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# Response of chips from different varieties of yam to larger grain borer (LGB) (*Prostephanus truncatus* (Horn) (Coleoptera: bostrichidae) infestation

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**Laboratory studies were conducted at the University of Port Harcourt to evaluate the response of dried yam chips as a host for *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae). The test was conducted using four improved yam varieties namely; Adaka, Ame, Nwokpoko and Obiaturugo. Ten grams of each substrate of the dried yam chips were placed in plastic containers of 300 ml and each container was infested with three pairs of one to three days old *P. truncatus*. Data on insect developmental periods in the various dried chips, as well as the susceptibility of the substrates, weight gain on the chips and the weight of frass produced were recorded. The beetles exhibited differential levels of preference for the yam chips from different varieties. They developed better on Obiaturugo and Nwokpoko than on Adaka and Ame. The mean developmental period of *P. truncatus* on yam dried chips were 96.33 and 65.33 days for Obiaturugo and Nwokpoko, respectively but failed to develop on Adaka and Ame. There was significant difference (P<0.05) in weight between the amount of frass produced on Obiaturugo and that produced on the other substrates. Also, there was significant difference (P<0.05) in weight gained between Nwokpoko and the other substrates. The study has shown that of the dried chips from the four varieties of yam, only Nwokpoko and Obiaturugo were found to be possible hosts of *P. truncatus* and thus need protection against the pest during storage.**

**Key words:** *Prostephanus truncatus*, infestation, yam, chips.

## INTRODUCTION

Yam belongs to the genus *Dioscorea* (Family: Dioscoreaceae), a perennial herbaceous vine cultivated for the consumption of their starchy tubers. Of the estimated 300-600 species that are available, there are just over half-dozen principal species that are grown for consumption, while others are grown for medicinal

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purposes (FAO, 2003). Yams originated in the Far East and spread westwards. They have since evolved independently in the Eastern and Western Hemispheres, and today yams are grown widely throughout the tropics. In the West African yam zone, which is the principal producer on a global basis, *Dioscorea rotundata*, *Dioscorea alata*, and *Dioscorea esculenta* are the most common species (FAO, 2003). Yam has a rough skin that is difficult to peel, but which softens after heating. The tuber is composed of a much softer substance known as the 'meat' which varies in colour from white or yellow to purple or pink in mature yam (Ensminger et al., 1983; IITA, 2009). They are grown in many tropical regions throughout the world, but the main production centre is the savannah region of West Africa, where more than 90% of the crop is grown (FAO, 2011). Yam is an important food crop in the yam zones of West Africa, comprising Cameroon, Nigeria, Benin, Togo, Ghana and Cote d' Ivoire, which together produce over 90% of the total world production estimated at about 20-25 metric tonnes (MT) per annum (p.a.) (Sanusi and Salimonu, 2006; Izekor and Olumese,2010). Nigeria with about 15.9 MT p.a. is the leading producer of yam in the world with about 71% of the world output followed by Côte d'Ivoire (2.7 MT p.a.), Benin (1.1 MT p.a.) and Ghana (1.0 MT p.a.) (FAO, 2010).

Yam contributes over 200 dietary proteins per capita daily for more than 150 million people in West Africa, while serving as a source of income and contributing immensely to food security of the people (Babaleye, 2003). It is rich in carbohydrate especially starch and consequently has a multiplicity of end uses and its availability throughout the year has made it preferable compared to other seasonal crops (FAO, 1987). However, the high perishability and losses during storage (up to 50%) are major constraints in yam production systems (FAO, 2010). Storage of fresh yam tubers has proven difficult over the years; with post harvest losses of between 30-85% being recorded (Coursey, 1982; Baco et al., 2004; FAO, 2011; Obadofin et al., 2013).

In order to minimize losses or damage, the yam tubers that normally will not store well as fresh tubers for example tubers of poor quality and badly damaged yams during harvesting or handling are processed into dried yam chips (Adeyusi, 1978; Vernier et al., 2005). The conversion of yam into chips and their storage for long periods exposes them to attack by some stored product insect pests, which threaten food security in sub-Saharan Africa (Isah et al., 2012). Yam and cassava chips and flour constitute important sources of carbohydrate for many people in West Africa (Obadofin et al., 2013).

One of the major insect pests that severely attacks yam chips, thereby reducing both its qualitative and quantitative value is the Lager Grain Borer (LGB), *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) (Vernier et al., 2005; Onolemhenhen, 2009). It is a native of Mexico and Central America was accidentally introduced into Africa in the early 1980s (Dustan and Magazini, 1981). The beetle has since spread to at least 17 countries on the continent (Farrell, 2000). In Africa, *P truncatus* is an outbreak pest of economic importance which has assumed a serious pest of stored maize and dry cassava chips (Dick, 1988; Chijindu, 2002; Chijindu et al., 2008; Danjuma et al; 2008; Isah et al., 2012). Losses of 61.5% on maize, 66% on cassava chips, 24% on cocoyam chips, 73% on plantain chips, 80% on maize, have been recorded in Mozambique, Benin, Ghana, Tanzania and Togo respectively (Cugala et al., 2007; Gnonlonfin et al., 2008; Isah et al., 2012; Boxall, 2002; Wright et al., 1993). This study assessed the susceptibility and post-harvest losses of chips of four yam varieties attributable to *P. truncatus* in the laboratory in the humid Niger Delta region of Nigeria.

## MATERIALS AND METHODS

### Study site

This laboratory study was carried out in the Department of Crop and Soil Science, University of Port Harcourt, Nigeria. The experiment was conducted under the prevailing conditions of 25-30°C and 70-90% relative humidity.

### Yam varieties

Chips from four improved varieties of yam: Adaka, Ame, Nwokpoko and Obiaturugo were obtained from the National Root Crop Research Institute, Umudike, Abia State, Nigeria. The chips were sterilized in a hot air oven at 100°C for 2 h to disinfest them from mites and insect pests. The plastic containers were sterilized in hypochloride diluted in water. Ten grams of each chip were weighed on a digital scale (Model MP2001) into 50 ml plastic containers.

### Mass rearing of *P. truncatus*

Adults of *P. truncatus* were obtained from the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria. Maize cobs and dried cassava chips were heat-sterilized in an oven (GNP-9082) at 60°C for 90 min. The adults were first cultured on the maize cobs and subsequently maintained on the sterilized cassava chips in 1-L Kilner jars in the laboratory under 25-30°C and 70-90% R.H. After one week, the adults were sieved out and eggs laid were allowed to develop to $F_1$ progeny of uniform age (1-3 days) (Zakka et al., 2010) and then used for the experiments.

### Functional and physico-chemical analysis

The yam chips were analysed for chemical composition using the official methods of analysis described by the Association of Official Analytical Chemists (AOAC, 1990).

### Progeny production

Three replicates of 10 g each of chips from the different yam varieties (Adaka, Ame, Nwopoko and Obiaturugo) were weighed

using a digital balance (Model J2003) and placed in 50 ml transparent containers with lids. Three pairs of the newly emerged adults of *P. truncatus* were introduced on each 10 g lot of yam chips. They were allowed to oviposit for one week after which they were removed. The set-up was left undisturbed until emergence of $F_1$ generation. The experiment was carried out in a completely randomized design (CRD). The number of adults, pupae, larvae, total progeny and developmental period (days) of *P. truncatus* were recorded after 96 days.

#### Frass weight

Frass was obtained by sieving off chips remaining and insects that remained at the end of the experiment and then weighed.

#### Determination of weight loss percentage

The final weight of chips was determined after 3 months of storage, by sieving off the insects and frass, the remaining chips were weighed and the observed changes in weight were used to correct the changes of corresponding trail samples (Hurlock, 1967). Percentage weight loss was calculated using the formula (Hurlock, 1967);

$$\text{Weight loss} = \frac{\text{Weight of sample} - \text{Final weight}}{\text{Weight of control sample}} \times 100$$

#### Susceptibility index

The susceptibility index was calculated using the formula developed by Dobie (1977);

$$\text{Susceptibility index (SI)} = \frac{\log_e F}{D} \times 100$$

Where, F = total number of $F_1$ adults and D = median development period (from the middle of oviposition period to 50% of emerged adults)

#### Data analysis

Data recorded on number of larvae, pupae, adults and total progeny were recorded and log ($Log_{10}$ (x+1) transformed (Zar, 1999), while data on percentage weight loss of chips was arcsine transformed. The data on weight of the adults, weight of frass produced by the insects and developmental period (days) were also recorded.

All data obtained were subjected to Analysis of Variance (ANOVA) where significant differences were observed ($P<0.05$) means were separated using Least Significant Difference (LSD).

## RESULTS

### Functional and physico-chemical analysis

The result on the physico-chemical and mineral composition of the chips from the four varieties showed the highest fat content in Ame (0.55) with Adaka (0.37) showing the least. Water absorption capacity was highest in Adaka (1.70). Oil absorption capacity was relatively higher in Adaka (1.75) and the least in Nwopkoko (0.95), although it was higher in moisture content (15.32%) than any other substrate. The ash content was highest in Ame (1.05%), but least in Obiaturugo (0.55%). Sodium percent was highest in Adaka (0.58%) and least in Nwokpoko (0.23%). Nwokpoko was higher in Phosphorus (0.88%), Potassium (0.33%) and Nitrogen (0.77%) but, was least in Obiaturugo (0.83%), Ame (0.18%) and Adaka (0.28%) respectively (Table 1).

### Mean number of adults

Table 2 shows the mean numbers of adults, pupae, larvae and total progeny that developed on the four substrates of yam chips. There were no significant differences between the substrates ($P>0.05$). No adult, pupal or larval progeny developed on chips of Ame and Adaka.

### Mean developmental period of *P. truncatus*

The developmental period was 96.33 days in Obiturugo and 65.33 days in Nwokpoko, although the difference was not significant ($P>0.05$). However, there were significant differences ($P\leq0.05$) in % weight gain between Nwokpoko and the other three chips. There were also significant differences in the weight of frass produced in Obiaturugo and the other three chip substrate. The higher susceptibility index of 1.30 was recorded on Nwokpoko, while the least of 0 was recorded on Ame and Adaka (Table 3).

## DISCUSSION

The study shows that *P. truncatus* can survive and breed on Nwokpoko and Obiaturugo as shown by the number of adults, pupae and larvae that developed in them. This could be attributed to its low bulk density (Hodges et al., 1985; Dick, 1988; Chijindu, 2002; Chijindu et al., 2008; Danjuma et al., 2008; Isah et al., 2012), high moisture content (Obeng-Ofori and Boateng, 2008) and low dry matter and high phosphorous content. Isah et al. (2012) reported that *P. truncatus* can survive on yam chips, but contradicts the work of Hill (2002) who reported that *P. truncatus* can only breed on maize and dried cassava chips. The study also showed that it took *P. truncatus* two months to develop on Nwokpoko and three months on Obiaturugo, but failed to develop on Adaka and Ame. This may be attributed to the differences in their physico-chemical properties and mineral content. The development period of 96 days recorded in this study was more than the 36-37 days found by Chijundu et al. (2008) on cassava chips and also longer than the 40.5-41 days

**Table 1.** Physico-chemical and mineral composition of chips from four yam varieties.

| Physico-chemical/ mineral composition | Ame | Adaka | Nwokpoko | Obiaturugo |
|---|---|---|---|---|
| WAC | 1.30 | 1.70 | 1.30 | 1.60 |
| Swelling index | 1.20 | 1.20 | 1.20 | 1.10 |
| GT (°C) | 67.00 | 65.00 | 65.00 | 66.00 |
| Bulk density | 0.89 | 0.85 | 0.82 | 0.88 |
| MC (%) | 12.87 | 12.45 | 15.32 | 12.07 |
| Dry matter (%) | 87.70 | 87.80 | 84.70 | 87.10 |
| OAC | 1.15 | 1.75 | 0.95 | 1.25 |
| Fat (%) | 0.55 | 0.37 | 0.39 | 0.42 |
| Crude fibre (%) | 0.16 | 0.24 | 0.26 | 0.27 |
| Ash (%) | 1.05 | 0.75 | 0.85 | 0.55 |
| Na (%) | 0.40 | 0.58 | 0.23 | 0.40 |
| K (%) | 0.18 | 0.23 | 0.33 | 0.28 |
| P (%) | 1.10 | 0.88 | 1.55 | 0.83 |
| N (%) | 0.63 | 0.28 | 0.77 | 0.43 |

GT-Gelation temperature, WAC, water absorption capacity; OAC, oil absorption capacity; MC, moisture content.

**Table 2**. Mean number of adults and immature stages of *P. truncatus* on four yam chips substrate.

| Substrate | Number of adults | Number of pupae | Number of larvae | Total progeny |
|---|---|---|---|---|
| Ame | 0 (1.00)[a] | 0 (1.00)[a] | 0 (1.00)[a] | 0 (1.00)[a] |
| Adaka | 0 (1.00)[a] | 0 (1.00)[a] | 0 (1.00)[a] | 0 (1.00)[a] |
| Obiaturugo | 0.33 (1.14)[a] | 0.33 (1.14)[a] | 0.33 (1.14)[a] | 1 (1.14)[a] |
| Nwokpoko | 0.67 (1.24)[a] | 0.33 (1.14)[a] | 0.33 (1.14)[a] | 1.33 (1.47)[a] |

Means in the same column with the same letters are not significantly different (P≥0.05).

**Table 3.** Mean developmental period of *P. truncatus*, weight loss and frass produced on the different yam chips.

| Substrate | % Weight (g) | | Developmental period (days) | Weight of frass (g) | Susceptibility indices |
|---|---|---|---|---|---|
| | Loss | Gain | | | |
| Ame | - | 10.43 (4.33)[b] | 0.00 (1.00)[b] | 0.20 (0.02)[b] | 0.00 |
| Adaka | - | 10.37 (3.67)[b] | 0.00 (1.00)[b] | 0.17 (0.20)[b] | 0.00 |
| Obiaturugo | - | 10.43 (4.33)[b] | 96.33 (9.86)[a] | 0.80 (0.80)[a] | 0.61 |
| Nwokpoko | - | 10.73 (7.33)[a] | 65.33 (6.97)[a] | 0.30 (0.03)[b] | 1.30 |

Means in the same column with the same letters are not significantly different (P≥0.05)

on cocoyam chips found by Isah et al. (2012). The implication may be that dried yam chips especially those of Ame and Adaka may not be at risk of infestation by *P. truncatus*.

There was an overall weight gain in the chips substrate at the end of the study; this can be attributed to their moisture content, swelling index and the high humidity during the study. It could also be as a result of the hygroscopic nature of the yam, thereby absorbing from the atmosphere. This is in agreement with the work of Zakka et al. (2013) who attributed it to the functional properties of the yam chips. There was little frass produced on the substrate implying that these yam varieties are not particularly suitable hosts.

This study also shows that Nwokpoko and Obiaturugo are both slightly susceptible to *P. truncatus*. All the yam chips also absorbed moisture from the atmosphere. The implication of this is that *P. truncatus* can also infest dried

yam chips in addition to dried maize and cassava and that when stored they should be stored in air-tight containers to avoid spoilage. This has grave implication for yam stored as chips and thus food security in the country, since yam is a major staple food. Therefore, urgent steps should be taken in developing novel techniques to protect yam chips during storage from infestation by *P. truncatus*.

## Conflict of Interests

The author(s) have not declared any conflict of interests.

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