EVALUATION OF THE EFFECT OF INTERSPECIFIC COMPETITION BY LARGER GRAIN BORER, *PROSTEPHANUS TRUNCATUS* (HORN) (COLEOPTERA: BOSTRICHIDAE) AND MAIZE WEEVIL, *SITOPHILUS ZEAMAIS* (MOTS.) (COLEOPTERA: CURCULIONIDAE) ON DAMAGE TO MAIZE GRAINS

A. A. Osipitan*, T. J. Adebowale*, I. G. Mohammed and D. I. Adekanmbi*****

* Department of Crop Protection, University of Agriculture, P. M. B. 2240, Abeokuta, Ogun State, NIGERIA. E-mail: osipitan1@yahoo.com
** Pest Management Technology Department, Niger State College of Agriculture, Mokwa, NIGERIA.
*** Department of Regulation and Utilization, Ministry of Forestry, P.M.B. 2008, Abeokuta, Ogun State, NIGERIA.

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ABSTRACT: This study evaluated the effect of interspecific competition between the larger grain borer – *Prostephanus truncatus* and maize weevil - *Sitophilus zeamais* on damage by the insects to infested maize grains. 50 g maize grains was weighed into 250 cm^3 kliner jars and infested with adult LGB and S. *zeamais* of between 1 – 10 days old as follows: 50 g maize + 6 pairs of LGB, 50 g maize + 6 pairs of *S. zeamais*, 50 g maize + 3 pairs of LGB + 3 pairs of *S. zeamais,* 50 g maize + 4 pairs of LGB + 2 pairs of *S. zeamais,* 50 g maize + 2 pairs of LGB + 4 pairs of *S. zeamais,* 50 g maize + No LGB + No *S. zeamais*. At 90 days post-infestation, the following data were taken: weight of grain dust (g), final weight of grains (g), weight of damage and undamaged grains (g), number of living adults and number of adult mortality. The result indicated a significantly ($p < 0.05$) higher % grain damage (91.33) and grain dust (2.42 gm) in maize grains solely infested with *S. zeamais*. In treatments with mixed insect infestation, treatment with higher population of *S. zeamais* (50 g maize grains + 2 pairs of LGB + 4 pairs of *S. zeamais*) had a significantly ($p < 0.05$) higher % damage (42.90) than other treatments of mixed insects infestation. However, a significantly ($p < 0.05$) higher % weight loss (5.01) and weight of grain dust (2.51 gm) was obtained in treatment with higher population of LGB (50g maize grains + 4 pairs LGB + 2 pairs *S. zeamais*). Mortality of adult LGB (7.3) was significantly ($p < 0.05$) higher in treatment with higher population of LGB (50 g maize grains + 4 pairs LGB + 2 pairs *S. zeamais*). In two of the treatments with mixed insect infestation, (3 pairs LGB + 3 pairs *S. zeamais*) and (2 pairs LGB + 4 pairs *S. zeamais*), all the introduced LGB died and no larvae nor pupae was seen in the treatments. The study indicated the ability of *S. zeamais* to suppress the activities of LGB in interspecific competition.

KEY WORDS: *P. truncatus*, *S. zeamais, Z. mays,* Interspecific competition, infestation.

Maize (*Zea mays* L.) also known as corn is widely grown throughout the world and a greater weight of the crop is produced each year than any other grain ((CIMMYT, 1994). The crop is high yielding, early maturing, easy to process, readily digestible and cost less than others. It is a stable human food and good source of energy for man through direct consumption of grains (CGIAR, 1997). Maize is the 3rd most important grain after rice and wheat and also serves as source of raw materials for industry and as a feed, forage and silage for livestock (CIMMYT, 1994). The crop is however affected by some pests in store; notably larger grain borer (LGB) - *Prostephanus truncatus,* Maize weevil - *Sitophilus zeamais,* Auguimous grain moth – *Sitotroga cereallela* (Oliv.) and lesser grain borer - *Rhyzopertha dominica* (Throne, 1994; Markham et al., 1994).

The Larger grain borer (Coleoptera: Bostrichidae), a pest of farm stored maize and dried cassava chips was accidentally introduced from Central America into Tanzania in the late 1970's and spread to the other countries in the region. In West Africa, it was first found in Togo in the early 1980's and is now becoming the most destructive pest of stored maize grains in many Africa countries including Benin, Burkina Faso, Burundi, Ghana, Guinea, Kenya, Malawi, Mozambique, Zambia and Nigeria (Dunstan & Magazini, 1981; Harnisch & Krall, 1984; Anonymous, 1986; Kalivogui & Muck, 1990; Bosque-Perez et al., 1991; Pike et al., 1992; Opolot & Odong, 1999). Adult LGB will attack maize in the cob both before and after harvest; they bore into the maize husks, cob or grain making neat round holes. They produce large quantities of grain dust as they tunnel within the grains and more damage is done to infested grains due to conversion of maize grains to maize dust by boring activities (Hodges et al., 1983). The LGB was reported to create enabling environment for infestation of damaged grains by fungi and bacteria (Osipitan et al., 2009).The adults prefer grains on cobs to shelled grains; thus damage to unshelled maize grain is greater than on loose shelled maize. LGB is tolerant of dry conditions so that development is possible in grains at equilibrium with a relative humidity as low as 40% (10% moisture content for maize). The insect develops best at fairly high temperatures of about 30°C and relatively high humidity of about 70% (13% grain moisture content), when it completes its life cycle in 25 days (Bell & Watters, 1982). LGB causes considerable losses in stored maize and weight loss as high as 41.2% and 44.8% have been reported in Tanzania and Togo respectively after six months storage (Keil, 1988; Pantenius, 1988) Adults often live for 7-8 months, and may survive for 2 years and under favourable conditions. A generation may be completed in less than 4 weeks; so there may be 12-13 generations a year.

Maize weevil *(Sitophilus zeamais)* is another serious insect pest of maize that belongs to the family Curculionidae and order Coleoptera. It is a pest of stored maize and cob maize prior to harvest. The infestation initiated in the standing maize crop further develop in storage as the grain dries as stored cobs or bulk grains. It may also infest other cereals if the moisture content is moderate or high (e.g. >15%) (CIMMYT, 2001). A consequence of the above fact is that maize weevil is a greater problem in developing countries than in developed countries. Studies have reported that over 20% weight loss caused by weevils for untreated grains of maize hybrids stored in traditional structures may occur in on-farm stores in tropical countries. Maize weevil is perhaps the most destructive pest of stored grains in the world, capable of destroying grains in elevators, bins, ships, and anywhere else where physical conditions for growth are favourable and the grain is left undisturbed for some time (Markham et al., 1994). Attack is evidenced by the presence of numerous adults, surface heating of the grain and dampness sometimes to the extent that germination occurs. Damage by the insect results in direct loss of food and may also reduce future maize production for farmers who use store grains as seed; a practice that accounts for 70% of all maize planted in Eastern and Southern Africa (CIMMYT, 1994). Apart from indirect effect arising from production of heat by maize weevil and larger grain borer; the major effect of the infestation by the insects is the damage to grains by the feeding activities of the adults and larvae within the grain. This not only reduces the grain quality but also produce a considerable amount of grain dust and eventual reduction in the quality of grain (Adem & Bourges, 1981; Longstaff, 1981).

Singly, maize weevil and LGB cause substantial damage to maize grains. The present study however, investigates their influence on each other in inter-specific competition for food and space in mixed infestation of maize grains.

MATERIALS AND METHODS

This study was conducted at the Entomological Research Laboratory of Department of Crop Protection, College of Plant Science, University of Agriculture, Abeokuta. The maize weevil *Sitophilus zeamais* used for the study was obtained from the Department of Crop Protection, University of Agriculture, Abeokuta and cultured in glass jars in the laboratory using clean maize grains (*Zea mays*). Larger Grain Borer (LGB) was obtained from the Department of Zoology, University of Ibadan, Ibadan and cultured in glass jars in the laboratory of Crop Protection Department, University of Agriculture, Abeokuta using maize grains and cassava chips. The maize grains used for the study were conditioned to 13% moisture content and disinfected using Force toxin tablets. Fifty grammes each of the maize grains was weighed into 250 cm^3 kliner jars and infested with adult LGB and S. *zeamais* as stated below:

The maize grains were diversely infested with LGB and S. *zeamais* as follows.

- 50 g maize+6 pairs of LGB
- 50 g maize+6 pairs of *S. zeamais*
- 50 g maize+3 pairs of LGB+3 pairs of *S. zeamais*
- 50 g maize+4 pairs of LGB+2 pairs of *S. zeamais*
- 50 g maize+2 pairs of LGB+ 4 pairs of *S. zeamais*
- 50 g maize + No LGB +No *S. Zeamais*

Each treatment was replicated four times and the treatment jars were arranged randomly on the work benches in the laboratory using Complete Randomized Design.

One of jar containing 50 grammes of the maize grains was kept free of insects and this serves to measure moisture gain or loss as result of environmental factors.

The introduced insects were allowed to feed on the grains and left undisturbed for 90 days, and then sieved out. Thereafter, the following data were taken:

- Weight of grain dust (gm)
- Final weight of grains (gm)
- Weight of damage and undamaged grains
- No of living adult (LGB)
- No of living adult (Maize weevil)
- No of adult mortality (LGB)
- No of adult mortality (Maize weevil)

Assessment of final population of insects

At 90 days post-infestation, the insects were sieved out of the grains and separated into living and dead.

The number of living and dead adults for each of the insect species was noted.

Assessment of percentage Grain Damage

The grains in each sample were separated into damaged and undamaged and weight of each was noted.

Percentage damage was calculated using the formulae:

$$\% \text{ Grain Damage} = \frac{\text{Weight of damaged grains}}{\text{Total weight of grains}} \times \frac{100}{1}$$

Assessment of percentage weight loss

The final weight of the grains was determined after sieving out the insects and grain dust. The uninfected samples were also weighed and the observed changes in weight were used to correct the changes in the weight of corresponding trial samples (Hurlock 1967). Percentage weight loss was calculated using the formulae:

$$\% \text{ weight loss} = \frac{\text{Weight of control Sample - final weight}}{\text{Weight of Control sample}} \times 100$$

Assessment of grain dust

The grain dust was sieved out of the infested and damaged grains and weighed using Mettler weighing balance.

Data Analysis

Statistical Analysis of data was based on SAS general statistical linear models procedure (SAS Institute, 2001). Analysis of variance (ANOVA) table was generated for all the variable and treatments at $P \leq 0.05$ and Student's Newman-Keuls Test (SNK) was used to separate significant means.

RESULTS

Assessment of percentage grain damage

The mean percentage grain damage is shown in Table 1. The % grain damage (91.3) in treatment of maize grains singly infested with 6 pairs of *S. zeamais* was significantly ($P < 0.05$) higher than % grain damage in other treatments. Conversely, the % grain damage in treatment of maize grains singly infested with 6 pairs of LGB was significantly ($P < 0.05$) lower than % grain damage in other treatments. In the treatments of mixed insects of LGB and *S. zeamais*, a significantly ($P < 0.05$) higher % grain damage (42.9) was caused by the combination of 2 pairs of LGB + 4 pairs of *S. zeamais*. The % grain damage (27.7) caused by the combinations of (3 pairs of LGB + 3 pairs of *S. zeamais*) and (4 pairs of LGB + 2 pairs of *S. zeamais*) (31.0) were not significantly ($P > 0.05$) different from each other.

Assessment of percentage grain weight loss

As shown on Table 1, the % weight loss (4.8) caused by single infestation of LGB was significantly ($P < 0.05$) higher than % weight loss (1.5) caused by single infestation of *S. zeamais*. In the treatments of mixed insects of LGB and *S. zeamais*, insect combination of 4 pairs of LGB + 2 pairs of *S. zeamais* caused a significantly ($P < 0.05$) higher % grain weight loss (5.0) relative to weight losses caused by other insect combinations. The % weight losses of 0.6 and 1.0 respectively caused by insect combinations of 3 pairs of LGB + 3 pairs of *S. zeamais* and 2 pairs of LGB + 4 pairs of *S. zeamais* were not significantly ($P > 0.05$) different from each other.

Assessment of grain dust

As shown on Table 1, maize grains singly infested by LGB caused a significantly ($P < 0.05$) higher grain dust (2.4) than grain dust (0.8) from maize grains singly infested with *S. zeamais*. In the treatments of mixed insects of LGB and *S. zeamais,* a significantly ($P < 0.05$) higher grain dust (2.5) was caused to maize grains infested with insect combination of 4 pairs of LGB + 2 pairs of *S.*

zeamais. The % weight of grain dust (0.3 and 0.5 respectively) from maize grains infested with insect combinations of 3 pairs of LGB + 3 pairs of *S. zeamais* and 2 pairs of LGB + 4 pairs of *S. zeamais* were not significantly (P >0.05) different from each other.

Assessment of mortality of adult *Sitophilus zeamais* and LGB

Mortality of maize weevil and LGB in the treatments is shown in Table 2. In mono-specie insect infestation, higher insect mortality (6) was recorded in LGB infested treatment relative to insect mortality (2) in maize weevil infested treatment. In the mixed infestation of LGB and *S. zeamais,* the LGB mortality (8.0) in treatment of 4 pairs of LGB + 2 pairs of *S. zeamais* was not significantly (P > 0.05) different from LGB mortalities of 6 at a piece in treatments of 3 pairs of LGB + 3 pairs of *S. zeamais* and 6 pairs of LGB. The mortality of maize weevil (5.0) was highest in treatment of 3 pairs of LGB + 3 pairs of *S. zeamais*. The mortality was however, not significantly (P > 0.05) different from LGB mortality (4.3) in treatment of 2 pairs of LGB + 4 pairs of *S. zeamais*. The lowest *S. zeamais* mortality was in treatment of 6 pairs of *S. zeamais*. It was however, not significantly (P > 0.05) different from *S. zeamais* mortality (2.7) in treatment of 4 pairs of LGB + 2 pairs of *S. zeamais*.

Assessment of final population of Adult LGB and *Sitophilus zeamais*

The population of adult LGB and *S. zeamais* in the treatments is shown in Table 3. A significantly (P < 0.05) higher number of LGB (34.0) was recorded in treatment of 6 pairs of LGB. No living LGB adult was seen in treatments of 3 pairs of LGB + 3 pairs of *S. zeamais* and 2 pairs of LGB + 4 pairs of *S. zeamais*. The number of *S. zeamais* (121.3) in mono-specie infestation of the maize grains by the insect was significantly (P < 0.05) higher than number of the insect in other treatments. The number of *S. zeamais* (63.0 and 61.3 respectively) in 3 pairs of LGB + 3 pairs of *S. zeamais* and 4 pairs of LGB + 2 pairs of *S. zeamais* were not significant (P > 0.05) difference from each other.

DISCUSSION

Competition for food, space and other requisites by store product insects plays a major role in regulating the population size at any point in time. It often results into fighting, predation and mutual disturbances that lead to adverse influences such as elongation of developmental and reproductive processes, death or emigration by insects. In this study, the mixed infestation of LGB and maize weevil in maize grains, the major host of the insects created inter-specific competition that created scramble competition for food and shelter since their needs coincides. Apart from sharing the same host diet, LGB and maize weevil lays their eggs in the grains and complete their entire life cycle within the grain (Hodges, 1982). In this study, all the LGB in the treatments of equal number of the two insect species died. This shows that *S. zeamais* have competitive advantage over LGB in the scramble for food that eventual result into exclusion of LGB in the treatment. This may be as a result of the voraciousness of *S. zeamais* in loose grains relative to LGB that thrives well on unshelled maize on cob rather than loose maize grains (Golob et al., 1983). This in consonance with the results of studies by Hodges et al. (1983) that reported LGB as major pest of maize, infesting both the stored and standing crop in the ear rather than shelled corn. Likewise, Golob et al. (1985) reported that maize stored on the cob suffered considerably more damage than shelled grains.

In this study, higher % of damage was caused by *S. zeamais* in monospecie infestation of maize grains compared to damage caused by monospecie infestation by LGB. This shows the ability of *S. zeamais* to cause higher damage in monospecie infestation of maize grains relative to damage cause by LGB. However, the percentage weight losses caused by monospecie infestation of LGB and *S. zeamais* showed that though lesser % of the infested grains were damaged by LGB, the damage elicited higher weight loss than weight loss in grains damaged by *S. zeamais.* This indicated that though, higher % of the grains infested by *S. zeamais* were damaged; the damage was paltry, while LGB caused substantial damage to the relatively fewer grains damaged. Giles and Leon (1975) reported LGB as a highly voracious insect pest capable of causing up to 40% yield loss in stored maize grains within six months. The insect was reported to cause losses that exceeded those of other insects under similar condition (Giles & Leon, 1975; GASGA, 1993). Booth et al. (1990) and Espinal et al. (1996) reported that the adult LGB and its larval stage cause damage to a wide range of commodities. Similarly, higher grain dust was generated from grains infested by monospecie infestation of LGB relative to maize grains infested with maize weevil. Hodges et al. (1983) reported that much grain dust is generated by the boring activities of LGB that gradually converts maize grains into grain dust.

In the treatments of mixed insects, *S. zeamais* thrive better than LGB when one considers the final population. In the treatments, the population of LGB was either totally repressed or reduced, suggesting the ability of *S. zeamais* to suppress the activities of LGB in interspecific competition. This study also shows that mixed infestation of maize grains by LGB and maize weevil would constitute additional damage to infested maize grains, especially in terms of weight loss since LGB has the ability to bore into any single maize grain infested and cause substantial weight loss, while maize weevil has the potential to damage higher percentage of infested maize grains. The effect of the damage of the insects on the nutritional quality of the infested maize grains is severe (Adem & Bourges, 1981; Torreblanca et al., 1983). Similarly, Osipitan et al. (2009) evaluated damage caused to some food commodities by LGB and microbial composition of frass induced by the insect and reported fungi such as *Aspergillus niger, A. tamari, A. parasiticus, A. ochraceus, Fusarium compacticum* and *F. oxysporium* and bacteria such as *Bacillus cereus, B. macerans, Proteus mirabilis, P. morganic, P. rettgeri, Proteus* sp., *Pseud geniculatum, Pseud fragii, Pseud putela* and *Serratia marcences* in the commodities. It therefore becomes more imperative to protect stored maize grains from infestation by LGB and maize weevil. Conscious efforts should be explored at using environmental and ecologically friendly methods of preserving our stored maize grains from infestation by the insects.

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Table 1. Percentage grain damage, Percentage grain weight loss and weight of grain dust in maize infested with LGB and *Sitophilus zeamais*.

Treatment	% Grain Damage	% Grain weight loss (gm)	Weight of grain dust (gm)
6 pairs of LGB	13.3^{d}	4.8^{a}	2.4^{a}
6 pairs *Sitophilus zeamais*	91.3^{a}	1.5^{b}	0.8^{b}
3 pairs LGB + 3 pairs *Sitophilus zeamais*	27.7^{c}	0.6^{c}	0.3^{c}
4 pairs LGB +2 pairs *Sitophilus zeamais*	31.0^{c}	5.0^{a}	2.5^{a}
2 pairs LGB + 4 pairs *Sitophilus zeamais*	42.9^{b}	1.0^{c}	0.5^{c}

Means with the same letter are not significantly different from each other at $P < 0.05$ based on Student's Newman-Keuls Test (SNK).

Table 2. Mortality of LGB and *Sitophilus zeamais* in maize grains infested with the insects.

Treatments	Insect Mortality.	
	LGB	Maize weevil
6 pairs of LGB	6.0^{ab}	0.0^{d}
6 pairs *Sitophilus zeamais*	0.0^{c}	2.0^{b}
3 pairs LGB + 3 pairs *Sitophilus zeamais*	6.0^{ab}	5.0^{a}
4 pairs LGB +2 pairs *Sitophilus zeamais*	8.0^{a}	2.7^{b}
2 pairs LGB + 4 pairs *Sitophilus zeamais*	4.0^{b}	4.3^{a}

Means with the same letter are not significantly different from each other at $P < 0.05$ based on Student's Newman-Keuls Test (SNK).

Table 3. Final population of LGB and *Sitophilus zeamais* in maize grains.

Treatments	Number of adult insects	
	LGB	*Sitophilus zeamais*
6 pairs of LGB	34.0^{a}	0.0^{d}
6 pairs *Sitophilus zeamais*	0.0^{c}	121.3^{a}
3 pairs LGB + 3 pairs *Sitophilus zeamais*	0.0^{c}	63.0^{c}
4 pairs LGB +2 pairs *Sitophilus zeamais*	19.3^{b}	61.3^{c}
2 pairs LGB + 4 pairs *Sitophilus zeamais*	0.0^{c}	76.7^{b}

Means with the same letter are not significantly different from each other at $P < 0.05$ based on Student's Newman-Keuls Test (SNK).