buckwheat products than barley grain.

This study reveals that *T. granarium* is a storage pest of plantain chips which fed on and utilized it for its reproductive biology. Babarinde *et al.* (2010b), Babarinde and Daramola (2006) and Odeyemi (1997) reported it as a pest of groundnut, where as Poplawska *et al.* (2001), Khattak *et al.* (1995), Jood *et al.* (1993) and Viljoen (1990) reported it as a pest of cereals. Adedire (2001), however, reported that it can attack dried fruits. Though works on infestation of plantain chips are scarce, this work reveals that stored plan-

Fig. 1 *Trogoderma granarium* larvae infesting plantain chips. The picture of the larvae is approximately 1.5X the actual size.

Fig. 2 *Trogoderma granarium* adults (male typically smaller in size than female). The picture of the adult is approximately 2X the actual size.

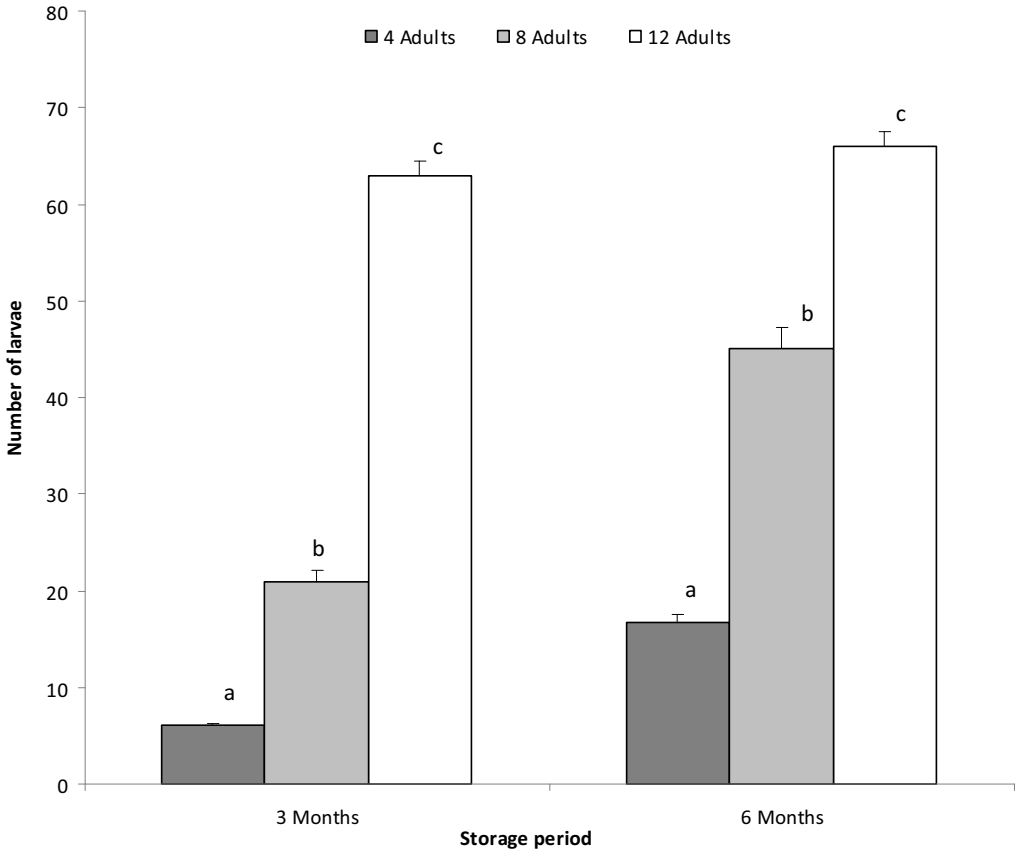

Fig. 3 Mean number of *Trogoderma granarium* larvae in stored plantain chips. Plantain chip was infested with 4, 8 and 12 adult *Trogoderma granarium*. A glass jar without any insect served as control. At 3 and 6 months after infestation, the number of larvae present was recorded. Values represent the mean ± standard error (SE) of three replicates. LSD ($P < 0.05$) initial adults = 9.3; LSD ($P < 0.05$) storage period = 6.6.

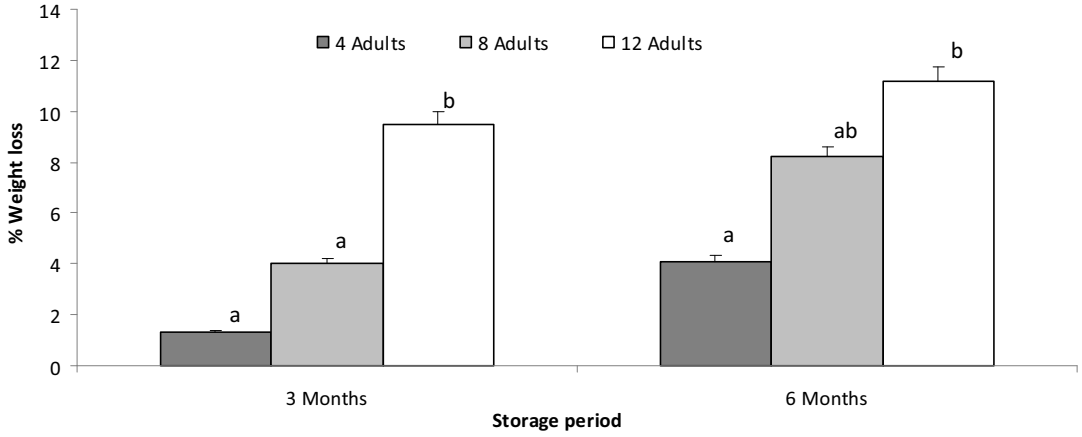

Fig. 4 Mean % weight loss of plantain chip due to *Trogoderma granarium* infestation. Plantain chip was infested with 4, 8 and 12 adult *Trogoderma granarium*. At 3 and 6 months after infestation, weight loss was estimated and expressed as a percentage proportion of the initial weight. Values represent mean ± standard error (SE) of three replicates. LSD ($P < 0.05$) initial adults = 4.6; LSD ($P < 0.05$) storage period = 3.2.

tain chips are prone to *T. granarium* attack. Whenever it infests plantain chips, it is better that the chips be disposed since the tendency of multiplication becomes higher with storage period. The values obtained in larval count over the storage durations were comparatively lower than values reported by Hill and Waller (1990) in grains. This observation suggests that grains supported reproduction of the insect than plantain chips. Since it can enter into facultative diapause when environmental conditions are unfavourable and to synchronize adult emergence (Haines 1991; Lale 2002), an access to plantain chips after diapause will favour its sporadic numerical growth. In areas where plantain chips are displayed along the highways for intending buyers on transit, an unrestricted access is somehow provided for insect cross-infestation.

Although, plantain chips are not being produced on a very large scale across the globe, it is worth noting that the medium scale production has a major threat from class insecta. Since the insect utilized it for its reproductive biology, it can cause cross infestation of the species to other stored crops. Therefore, plantain chip should be protected from insect infestation. Recently, Ofuya *et al*. (2007) studied potentials of using plantain flours for mixing botanical dusts to control *Callosobruchus maculatus*. Plantain flours have also been recommended for formulating weaning foods (Ihekoronye and Ngoddy 1985). The flour is often recommended for diabetic patients in southwestern Nigeria to be used instead of yam paste, locally called amala. With all these potentials, insect infestation will cause great havocs to the usefulness of *Musa* family. This study reveals that *T. granarium* can use plantain chips as its alternative host when its preferred substrates are not available. Efforts should therefore be geared towards preventing its infestation in areas where chips are stored for a relatively long period for

family consumption.

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