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Preliminary investigation on the damage assessment and control of *Bostrychoplites Cornutus* (Olivier, 1790) on dried cassava chips

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Abstract

Preliminary investigation on the damage assessment and control of *Bostrychoplites cornutus* (Oliver, 1790) (Coleoptera: Bostrichidae: Bostrichinae) was carried out after a preliminary market survey revealed it to be the most abundant and damaging of all the insect pests of dried cassava chips and tubers in Main market, Enugu, Enugu State, Nigeria. The result of the insect morphometrics showed that it has a body size of 8mm by 3mm with a horn-bearing prothoracic neck shield of 3mm in length and a body weight of 30mg. Using two processed cassava varieties, TMS 0581 and TME 419 of 10% and 8% moisture content respectively under an ambient mean temperature of 28.5 ºC and mean relative humidity of 78.5%, the biology of the bostrichid and its damage on the cassava varieties were studied. Within the 30 days of the study, no new larvae or adult emerged and the cassava varieties were moderately damage, with a visual scale damage of 7.0% and 7.2% respectively. In addition, the percentage frass recorded on the two cassava varieties were 2.3% and 3.3% respectively while the percentage weight losses were 3.6% and 4.8% respectively. Statistical analysis showed significant differences ($P< 0.05$, $P = 0.035$) between the varieties. The study on the susceptibility of the bostrichid using residual treatment of deltamethrin 12.5 EC showed that it is resistant to deltamethrin as up to 50% mean mortality was not obtained until 72 hours of exposure. The probit graph of the mortality showed the LD_{50} was 194.36*u*l/ml whiles the LT_{50} was 100 hours. From the study, it is suggested that the source of the bostrichid be traced; its life cycle re-studied and several pesticides tested against it to halt its invasion into the cassava production industry.

Keywords: Damage assessment, susceptibility, *Bostrychoplites cornutus,* Deltamethrin

Introduction

Cassava, *Manihot esculenta* (Crantz) constitute one of the most economically important and widely used food crops in sub-Saharan Africa [1]. It plays a major role in diets of the sub-region and contributes significantly towards efforts to alleviate food crises in Africa because of its efficient production of energy, its year-round availability, tolerance to extreme stress conditions and suitability to the peasant farming system on the continent [2]. [3] reported that over half of the world's cassava is produced in the humid and sub-humid tropics of sub-Saharan Africa. To a very great extent, the sustenance and constant availability of cassava are dependent on their storage after harvest. Thus, they can be sun-dried and stored to prolong their shelf-life and availability during the off-season [4, 5]. Processed cassava also serves as material for obtaining income and foreign earnings [6] [7]. In Nigeria for instance, the government policy of the use of 10% cassava flour in bread product saves the country about US$14.8 million per year in foreign exchange [8].

The conversion of cassava into chips followed by drying and storage for long periods until needed exposes it to attack by insect pests, thereby, threatening the food security of sub-Saharan Africa. This situation is worsened by the fact that there are no proper pest management methods defined for dried cassava chips and other tubers apart from farmers' method of regular inspection and re-drying in the sun. This lack of pest control measures probably is attributed to the low economic value attached to the dried chips [9]. Farmers are therefore handicapped and have since been conditioned to accepting the losses as inevitable.

Among the stored product insect pest of dried cassava are: *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae), *Aracerus fasciculatus* (Degeer) (Coleoptera: Anthribidae) and *Dinoderus* species (Coleoptera: Bostrichidae) [10]. However, the insect pests from the family Bostrichidae have continue to cause a lot of damage to stored products. Among the Bostrichids are the powder-post beetles.The term "powderpost" comes from the fact that the larvae of these beetles feed on wood and given enough time, can reduce it to a mass of fine powder. Because of this behavior, they are considered pests. Powder-post beetle larvae spend months or years inside wood while developing, feeding mainly on the starch content. Some hardwoods are naturally immune if they have low starch content or if their pore diameters are too small for the female beetle's ovipositor to lay her eggs in [11]. Their presence is only apparent when they emerge as adults, leaving behind pinhole-sized openings, often called "shot holes". They may also leave piles of powdery frass below. Shot holes normally range in diameter from 1⁄32 inch (0.79 mm) to 1⁄8 inch (3.2 mm), depending on the species of beetle [11]. If wood conditions are right, female beetles may lay their eggs and re-infest the wood, continuing the cycle for generations. Studies on their life history have rarely been made because the propensity of the Bostrichidae to burrows into sapwood made the task of studying their life cycle very difficult [12].

Bostrychoplites cornutus (Olivier), otherwise called false powder-post beetle is an ubiquitous scavenger and one of the common horned shot-hole borers riddling stored and sawed timber as well as structural wood, cassava and sweet potatoes. This pest was intercepted on rubber from Nigeria in Norfolk, VA by CBPA Edwards. They are common and wide-spread in the Afro-tropics. According to [13], they are found in parts of Africa and Arabia and are often imported to Europe as larvae in African wooden bowls. The adults are 6.5-17mm long, dark brown beetle with distinctive front thorax that carries two stout horns [13]. In West Africa, it reproduces in over 20 species of tress including teak [14]. The larvae attack furniture, poles and logs of a variety of trees including *Acacia, Albizia, Chlorophora, Commiphora, Podocarpus* and *Eucalyptus.*

However, extensive work and researches has been carried out on stored product bostrichids, particularly *P.truncatus* (larger grain borer) in the affected African countries. *P.truncatus* was accidentally introduced from Central America to Africa between 1970 and 1980 and since then has been identified as one of the major cause of direct and indirect losses in quantity and quality of agricultural stored produce like maize and cassava [15]. The devouring activities of *B. cornutus* was found to be similar to that of *P.truncatus* adults and larvae that cause a lot of damage to stored cassava by boring through them and producing a large amount of frass or dust on which the larvae feed.

There is dearth of information on the damage potential of *Bostrychoplites cornutus* especially in Nigeria which is African largest producer of cassava. Although these bostrichids are known to be primary pests of maize and cassava, they have been reported to occur in natural wooded habitats remote from maize and cassava cultivation [16]. Hence, they remain a major threat to food security and building industry in Nigeria. Therefor knowledge of their damage potential will be essential in decision-making process and for further study on this pest.

Materials and methodology

Preliminary Market Survey

Prior to this study, a preliminary market survey was conducted to identify bostrichids associated with stored cassava chips in Enugu main market, Enugu State, Nigeria. Previous reports showed that the major bostrichids reported on stored cassava are, *Rhyzopertha dominica* and *Prostephanus truncatus* with *P. truncatus* being the most damaging. However, in the course of this survey, another bostrichid, *Bostrychoplites cornutus* (Olivier) was identified. This therefore, necessitated the need to embark on this study. Hence, a laboratory investigation was carried out from February-September, 2014 on the damage potential of this most abundant bostrichid identified in the market survey.

Samples of dried cassava tubers were collected from different stores and warehouses in the market. The estimated damage and frass generated by these insects are presented in plates 1 and 2 respectively.

Plate 1: Damaged Cassava tubers by *Bostrychoplites cornutus*

Plate 2: Frass produced by *B. cornutus*

Laboratory assessment

Study Area

This study was conducted in the Research Laboratory of the Department of Parasitology and Entomology, located 06º15' 11.2N to 0706'53.3E of the Faculty of Biosciences, Nnamdi Azikiwe University (6º14'N, 6º14.5'N to 7º8.6'E, 7º9E), Awka (6º25'N, 7º12'E), Anambra State, Nigeria.

Collection and culturing of the bostrichid

The initial cultures of the adult of *B. cornutus* were acquired from market infested cassava from Enugu main market. These strains of the insects were reared on cassava variety from the same market. One thousand grammes of cassava containing both the adult (plate 3) and the larvae (plate 4) of the insects were measured into one litre capacity kilner jars of transparent plastic buckets, after which, the top end of the plastic buckets were covered with muslin cloth and secured firmly with rubber bands to allow for ventilation and free air circulation. The culture was allowed to stand under ambient conditions for three month. From the culture, adults of the bostrichids were used for the study.

Plate 3: Lateral view of *Bostrychoplites cornutus* collected from the market

Plate 4: *Bostrychoplites cornutus* larva collected from the market

Morphometrics of *Bostrychoplites cornutus*

The body size (length and width) of ten adult *B.cornutus* was taken using the metre rule (plates 5 and 6) while the body weight was taken using an electronic mettler balance. *B.cornutus* was identified using identification key by [17, 11].

Plate 5: Measurement of the body length of *B.cornutus*

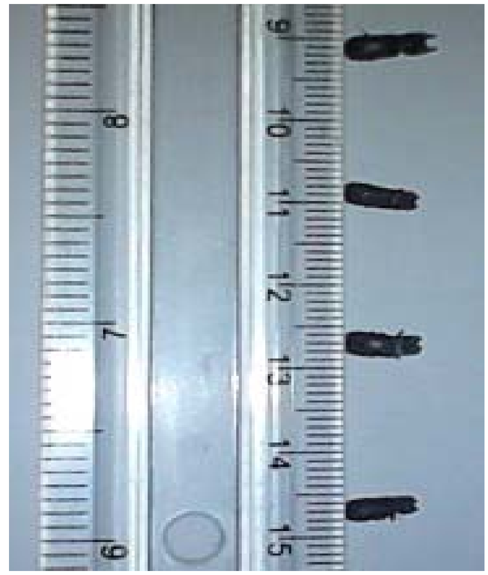

Plate 6: Measurement of the body width *B.cornutus*

Source of experimental crop

Two different cassava varieties, namely; TMS 0581 and TME 419 were used in the study. They were collected from Anambra State Agricultural Development Programme (ADP), Awka and were also identified there.

Processing of cassava

Fresh cassava tubers of each cultivar were peeled immediately after harvest. They were chopped up manually into rectangular chips approximately 5cm by 5cm by 1cm. The cut chips were spread on wire gauze of 3mm width at a loading rate of $5kgm^{-2}$. The chips were allowed to stand for 24 hours under the sun. Subsequently, they were pre-heated in an oven at 50 ºC for 24 hours to kill any existing infestation during sun drying. Later, the same samples were conditioned in a room with ambient mean temperature of 28.5 ºC and humidity of 78.5% r.h before they were used.

Determination of moisture of content the dried cassava

The moisture content of the initial un-infested samples was determined by oven method as described by [18]. Ten grams weight of cassava chips each of the processed cultivar were weighed into crucible and the weight of the samples taken as (W_1). The weight of the samples and the crucibles was taken (W_2). They were exposed in the oven for two hours at 130ºC and allowed to cool before final weights of the sample and the crucibles (W_3) were taken. The percentage moisture content of the samples was obtained using the formula;

$$\% \text{ moisture content} = \frac{(W_2 - W_3)}{W_1} \times \frac{100}{1}$$

Artificial infestation of cassava chips by *B. cornutus* to determine its susceptibility

This test was conducted at ambient mean temperature of 28.5 ºC and mean relative humidity of 78.5% in the laboratory. One hundred grams of each processed cassava cultivars were weighed into glass jars. Ten, 1 – 4 weeks old adult of *B.cornutus* were introduced into each jar, which was then covered with heavy-duty wire gauze. Each treatment was replicated four times and then allowed to stand for 1 month. The numbers of adult insects at the end of each trial were recorded. Control treatments were provided for each processed form to monitor changes due to fluctuations in the environmental conditions over storage duration. A thermo-hygrometer was mounted throughout the experiment to record temperature and relative humidity. Loss assessment was based on the percentage weight loss, percentage frass produced by the bostrichid and visual scale damage assessment.

Data collection

Determination of percentage weight loss of dried cassava chips

The initial weight of the samples before infestation was noted and was denoted as T, the weight (wt) of undamaged samples was also noted and denoted as A and that of damaged was also noted and denoted as B. Then, the percentage weight loss was measured as described by [19].

Percentage weight loss =

$$\frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times \frac{100}{1} = \frac{T - (A+B)}{T} \times \frac{100}{1}$$

Determination of percentage frass produced in the dried cassava chips by the bostrichid

This was done by determining the weight of the samples, and then using a sieve of 3.00mm mesh size to sieve out the frass [20]. The weight was taken using a weighing balance. Estimated percentage frass was determined using the formula;

$$\text{Percentage frass} = \frac{WF}{W_1} \times \frac{100}{1}$$

Where WF = weight of frass

WT = Total weight of the samples

Damage assessment by a visual scale

A visual scale loss assessment was used to categorize the chips according to their level of damage [21] and the class is as follows:

Class 1 = No damage
Class 2 = Light damage
Class 3 = Medium damage
Class 4 = Medium-high damage
Class 5 = Severe damage

Toxicity study to determine lethal dose

Serial dilution of deltamethrin

The pyrethroid insecticide used was Deltamethrin 12.5EC with active ingredient of 12.5g/l. It was serially diluted with acetone to give the following concentrations of 400, 200, 100, and 50µg/ml and a control using acetone only.

Bioassay using contact application

The method and standard followed was adopted from [22]. No 1 Whatman filter papers measuring 9cm in diameter were placed in each of the petri-dishes used for the experiment. The various concentration levels of the insecticide preparation described above were used and each replicated four times. 2ml aliquots of each was evenly dispensed onto the filter paper and was left for about an hour to ensure proper spreading of the toxicants and for the acetone solvent to evaporate. Subsequently, five unsexed adults picked with an aspirator were introduced into each petri-dish. Each of the petri-dishes was covered with its lid to avoid escape of the insects. Daily mortality counts were taken for 3 days (72 hours).

Data analysis

The data collected on insect damage and weight losses were analyzed statistically using simple factorial ANOVA model in SPSS version 17 for window statistical package. Treatments with significant differences were compared and separated at 0.05% level of significance using Student-Newman-Keuls (SNK) test. Least significant difference (LSD) was used to separate differences between mean values. Mortality values collected were subjected to log-probit regression analysis [23] for determination of LD_{50}.

Results

Determination of the Morphometrics of *Bostrichoplites cornutus.*

The morphometrical analysis of *B. cornutus* shows that it is a bostrichid of about 8mm by 3mm in body size with a horn-bearing prothoracic neck shield measuring about 3mm in length while its body weight is 30mg. Table 1 shows the various morphometrical parameters of the bostrichid and their mean values.

Table 1: The morphormetrics of *B. cornutus*

Parameter	Mean value (±s.e)
Body length	8.0 ± 0.4 (mm)
Body width	2.0 ± 0.1 (mm)
Prothoracic neck shield	3.0 ± 0.1 (mm)
Body Weight	30.0 ± 0.8 (mg)

Loss and damage assessment of the two processed cassava varieties infested with *B. cornutus*

The result of the loss and damage assessment of the cassava varieties by the infestation of *B. Cornutus* shows that more loss and damage were recorded in TME 419 than TMS 0581 both in their percentage weight losses and in the amount of frass produced in them by the bostrichids, *B. Cornutus* (Table 2). Also, statistical analysis using t-test ($\alpha = 0.05$) shows that significant difference ($P < 0.05$) exist in their percentage weight losses with ($P = 0.035$) and also in the percentage of frass produced with ($P = 0.003$) in the two cassava varieties infested by *B. cornutus*. However, the two varieties were of medium damage using visual scale damage assessment as the number of holes produced in the two cassava varieties by *B. cornutus* were relatively the same.

Table 2: Loss and damage assessment of the two cassava varieties infested with *B. cornutus*.

Cassava Varieties	% M.C	Mean % Frass	Mean % weight loss	% Visual Damage
TMS 0581	10	2.3 ± 0.2	3.6 ± 0.3	7.0
TME 419	8	3.3 ± 0.1	4.8 ± 0.4	7.2

Means of four replicates (± s.e)

Contact Toxicity

The result of the residual treatment with different concentrations of deltamethrin over a period of 72 hours (Table 3) shows that at concentrations of 100*u*g/ml and 50*u*g/ml, the percentage mortality of the insect was 6% respectively while at the concentration of 200*u*g/ml the percentage mortality was 43%. Mortality also increased as exposure time increased with 37% mortality recorded after 72 hours of exposure. The LD_{50} and LT_{50} were respectively 194.36μg/ml and 100 hours (Figures 1 and 2).

Table 3: The percentage mortality effects of different concentrations of deltamethrin on *B. cornutus* after 72 hours of exposure

Concentrations (μg/ml)	LogDose	Exposure Time 24 48 72			Mean Mortality		Probit	% Mortality
400	2.6021	2.7	7.1	9.2		**6.3±1.9**	6.4051	**92.0**
200	2.3010	0.7	2.8	4.3		**2.6±1.0**	4.8236	**43.0**
100	2.0000	0.0	0.6	0.6		**0.4±0.2**	3.4452	**6.0**
50	1.6990	0.0	0.0	0.6		**0.2±0.2**	3.4452	**6.0**
Total mortality		3.4	10.5	14.7				
Mean ± s.e. **% mortality** **Probit**		**0.9±0.6** 9.0 3.6592	**2.6±1.6** 26 4.3567	**3.7±2.0** 37 4.6681				
Control		0	0	0				

Means of four replicates (± s.e), LSD for concentration=3.100

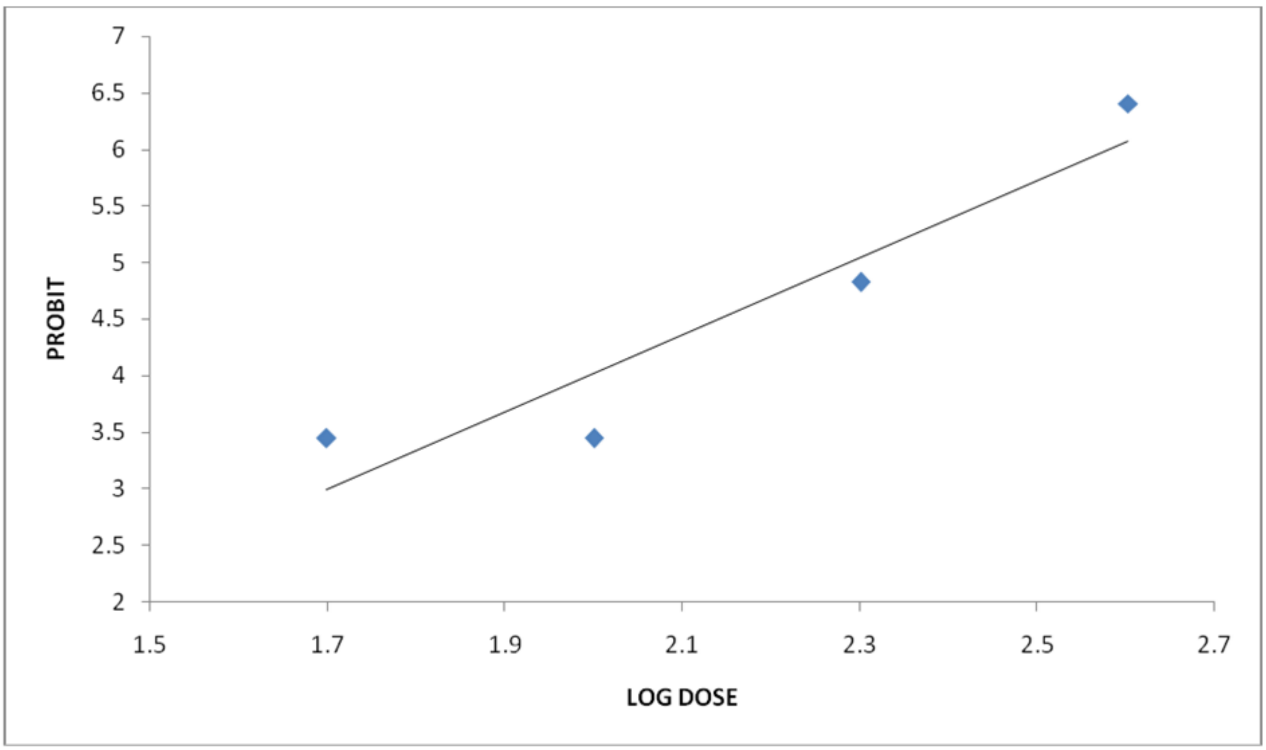

Fig 1: Probit/Log dose graph of the mortality of *B. cornutus* with residual treatment of deltamethrin.

The regression equation is 3.4077logdose – 2.7987

$R^2 = 0.8835$

Y = a +bx; where a = -2.7983, b = 3.4077

LD_{50}, that is when Y = 5

5 = -2.7987 + 3.4077x

x = 2.2886 Antilog (2.2886)

LD_{50} = 194.36 μg/ml

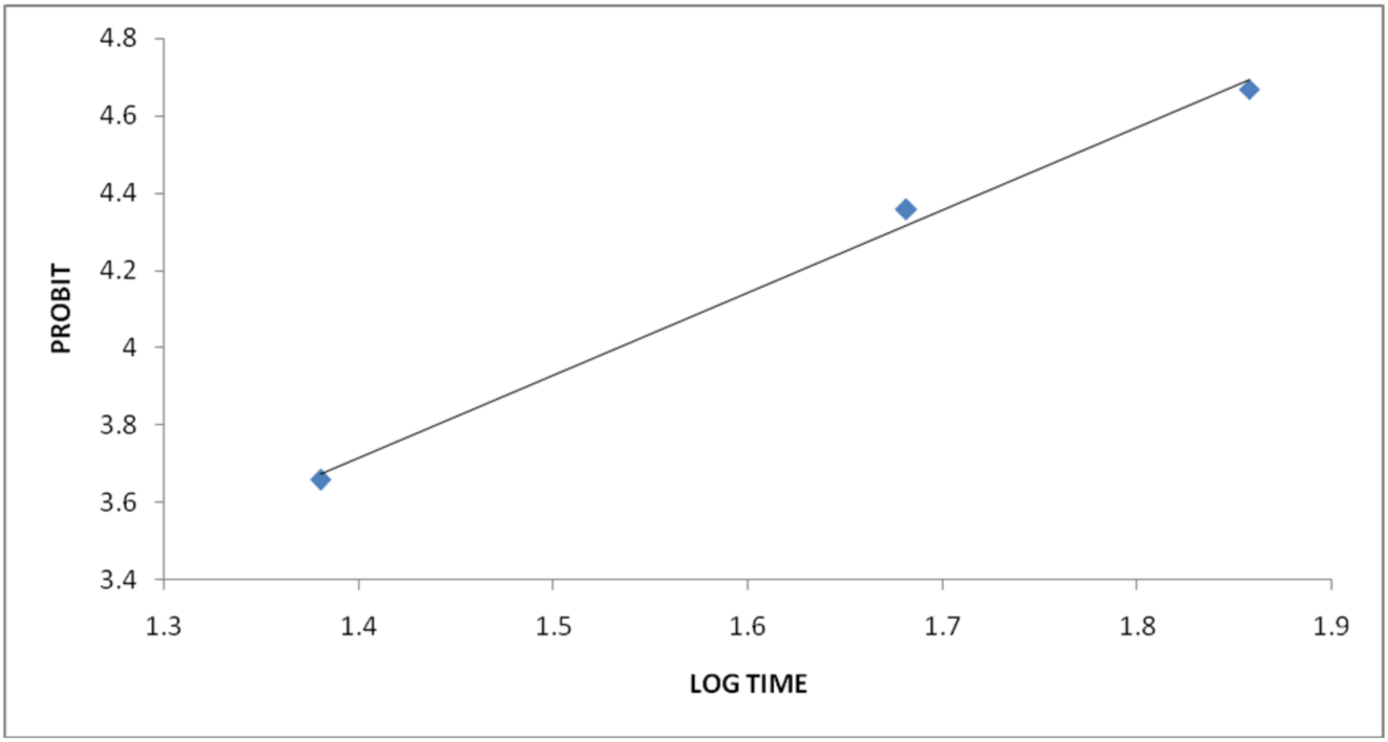

Fig 2: Probit/Log time graph of the mortality of *B. cornutus* with residual treatment of deltamethrin

The regression equation = 2.1365logtime + 0.7251
$R^2 = 0.9955$
Y = a + bx; where a = o.7251,b = 2.1365
LT_{50}, that is when Y = 5
5 = 0.7251 + 2.1365x
X = 2.0001 Antilog (2.00)
LT_{50} = 100 hours

Discussion

The study on the damage assessment and control of *Bostrychoplites cornutus* was carried out under laboratory condition following its observed abundance in a preliminary market survey of dried cassava chips sold in Main Market Enugu, Enugu State. Earlier market surveys by [24] and [25] reported *P. truncatus* as the major and most abundant pest of dried cassava chips in Anambra and Enugu States of Nigeria. In their study, they observed large coma shaped grubs of an unidentified coleopterous insect having characteristics of the family Bostrichidae which according to [24] caused enormous damage than *P. truncatus*. In the present study, this grub from the stock supply of dried cassava chips was identified as the larva of *B. Cornutus* while the preliminary market survey indicated *B. Cornutus* to be the most abundant and the most damaging of all the insect pests observed in the dried cassava collected from this market.

According to [26], insect pests feeding directly on cassava chips and other stored produce cause damage and weight loss to the produce and the result of this study confirms that. Using two improved varieties of cassava, TMS 0581 and TME 419, the result of this study showed that the percentage weight loss and the amount of frass produce in variety TME 419 was higher and significantly different ($P < 0.05$) from that of TMS 0581. This could be due to their differences in nutrient composition as [27] in their study with *P. truncatus* found out that the nutritional compositions (particularly that of starch and fiber) positively correlate with their percentage weight losses and the amount of frass produced in them by *P. truncatus*. Alternatively, this could be due to the difference in their percentage moisture content as [28] observed that moisture content of 10.6% heavily increased the susceptibility of maize to *P. truncatus* while [29] noted that *Lyctus brunneus* (a wood boring bostrichid) would not attack wood of less than 10% moisture content. From the result of the present study, TME 419 variety with lower moisture content of 8% was damaged more than TMS 0581variety of 10% moisture content. This suggests that the suitable percentage moisture content for the infestation of a cassava variety by *B. cornutus* could be within the range of 8-12%.

The result of the morphometrics of *B. cornutus* shows its average size to be 8mm by 3mm with a horn-bearing prothoracic neck shield of about 3mm which covers the head while its body weight is 30mg. These findings agree with the pictorial description of [30]. When this value on the body size is compared with the body size of other stored produce bostrichids such as *P. truncatus* whose body weight is about 4mm and *R. Dominica* about 3mm, *B. cornutus* was found to be larger in size and have heavier body weight. Hence, it can cause more devastating damage not only because of its body size and weight but also due to its horns which have sharp ends. This could be seen by the large holes it makes on dried cassava chips.

Though only few and scattered literature exist on *B. cornutus* where either the larvae or adult were just reported as xylophagous intercepted species [31], [32] and [33], the result of the study on its damage assessment within 30 days showed that the larvae and adult could not emerge within this period. Previous Studies on other xylophagous relatives such as *Heterobostrychus aequalis* and *Amphicerus anobioides,* [29] recorded that the length of development of *H. Aequalis* from egg to adult is variable from one to several years while that of *A. anobiodes* is from one to three years. Thus, the result of this study suggests that the life cycle of *B. cornutus* may probably exceeds 30 days.

The result of the contact toxicity of *B. cornutus* to deltamethrin showed that mortality increased as concentrations increased. This report agrees with the findings of [22] on *P. truncatus*. Mortality also increased with increase in the exposure time. Results obtained in the present study demonstrate the importance of timing of application of insecticides. According to [34] nearly all storage insects are more active in the dark than in the light. In the present study, higher mortalities of *B. cornutus* occurred at the last 72 hours of exposure. Timing of spray application is important in any pest management operations. According to [35], few applications of pesticides may be needed if they are timed more accurately and this will reduce selection pressure for resistance. However, after 72 hours of exposure, the insecticide could not kill 50% of *B. cornutus*. On the contrary, [22] reported that after 12 hours of exposure, up to 50% of *P. truncatus* was killed using deltamethrin insecticide. It may therefore be possible that low toxic effect of deltamethrin could be due to inherent resistant gene in *B. cornutus* against deltamethrin as [36] working with *Cydia pomonella* (codling moth), [37] working with *Ryzopertha dominica* and [38] working with *Cimex lectularis* (bedbug) observed resistance to deltamethrin in these insects.

The lowest mortality occurred on the first 24 hours, this contradicting [39] on the quick knock down effects of pyrethriods of which deltamethrin is among. Also differences in toxicity according to [39] are determined by the rate of cuticular penetration, solubility in haemolymph and the polarity of the compounds as polar compounds penetrate faster than less polar compounds [40]. Reported that toxicity of insecticides depends on the route of transport to the nervous system, the distance to the target and the permeability of the insect nerve sheath, which is more permeable to highly lipo-soluble compounds. Therefore the route of application in the present study which was contact toxicity may explain the differences obtain in this study and that of previous authors.

Conclusion

The study on the damage assessment and control of *Bostrychoplites cornutus* (Olivier) a bostrichid identified in a preliminary market survey shows that the bostrichid is becoming an invasive and deltamethrin-resistant insect pest of dried cassava chips with more abundance and severe damage than *Prostephanus truncatus.* Consequently, it is important to trace the source and the origin of this invasive species and further studies carried out on its biology. It is also suggested that several control strategies be tested against it to determine the most effective. This would help to put the pest in check before it becomes a cosmopolitan pest of cassava. This would be necessary particularly now that the federal government of Nigeria has promoted large scale production and exportation of cassava products and also the incorporation of 10% of cassava flour in bakery and mill industry. Finally, there is need for the development of alternatives to synthetic pesticides for the control of insect pests of dried cassava and different processing methods that could confer resistance to dried cassava against storage pests.

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