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EVALUATION OF INFESTATION AND DAMAGE BY THE LARGER GRAIN BORER (*PROSTEPHANUS TRUNCATUS*) (HORN) (COLEOPTERA: BOSTRICHIDAE) ON SELECTED FOOD GRAIN CROPS.

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ABSTRACT

The study evaluated the ability of the larger grain borer (LGB), *Prostephanus truncatus (*Horn) to infest and damage two varieties of sorghum (*Sorghum bicolour*), Sesame (*Sesamum indicum*) Cowpea (*Vigna unguiculata*) and maize (*Zea mays*). 100 g each of the grain products were infested with 5 pairs (5 males and 5 females) of 1-10 day old LGB for 90 days. At 90 days post-infestation of the crops, the insects and grain dust generated by the feeding activities of the insects were sieved out of the grains; the grains were separated into damaged and undamaged and data were taken on number of adult *P. truncatus*, number of larvae and pupae, number of larvae and pupae, number of adult mortality, weight of dust (g), weight of damaged grains (g), weight of undamaged grains (g) and final weight of grains (g). The results showed that all the 5 pairs of adult LGB introduced into the cowpea and sesame varieties died. Likewise, neither larvae nor pupae were found in the two grain products. The highest mean number of larvae and pupae (18.5) was recorded in the Suwan-1 maize variety, and it was significantly (P < 0.05) higher than the mean number found in the other grain products studied. The mean number of larvae (7.25) in Solo maize variety was significantly (P < 0.05) higher than the mean larvae number of 4.25 and 2.50 in Eyinfun and Ex- Minna sorghum varieties respectively. Significantly (P < 0.05) higher percentage grain damage (49.76) and percentage weight loss (12.89) were recorded in the Solo maize variety compared to percentage grain damage and percentage weight loss in other grain products. Likewise, the grain damage (23.06 %) and weight loss (8.04 %) in the Ex-Minna sorghum variety were significantly < 0.05) higher than percentage grain damage and percentage weight loss obtained in other grain products except Solo maize. A significantly (P < 0.05) lower grain damage (1.35 %) and grain weight loss (1.43 %) were obtained in the NICRIBEN and E8 sesame varieties respectively. The result of this study indicates the ability of LGB to bore and damage sorghum, maize, sesame and cowpea; with breeding restricted only to maize and sorghum. There were varietal differences in response of the grain products to LGB infestation and damage. Considering the importance of sorghum, maize, sesame and cowpea as a cheap source of carbohydrate and protein; concerted effort should be geared at controlling infestation of the grain products by LGB.

Keywords: Grain products, *Prostephanus truncatus,* larvae, pupae, infestation, feeding ratio.

INTRODUCTION

The larger grain borer (LGB) (*Prostephanus truncatus*) (Horn) (Coleoptera: Bostrichidae) belongs to the family of insects called the Bostrichidae, most of which are wood boring beetles. LGB is another exotic storage pest native to Mexico, but has now been introduced to Africa, where it is currently a more destructive pest of stored maize and cassava than in its native Central America (McFarlane, 1988; Pike *et al*., 1992). LGB is a storage pest which is among the major pests responsible for serious losses of maize worldwide. Its damage results directly in reduction of yield, and may also reduce future maize production for farmers who use stored grain as seed in the tropics (Pingali and Pandey, 2001). The insect is currently the most damaging post-harvest pest of maize causing substantial losses and aggravating hunger and poverty (Nwokolo *et al.,* 2010). Adults bore into the maize cob causing severe damage and weight loss. In Tanzania, maize losses of up to 35 % may occur due to *P. truncatus* in 5 -6 months if improperly stored (Mallya, 1992), and up to 60 % after nine months of storage (Keil, 1988); a situation that may result in a serious famine.

Howard (1983) reported a reasonable correlation between the maize growing regions and the occurrence of the pest. *P. truncatus* was recorded in a list of stored products insects of Thailand. However, in 1981, larger grain borer was identified as a new pest causing severe losses to farm-stored maize in the hot dry Tabora region of Tanzania. It subsequently spread widely within Tanzania and into southern Kenya, Burundi and Malawi (Kega and Warui, 1983). In West Africa, a serious outbreak of the pest was found in 1984 in Togo. The insect has now been identified in Ghana, Benin, Guinea, Burkina Faso and Nigeria (Kalivogue and Muck, 1990; Pike *et al.,* 1992; Osipitan *et al.*, 2007). *P. truncatus* was believed to have the potential of spreading to all the major maize-producing regions in Africa.

LGB is highly voracious and destructive. It is a primary pest of farm stored maize and could attack whole grains on the cob before and after harvest (GASGA, 1993). The insect also infests and damages dried cassava tubers (Hodges *et al.*, 1995). The adult beetle and its larval stage can damage a wide range of commodities including some cereals, pulses and wooden structures (Booth *et al.*, 1990). The insect was also reported to attack wooden structures, ornamental articles and chickpeas in laboratory cultures (Booth *et al*., 1990). Osipitan *et al.* (2008) reported the ability of LGB to infest and damage root and tuber crops such as cassava (*Manihot esculenta*), white yam (*Dioscorea esculentum*), water yam (*D. alata*) and sweet potato (*Ipomea batatas*). Hodges *et al.* (1983) reported the ability of the insect to penetrate materials in which there is no evidence of breeding such as wood, perspex and polythene. LGB is capable of causing weight losses of between 34 - 40 % in infested maize after 3 - 4 months of storage (Giles and Leon, 1975). The ability of the insect to develop in grain at low moisture content may be one reason for its success; under such conditions, many other storage pests are unable to increase in number (Birch, 1945). Thus, in dry conditions, *P. truncatus* probably benefits from the absence of any significant competition from other storage pests. Giles and Leon (1975) reported weight losses up to 40 % in maize in Nicaragua. Likewise, Hodges *et al.* (1983) reported weight loss of 34 % in stored maize in Tanzania. Hodges *et al*. (1983) reported that the most obvious cause of loss is the conversion of maize grains into maize flour by adult boring. The composition of maize has been reported to change as a result of *P. truncatus* infestation (Adem and Bourges, 1981; Torrenblanca *et al*., 1983). Maize kernels inoculated with 60 adults per kilogram, maintained at 27°C and 60 % relative humidity, suffered 21.9 % weight loss after 90 days. Proximate analysis of the maize kernels showed apparent declines in the concentration of the amino acids, lysine and tryptophan and reduction in the ether extract and ash component by 20.68 % and 28.38 % respectively (Torrenblanca *et al*., 1983). Larval infestation is apparently responsible for the greatest changes (Adem and Bourges, 1981).

Grains such as Maize (*Zea mays*), sesame (*Sesamum indicum*), sorghum (*Sorghum bicolour*) and cowpea (*Vigna unguiculata*) are sources of sustenance in many part of sub-Saharan Africa. The commodities play significant roles in the food requirements of many households in developing countries by serving as source of protein, carbohydrates, vitamins, minerals, fat etc. They are also used as raw materials in the industries. Maize for instance is a staple food for an estimated 50 % of the human population in sub-Saharan Africa, and is industrially used to produce oil, starch, syrup, dextrose and plastics (CGIAR, 1996). The ability of LGB to bore into solid substrate irrespective of their nutritional quality and develop in grains at low moisture content suggests the ability of the insect to damage wide variety of food items. Since food grain crops such as Maize (*Zea mays*), sesame (*Sesamum indicum*), sorghum (*Sorghum bicolour*) and cowpea (*Vigna unguiculata*) play significant roles in the food requirements of many households and serves as sources of sustenance in many part of sub-Saharan Africa. This study evaluated the ability of LGB to infest and damage maize (*Z. mays*), sesame (*S. indicum*), sorghum (*S. bicolor*), and cowpea (*V. unguiculata*).

MATERIALS AND METHOD

Experimental site / Insect culture

This study was conducted in 2010 at the Entomological Research Laboratory, Department of Crop Protection, College of Plant Science and Crop Production, Federal University of Agriculture, Abeokuta (FUNAAB) in Nigeria. The larger grain borer, *P. truncatus* used for the study was cultured in shelled maize grains in 500 cm^3 capacity Kilner glass jars. Several LGB adults of mixed sexes and unknown ages were introduced into the culture media. Frass generated by feeding activities of the insects was sieved out on weekly basis using sieve of mesh size 0.25 mm to prevent excessive grain moisture content and growth of mould. Culture media were rejuvenated monthly to replace depleted ones, and adults were sieved out to set up new culture to guarantee regular source of insect.

Experimental procedure

Two varieties of maize (*Zea mays*), sorghum (*Sorghum bicolour*), sesame (*Sesamum indicum*) and cowpea (*Vigna unguiculata*) were used for the study. The varieties and characteristics of the grains evaluated are shown in Table 1. The grains were disinfested in the deep freezer at temperature of -20°C for 48 hours to get rid of any insect or pathogen and were allowed to acclimatize for 48 hours before use.

100 g each of the grains (maize, sesame, sorghum and cowpea) were weighed into 250 cm^3 jars using Mettler weighing balance (Mettler Toledo, P1210). They were separately infested with 10 pairs (5 males and 5 females) pairs of 1-10 day old LGB for 90 days. Insects were sexed using the method of Shires and McCarthy (1976). Each treatment was replicated four times and arranged on work table in the laboratory using complete randomized design (CRD).

Table1. Grain crops evaluated for infestation and damage by *Prostephanus truncates*

S/N	Crops	Botanical Names	Variety	Colour	Type
1.	Maize	*Zea mays*	SUWAN-1 SOLO	Yellow Yellow	Dent, Improved Flint, Local
2.	Sesame	*Sesamum indicum*	E8 NICRIBEN	White White	Early Maturing Late Maturing
3.	Sorghum	*Sorghum bicolor*	EYINFUN EX-MINNA	White Red	Medium maturing Medium maturing
4.	Cowpea	*Vigna unguiculata*	OLOYIN PEU	Brown Brown	Local Local

One hundred grams each of the treatment were weighed into 250 cm^3 Kilner jars to monitor change in weight of grains as a result of moisture loss or gain (Hurlock, 1967). At 90 day post-infestation of the grain; the grains, insects and grain dust generated by the feeding activities of the insects were poured into a plastic sieved of 0.25 mm mesh size that separated the grains from the insects and grain dust. The grain dust was sieved from the lots of insects and grain dusts with sieve of 500 um mesh size. The grains were separated into damaged and undamaged. A grain with a hole was considered as damaged. The following data were Number of adult *P. truncatus*

i. Number of larvae and pupae
ii. Number of adult mortality
iii. Weight of dust (gm)
iv. Weight of damaged and undamaged grains
v. Final weight of grains

Insects that did not move or respond to three blunt probes were considered dead (Obeng- Ofori *et al.,* 1997).

Percentage grain weight loss (GWL) and percentage grain damage (GD) respectively were calculated using the formulae of Baba Tierto (1994).
Where;

$$\% GWL = \frac{WCS - FWG}{WCS} \times 100$$

GWL = Grain weight loss,
WCS = Weight of control sample,
FWG = Final weight of grains

$$\% GD = \frac{WDG \times 100}{WDU}$$

where;

GD = Grain damaged,
WDG = Weight of damaged grains
WDUG = Weight of damaged and undamaged grains

Feeding ratio (Fr) was calculated using the formulae:

$$Fr = \frac{1 - FW}{100}$$

FW = Final grain weight

Statistical analysis

Statistical analysis of data generated was based on SAS's general linear models procedure (SAS Institute, 2001). The data were subjected to Analysis of Variance (ANOVA). Significant means were compared using Student's Newman-Keuls Test (SNK) at P < 0.05.

RESULTS

Number of Prostephanus truncatus in grains studied

The number of *P. truncatus* in the commodities is shown in Table 2. A significantly (P < 0.05) higher number (37.5) of living adult of LGB was observed in the Solo maize variety relative to other grain products (Table 2). No living adult LGB was found in the Oloyin and Peu cowpea varieties and in Sesame E8 and NICRIBEN varieties. The highest mean number of larvae and pupae (18.5) was recorded in the Suwan-1 maize variety, and it was significantly (P < 0.05) higher than the number in the other grain crops. The lowest mean number of larvae and pupae (2.5) was recorded in the Ex-Minna sorghum variety, and it was significantly (P < 0.05) lower than the number in the other grains. Neither larvae nor pupae were found in Oloyin and Peu cowpea varieties and in Sesame E8 and NICRIBEN varieties. The lowest mean number of adult mortality (6.75) was recorded in the Solo maize variety, followed by 7.25 recorded in Eyinfun sorghum variety; the mean number of adult mortalities were however, not significantly (P > 0.05) different from each other.

Percentage *grain damage and percentage grain weight loss in the grains.*

The highest grain damage (49.76 %) was recorded in the Solo maize variety and it was significantly (P < 0.05) higher than the percentage grain damage in the other grains products (Table 3). Ex-Minna Sorghum variety had significantly (P < 0.05) higher percentage grain damage (23.06 %) than percentage grain damage in other grains except Suwan-1 maize variety. A significantly (P < 0.05) lower percentage grain damage (1.35 %) was recorded in NICRIBEN sesame variety.

Likewise, the highest percentage grain weight loss (12.89 %) recorded in the Solo maize variety was significantly (P < 0.05) higher than for Ex-Minna sorghum variety (8.03), which was also higher than Suwan-1 maize variety (5.90). A significantly (P < 0.05) lowest percentage grain weight loss (0.64 %) was recorded in Oloyin compared to other grains.

Table 4 shows the weights of powder generated from the grains as a result of LGB feeding activities and its feeding ratios. The highest quantity of grain powder (8.9 g) was recorded in the Solo maize variety and it was significantly (P < 0.05) higher than grain powder in other grains studied. The lowest quantity of grain powder (0.19 g) was from Oloyin cowpea variety and it was not significantly (P > 0.05) lower than grain powder from the Peu cowpea variety (0.23 g) and NICRIBEN sesame variety (0.34 g).

Table 2. Number of *Prostephanus truncatus* in infested grain crops.

Crops	Botanical names	Variety	No. of living LGB adult	No. of dead LGB adult	No. of larvae and pupae
Sorghum	*Sorghum bicolor*	EYINFUN	2.75±0.25^{c}	7.25±0.25^{bc}	4.25±0.48^{c}
		EX-MINNA	1.50±0.29^{d}	8.50±0.29^{ab}	2.50±0.65^{d}
Maize	*Zea mays*	SUWAN-1	9.25±0.48^{b}	9.50±1.1 9^{a}	18.50±0.5^{a}
		SOLO	37.50±1.04^{a}	6.75±0.48^{c}	7.25±0.25^{b}
Cowpea	*Vigna unguiculata*	OLOYIN PEU	0.00±0.00^{d}	10.00±0.00^{a}	0.00±0.00^{e}
			0.00±0.00^{d}	10.00±0.00^{a}	0.00±0.00^{e}
Sesame	*Sesamum indicum*	E8	0.00±0.00^{d}	10.00±0.00^{a}	0.00±0.00^{e}
		NICRIBEN	0.00±0.00^{d}	10.00±0.00^{a}	0.00±0.00^{e}

Means followed by the same letter along the column are not significantly different ($P < 0.05$) according to Student-Newman- Keuls Test.

Table 3. Percentage Grain damage and percentage Grain weight loss in infested grain crops.

Crops	Botanical names	Variety	Grain damage %	Grain weight loss %
Sorghum	*Sorghum bicolor*	EYINFUN	3.17±0.23^{f}	3.42±0.06^{d}
		EX-MINNA	23.06±0.29^{b}	8.04± 0.14^{b}
Maize	*Zea mays*	SUWAN-1	10.83±0.29 ^{c}	5.90±0.10^{c}
		SOLO	49.76±0.52^{a}	12.89±0.07^{a}
Cowpea	*Vigna unguiculata*	OLOYIN	2.98±0.22^{f}	0.64±0.14^{g}
		PEU	8.27±0.10^{d}	2.57±0.20^{e}
Sesame	*Sesamum indicum*	E8	4.01±0.05^{e}	1.43±0.21^{f}
		NICRIBEN	1.35±0.13^{g}	1.67± 0.21^{f}

Means followed by the same letter along the column are not significantly different ($P < 0.05$) according to Student-Newman- Keuls Test.

The feeding ratios of LGB on the grain products as shown in Table 4 were significantly (P < 0.05) different from each other except in Oloyin cowpea variety and E8 sesame variety. The highest feeding ratio (0.977) of the insect was obtained for Solo maize variety and was not significantly (P > 0.05) higher than the feeding ratios in Suwan-1, Eyinfun and Ex-Minna-infested grains. The feeding ratio of 0.630 in sesame E8 varieties was the lowest, but was not significantly (P > 0.05) lower than the feeding ratios of 0.650, 0.660 and 0.680 in sesame NICRIBEN variety, Peu and Oloyin cowpea varieties respectively.

Table 4. Weight of dust and feeding ratio of LGB in infested grain crops

Crops (FR)	Botanical names	Variety	Weight of dust (g)	Feeding Ratio
Sorghum	*Sorghum bicolor*	EYINFUN	2.33 ± 0.22^{c}	0.957 ± 0.00^{a}
		EX-MINNA	4.61 ± 0.41^{b}	0.960 ± 0.00^{a}
Maize	*Zea mays*	SUWAN-1	4.15 ± 0.09^{b}	0.970 ± 0.00^{a}
		SOLO	8.73 ± 0.18^{a}	0.977 ± 0.00^{a}
Cowpea	*Vigna unguiculata*	OLOYIN	0.19 ± 0.01^{e}	0.680 ± 0.00^{b}
		PEU	0.23 ± 0.07^{e}	0.660 ± 0.00^{b}
Sesame	*Sesamum indicum*	E8	1.71 ± 0.15^{d}	0.630 ± 0.00^{b}
		NICRIBEN	0.34 ± 0.02^{e}	0.650 ± 0.00^{b}

Means followed by the same letter along the column are not significantly different (P < 0.05) according to Student-Newman- Keuls Test.

DISCUSSION

The results of the study revealed the ability of LGB to infest and damage sorghum, maize, cowpea and sesame. Giles and Leon (1975), Hodges *et al*. (1983) and Howard (1983) reported the ability of the insect to infest and damage wide range of commodities including ones with no evidence of breeding. The insect was reported to have the ability to bore into solid substrates irrespective of their nutritional quality. Howard (1983) reared adult *P. truncatus* from eggs placed on artificial cereal grains consisting of a gelatine capsule filled with wheat, millet, maize, barley, rice or oats and reported that all the commodities supported the development of *P. truncatus,* although the development period was extended in the last three named cereals. Accordingly, the author reported that most cereal grains are nutritionally adequate for infestation and damage by LGB. The feeding ratios for all the commodities was close to 1 and were significantly (P < 0.05) different from each other indicating that feeding of LGB on the commodities varied.

In this study, maize and sorghum that were more preferred relative to cowpea and sesame had relatively higher feeding ratio. The results of this study revealed that LGB bred only on maize and sorghum, but only bored into other commodities as indicated by the final population of the insect in the commodities. The result was similar to the findings of Shires (1977) and Mushi (1984) who reported that attempts to rear LGB on haricot beans, cocoa, coffee beans, hard winter wheat, and rough rice failed and resulted only in the commodities being bored. The insect was however, reported to breed on a soft variety of wheat (*Triticum aestivum*), chick pea (*Cicer arietum* L.) and dried sweet potato. In this study, although no evidence of breeding by LGB on cowpea and sesame was noticeable, the percentage grain damage of between 1.35 and 8.27 and grain weight loss of between 0.64 % and 2.57 % within three months warrant the need to explore means of controlling infestation of the insect in the commodities. Likewise, the likelihood of secondary infection of the LGB-damaged grains by fungi such *Aspergillus niger, A. tamari, A. parasiticus, A. ochraceus, Fusarium compacticum* and *F. oxysporium* and bacteria such *Bacillus cereus, B. macerans, Proteus mirabilis, P. morganic, P. rettgeri, Proteus* sp., *Pseud geniculatum, Pseud fragii, Pseud putela, Serratia marcences* was reported by Osipitan *et al.* (2011). Food borne infections caused by contamination from rodents, insects, fungi and bacteria during processing, storage remains a major public health problem. US EPA (2007) reported that infection caused by microbial pathogens may result in temporary inconveniences such as diarrhoea and vomiting; serious immediate consequence such as spontaneous abortion, as well as long lasting conditions such as reactive arthritis, Guillain-Barre Syndrome (the most common cause of acute paralysis in adults and children and haemolytic uremic syndrome (HUS) which can lead to kidney failure and death.

Of all the commodities tested, maize was the most preferred as indicated by the high population of LGB, % grain damage, % grain weight loss. This is in consonance with earlier studies that reported maize as the major host of the insect (Chitenden, 1911; Giles and Leon, 1975; Hodges *et al*., 1983). The less preference of LGB for sesame and cowpea in this study may be due to physical and bio-chemical composition of the commodities. The seeds of sesame is rich in manganese, copper, calcium, vitamin B1 (thiamine) and vitamin E (tocopherol), phytosterols, lignans and sesamin that may deter feeding by LGB, further studies should be conducted to establish the bio-chemical composition of the commodities that may confer preference or non-preference.

The study also indicated varietal response of the crops to infestation, damage and breeding. For sorghum, the variety Ex-Minna was more damaged and lost more weight than Eyinfun. Grain size and genetic make-up of commodities could influence the extent of infestation and damage by LGB. Hodges *et al*. (1983) reported that the ability of LGB to develop in a particular cereal may be determined by other factors that may include morphological. It was further reported that Tanzanian local red varieties of sorghum, with relatively small grain size escaped infestation by the insect. The dispersed nature of the grain on the stored sorghum heads and the small grain size relative to the size of the beetle seem to prevent it from being a suitable host. Since, current efforts at safeguarding the environment from pollution of pesticide now emphasise integrated pest management; use of varieties with physical and biochemical factors that deter LGB feeding may be integrated with other control options. The high percentage grain damage of about 50 in the solo maize variety corroborates the reported voracity and destructive tendencies of LGB in infested maize grains. Giles and Leon (1975) reported weight losses of up to 40 % in infested maize in Nicaragua. Also, Hodges *et al.* (1983) reported weight loss of 34 % in stored maize and observed that the most obvious cause of this loss was the conversion of maize grains into maize flour by boring activities of adult LGB.

CONCLUSION

The study revealed the ability of LGB to damage sorghum, maize, sesame and cowpea, but breeding by the insect was restricted to only maize and sorghum. Maize was the most preferred host while sesame and cowpea were not preferred by the insect. There was varietal response in the grain products to damage and breeding by LGB. Further studies should therefore be conducted to determine physical and biochemical factors that may be responsible for non- preference of sesame and cowpea as host by LGB.

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