WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

# Assessing *Trogoderma granarium's* Infestation of Some Legumes and Cereal Crops and the Monitoring of Stored Pests Using Synthetic Lures in Obudu Cross River State, Nigeria

***Lawrence Ahmed Ugbe[1] and Akinmola Solomon Morebise[2]***

**[1]Federal College Of Education Obudu In Affiliation With University Of Calabar, Calabar, Cross River State, Nigeria**
**[2]Santa Cruz State University, Ilheus, Bahia, Brazil**
**Email: ugbeahmed@gmail.com,**
**DOI : https://doi.org/10.5281/zenodo.17355657**

**ABSTRACT**

*Two experiments were carried out in two different markets in Obudu, to first monitor the presence of insect pests in stored produce houses in the two markets using synthetic lures. The second experiment was toassessess infestation of some legumes, cereals and oil seed crops by Trogodermagranarium. For the stored produce pests, four warehouses were selected, two each in Katube andUdama Market. In each of the warehouses, three traps were laid, one with BFL 225 Pheromone dispenser, the second with Bullet Lure Dispenser while the third trap was left blank (i.e control). The experiment was replicated three times. Data were taken weekly for eight months, the insects caught by the traps were identified, counted and recorded. In the second experiment, 3 day old Trogodermagranarium were introduced into containers for mating and oviposition, insect emergence and weight loss were the indices for assessing the infestation by Trogodermagranarium. The stored produce were the treatment and the set up replicated six times and laid out in a Completely Randomize Design (CRD). Data were collected weekly on weight loss for 16 weeks. During the first five weeks, data on the number of emerged adults were collected. The result showed that traps baited with the multi-attractant pheromone BFL 225 lured significantly (p<0.05) caught higher number of insects (177.99) than the bullet lure (145.17) and the control trap (141.91). The Trogodermagranarium that emerged from castor oil seed was significantly (p<0.05) higher (20.23) in 5 weeks than the number emerged from other produce. Generally, the adult emergence of T. granarium was significantly higher in castor seeds, and in cereals compared to the other produce. Also at 16 weeks of storage, castorseeds recorded the highest weight loss (14.52) compared to the other produce, with the lowest weight loss in Soybean (1.98). The trial indicated that there are possibilities of using synthetic insect pheromones in monitoring insects' population in food storage facilities. The result of assessment of infestation of T. granarium showed that although the insect preferred castor seeds, it can also infest other grains such as cereals and soybean in market stores.*

***Keywords: Pheromone, Trogodarmagranarium, BFL 225 pheromone dispenser, infestations, multi-attractant, Bullet Lure dispenser.***

## Introduction

One major challenge facing the storage of dried food crops has been that of insectpests' infestation.In Nigeria and in most African countries, farmers store their crops in a traditional manner, which are usually open storage facilities with a capacity of about 1000 to 1500kgs of the total harvested crops (Duke *et al*., 2003). Records of storage of crops and their infestations has been as far back as 6000 BC (Levinson, 1994). Several figures have been estimated in literatures on the extent of damage of stored grains arising from insect pest attacks. Example, Duke et al (2003) reported that about 15 to 20% losses were recorded globally, while 30 to 40% was reported in the tropics. In West Africa alone, 25 to 30% of stored grains have been destroyed within few months of storage (Holst *et al.*, 2002; Meikle*et al.*, 2002). A high level infestation of the grains is usually recorded when the moisture content of the grains is as high as between 30% and 40%.

A few number of insects present in a bulk of produce is capable of causing a severe damage and drastic reduction in its market value especially in developed countries (Faruki*et al.*, 2005). In some of these developed countries, even if a single live insect is found in gains, the grains can be graded low and are completely rejected (Fields *et al.,* 2009). There is therefore the need to safeguard stored food grains from being infested by insect pests especially during long-term storage since they can destroy large quantities in long periods.Storage is one of the most critical post-harvest operations. If not properly handled, can result in contamination with moulds and insects causing rapid deterioration of the grains' quality and reduced seed viability (Scott, 1999).

Insects also contaminate stored grains with frass (a mixture of excretions, moulting and dead insects) thus expounding the infestation with bacterial and fungal diseases through the transmission of their spores. Often, insect contamination causes an unpleasant smell and taste of the product, while fungal contamination can affect the taste of the commodity and lead to the production of mycotoxins, such as aflatoxin from *Aspergillusflavus* or *Aspergillusparasiticus* that can have acute and chronic health effects on humans and livestock (Haines, 1991).

*Trogodermagranarium*Everts (Coleoptera: Dermestidae) is a stored product pest of great importance. Its economic importance lies not only in the serious damage,it can cause to stored dry commodities but also in the export restrictions faced by countries when they have established populations of this pest (Pascal,1995). According to Wright *et al* (2002). Live populations of the insect can stay in uncleaned containers, packaging material, and cargo holds for extended periods of time infesting non-host materials. *Trogodermagranarium*may also increase the livelihood of contamination by *Aspergillusflavus* (Banks, 1994).

*Trogodermagranarium* may have originated from the Indian subcontinent and it is now present in some areas of Asia, the Middle East, Africa and a few countries in Europe (Barak, 1982). It is one of the very few stored products pests with a limited distribution. It usually occurs in various dry stored products of primarily plant origin.Primary hosts include oil seeds, cereals, buckwheat, cereal products, pulses, alfalfa, various vegetable seeds, herbs, spices and various nuts. The insect can also successfully complete its life cycle in copra, dried fruits and various gums as well as many different dried products wholly or partially of animal origin, such as milk powder, skin, dried dog food, dried blood, dead insects and dried animal carcasses (Barak, 1982). As a pest, it is most prevalent under hot dry conditions, where very heavy infestations can develop. In cooler and also in hot and humid conditions it tends to be out-competed as a pest by other species such as *Sitophlus spp.* And*Rhyzoperthadominica (*Fabricuis*).* Wright *et al.,* (2002). Reported that commodities stored in bags in traditional warehouses are more at risk from the pest than commodities that are stored in bulk.

*Trigodormagranarium*may have from one to more than ten generations per year depending on food availability and quality, temperature and humidity. A complete life-cycle may be as short as 26 days (temperature, 32-35$^{o}$C) or as long as 220 days or more in a suboptimal environment. Over 80% of physical and nutritional losses in stored crops (Cereals and pulses) incurred in third world countries including Nigeria, are due to infestations by insect pests. The pests, mostly their Larvae feed on the germs, eat up the albumen or germ and sometimes both. The attack on the endosperm results in severe weight loss and reduction in the nutrient content of the grains and consequent deterioration of their quality (Duke *et al.,* 2003). There is therefore the need to deploy protective measures to safe guide the stored products.

Stored products protection has depended so much on the use of synthetic pesticides, the organophosphorus and organochlorine insecticides (Subramanyam and Hagstrum, 2000). These synthetic pesticides have limitations such as the development of resistance by the insect pests, the destruction of the ecosystem with adverse effect on the target and non-target organisms such as wildlife and other beneficial organisms. The limitations also include leaving of residue on the crops as well as the environment which in turn lead to health hazards to the various consumers (Adler *et al.*, 2000). There is therefore the need to develop other alternative means of controlling the stored product pests, and such methods should not only be safe to the user and the consumers of the products, but should be affordable and environmentally friendly. Such alternative methods to the use of synthetic pesticides include the use of pheromone and baited traps to divert insect populations from the stored products.

Objectives

The objectives of the research is to design an alternative method of insect pests control for stored produce rather than the use of synthetic pesticides. The specific objectives include:

i. To evaluate the percentage weight loss caused by *Trogodermagranarium*to some selected cereal and legume crops
ii. To compare the efficacy of the synthetic general beetle lure (BFL 225) and Bullet synthetic multi-attractant in trapping insect pests in grain stores.
iii. To recommend the best method between the two (synthetic general beetle lure (BFL 225) and bullet synthetic multi-attractants.

## Materials and methods

**Floor traps and pheromones setting**

Artificial multi-attractant pheromones (BFL 225) and floor traps with sticky bases were procured from Agric Science BSC Ltd, in the UK. The pheromone dispensers, one made up of non-harmful plant extracts impregnated with a flat profile cellulose matrix controlled medium. Also use was the “bullet” multi-attractant synthetic pheromone capsule which was procured from “insects” limited Inc., USA. Both the pheromone dispenser and the pheromone capsule were for use in the monitoring of insect pests.

**Determination of insect emergence**

An experiment was conducted in the laboratory to evaluate the susceptibility of the following crop produce to infestation by *Trogodemagranarium*

*i.* Cowpea – *Vignaunguiculata L (walp)*
ii. Soyabean - *Glycine max* L. *merr*
iii. Guineacorn - *Sorghum bicolor*L Monch

iv. Rice - *Oryza sativa* L

v. Castor beans - *Ricinuscommunis*L

vi. Maize - *Zea mays* L Monch

One hundred grammes of each of the listed crops above were placed in separate transparent plastic containers. Twenty pairs of three day old *T.granarium*were placed in each of the transparent containers for mating and oviposition (egg laying) to take place (Ukeh and Mordue, 2011). Each cover of the plastic container was perforated with holes to facilitate air circulation. The mouths of the transparent containers were covered with nylon mesh before the perforated lids were screwed firmly in place to ensure the confinement of the insects. The plastic containers with the grains and insects were arranged in block on a bench in the laboratory and repeated six times in a CompletelyRandomized Design (CRD) design. The treatments were kept for four weeks to allow for mating, oviposition, and progeny emergence. The progenies were sieved out and counted daily, until no more progeny emergence was observed.

**Determination of weight loss**

Data for percentage weight loss were taken on weekly bases after 28 days of setting the experiment, for 16 weeks. In each occasion, the insects and the produce were separated from the powder produced by the grains as they are being attacked by the insects. After separation by sieving, the grains were weighed using a sensitive electronic balance (metel)

**Assessing the Efficacy of the Synthetic General Beetle Lure (BFL 225) and Bullet Synthetic Multi-Attractant Trap on Insects**

During the period of research, four wholesale food shops were selected in two different markets (Katube and Udama Markets) in Obudu Local Government Area. Three traps were kept in each of the four stores and at different locations. In each case, one of the three traps was baited with BFL 225 lure, the other trap as a bullet trap and the third one unbaited (as control). This trap setting arrangement was replicated three times. The traps were inspected on weekly basis, they were changed monthly for insect catch. Insect catch was based on the efficacy of each trap. The insects caught were identified and recorded, in accordance with methods of Ukeh and Mordue (2009). All traps were changed on monthly basis to ensure efficiency.

**Data analysis**

Students t-test statistical analysis at 5 percent level of probability was used to compare data on percentage weight loss of each produce with the control (untreated).Data obtained from the laid out experiment as factorial in RCD were subjected to analysis of variance using Genstat Statistical Soft Ware and the means were compared using LSD and DNMRT at 5 percent level of probability.

## Results

The number of adult *Trogodermagranarium*that emerged in castor seed and cereal crops (maize, Guinea corn, and rice) at one week was significantly ($p<0.05$) higher than the number that emerged from the legume crops (cowpea and soybeans). However, the number of emerged adults in castor bean was higher than in all the crops

(Table 1). At two weeks after storage, the result was the same, with adult emergence higher in castor and Cereals than in the legumes. There was no significant ($p>0.05$) difference in the adult emergence between the two legume crops (Soybean and Cowpea). At 3 and 4 weeks of storage, the trend remained the same. The lowest adult emergence was recorded in soybean. At the 5$^{th}$ week of storage there was a highly significant ($p=0.01$) difference in the emerged adults in caster and maize compared to other host crops. Still at 5$^{th}$ week, there was no significant ($p>0.05$) difference in the number of adult emergence in rice and in legume crops.

**Table 1: Effects of Progeny Development of *T.granarium* in Some Crops after Five Weeks of Infestations in Storage**

<

| Types of grains (100g) | Mean number of progeny emergence in weeks | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Cowpea | 16.22$^{a}$ | 3.7$^{a}$ | 2.81 | 2.60 | 0.00$^{a}$ |
| Soybean | 8.74$^{b}$ | 6.22$^{a}$ | 1.25$^{a}$ | 2.26$^{a}$ | 0.00$^{a}$ |
| Castor beans | 98.41$^{c}$ | 74.35$^{b}$ | 66.80$^{b}$ | 40.25$^{b}$ | 20.23$^{b}$ |
| Guinea com | 28.52$^{d}$ | 20.52$^{c}$ | 18.65$^{c}$ | 18.92$^{c}$ | 10.28$^{c}$ |
| Maize | 78.36$^{c}$ | 65.26$^{b}$ | 40.81$^{b}$ | 38.21$^{b}$ | 18.66$^{b}$ |
| Rice | 08.22$^{e}$ | 08.08$^{d}$ | 07.32$^{d}$ | 03.56$^{d}$ | 9.25$^{d}$ |

**Means followed by the same letters within a column are not significantly different according to DMRT at 5% probability level**

Analysis of data in table 1, showed that the percentage weight loss in the infested grains was significantly ($p<0.05$) higher than in control. Also, the percentage weight loss in infested soybean was significantly ($p<0.05$) different from that of control. Within 16 weeks of storage there was no significant ($p>0.05$) difference among the weight loss in cereals, but there was a significant ($p<0.05$) difference between the cereals and the legumes and between the cereals, legumes and castor bean.

Table 3 revealed a significantly ($p=0.01$) higher number of insect infestations in Udama market than katube market. There was also a significant ($p<0.05$) difference between the traps baited with lure and the unbaited (control) traps. The baited traps caught more insects than the unbaited traps (control). From the result of the experiment, the BFL 225 traps significantly caught a higher number of insects than bullet traps. The interaction between the market and the traps was significant ($p<0.05$). In both the control and baited traps, the result shows that the number of insects caught in Udama market were significantly ($p<0.05$) higher than those caught in Katube market.

**Table 2: Effects of *T.granarium* infestations on the weight of some stored grains**

<

| | Weight loss (kg) | | | | | |
|---|---|---|---|---|---|---|
| | Rice | Cowpea | Soybean | Castor | Guinea corn | Maize |
| Control | 6.82 | 2.36 | 1.98 | 14.52 | 8.62 | 9.88 |
| Treated | 18.22 | 9.82 | 8.64 | 36.41 | 7.92 | 20.54 |
| SED (±) | 3.22 | 1.5 | 1.62 | 5.33 | 1.83 | 3.86 |
| t-cal | 3.68 | 5.42 | 5.22 | 4.86 | 3.21 | 3.65 |

**Tab (0.03) 3.52**

**Tab (0.01) 5.20**

**Table 3: Comparative efficacy of insect catch of Synthic general beetle lure (BFL 225) and bullet synthetic multipurpose attractant in two market stores**

**Means no of insect trapped**

| **Treatment** | **Katube** | **Udama market** | **Mean** |
|---|---|---|---|
| BFL 225 | 1412.00 | 1562.00 | 1,487.00 |
| Bullet | 1386.00 | 1634.00 | 1,510.00 |
| Blank (control) | 1224.00 | 1362.00 | 1,293.00 |
| **MEAN** | 1,340.66 | 1,519.33 | |

LSD (0.05) Trap (T) = 64.23

LSD (0.05) Market (MI) = 46.60

LSD (0.05) (MxT) Interaction = 88.24

**Key:**

BFL 225 = Synthetic general beetle lure

BK = Blank trap

BUL = Bullet synthetic multi-attractant lure

Traps that were baited, significantly ($p<0.05$) caught more insects than the ones that were unbaited (Blank traps). However, between the baited traps, BFL 225 significantly ($p<0.05$) varied in the number of insects caught. A significantly high number of insects was caught during the wet month of August, followed by the month of June. A significant number was also caught in the months of January and February. The least number of insects was caught in the months of April and May. The interaction between trap type and the month was significant ($p<0.05$). it was generally observed that higher number of insects was caught in both the baited and unbaited traps in the wet months (June – August) compared to other months. BFL 225 trap significantly caught the highest number of insects in August, followed by the bullet trap and the blank trap (control) all in the same month. The bullet trap caught the least number of insects in April and May, hence not significantly ($p>0.05$) different from the number caught by the blank trap (control) in the months of April. The BFL 225 baited trap caught the highest number of insects in all.

**Table 4: Effect of trapping and time of trapping (months) on the number of insects at Katube market**

**Means no of insect trapped**

| **Months** | **BB** | **BFL 225** | **BLK** | **(Mean of months)** |
|---|---|---|---|---|
| January | $142.00^{a}$ | $154.00^{a}$ | $116.00^{a}$ | 137.33 |
| February | $102.00^{b}$ | $143.23^{a}$ | $138.22^{b}$ | 127.81 |
| March | $88.56^{c}$ | $76.00^{b}$ | $65.12^{c}$ | 76.56 |
| April | $34.21^{d}$ | $58.22^{c}$ | $45.24^{d}$ | 45.89 |
| May | $38.35^{d}$ | $52.63^{c}$ | $55.51^{c}$ | 48.83 |
| June | $242.24^{e}$ | $275.42^{d}$ | $235.21^{e}$ | 250.95 |
| July | $232.00^{e}$ | $280.23^{d}$ | $230.01^{e}$ | 247.41 |
| August | $282.00^{f}$ | $284.22^{e}$ | $250.00^{f}$ | 305.41 |
| **MEAN** | **145.17** | **165.49** | **126.28** | |

**Key:**

BB = Bullet trap

BFL = NFL 225 trap

BLK = Blank trap (unbaited)

The effects of the different traps and month on the number of insects caught in Udama market (Table 5) almost followed the same trend with that of Katube market in (Table 4). The highest number of insects caught was recorded in BFL 225 trap. This is followed by the number caught in bullet trap. The highest significant ($p<0.05$) number of insects caught was in the month of August, followed by the month of June. The least number of insects caught was recorded in the months of April and May. The interaction between the type of trap and the month of catching was significant ($p<0.05$). Generally, a significant ($p<0.05$) number of insects was caught in both the baited and unbaited traps during the wet months of June to August, while a considerable lower number was caught in the months of April and May. The highest number of insects caught was in the months of June and August, and in the BFL 225 trap. In the month of February, the blank trap (control), significantly ($p<0.05$) caught more insects than the baited traps. In the month of April, the blank trap (unbaited) caught the least number of insects.

**Table 5:Effect of trapping and time of trapping (months) on the number of insects at Udama market**

**Means no of insect trapped**

| **Months** | **BB** | **BFL 225** | **BLK** | **(Mean of months)** |
|---|---|---|---|---|
| January | 170.00a | 195.00a | 113.00 | 159.33 |
| February | 86.50b | 130.00b | 136.00b | 117.50 |
| March | 119.50c | 128.00b | 110.00a | 119.20 |
| April | 87.10b | 112.34c | 82,00c | 93.81 |
| May | 115.26c | 104.32c | 93.36c | 104.31 |
| June | 208.56d | 350.20d | 301.22d | 289.66 |
| July | 168.00a | 152.82 | 145.72b | 155.51 |
| August | 318.10e | 385.28f | 235.63d | 313.00 |
| **MEAN** | **159.13** | **194.75** | **154.62** | |

Means for traps, months and interaction for traps and months followed by the same letter in the same column are not significantly different at 5% level of probability according to DMRT

**Key:**

BB = Bullet trap

BFL = NFL 225 trap

BLK = Blank trap (unbaited)

## Discussion

Results of this experimental work demonstrated that the longer the grains are exposed to insect pests attack, the higher they lose weight. The result also demonstrated that insects can always find secondary host grains anytime the primary host is not available. This result is in line with the report of Egbon and Ayertey (2009) that Sitophilus species will most preferably switch host to cowpea in the absent of maize.

The result showed that the weight loss caused by *T. granarium*on oil seed crop (castor bean) and cereals was higher than in legumes (Table 2). This means that the insect has special preference for the oil in the castor beans (Cox and Collins 2002). It was observed that the grains treated with insects experienced remarkable weight loss compared to those that were not treated with the insects (*T. granariuim)*. There was a significant ($p<0.05$) difference in the weight loss between cereal crops and legumes and also between the oil seed and the cereals. The cereals suffered a more significant weight loss compared to the legumes while the castor oil seeds were attacked more than the cereals (Table 2).

The study on trapping showed that the traps baited with BFL 225 were more efficient in catching a variety of insects such as *Trogodermagranarium, Sitophilusspp, Corcyra ciphilonica, Prostephanustronutrus, Triboliumcastaneum and Callosobrochusmaculatus,* than the bullet lure and the control set up (unbaited)(Table 3). This result is in line with the report of Arthur and Philips (2002), Ukeh et al (2008). They observed that constant monitoring with various insect traps of diverse types at many different locations all through a facility can provide data concerning the presence of particular species of insect. It can also provide data on the relative changes in species compositions and numbers over a period of time. This also include the comparative magnitude of their population at different locations (Likbayo and Hodges, 2002). The insects captured in baited traps strongly suggested that the population was increasing towards the end of the study period (Tables 4 and 5).

In this experiment, castor beans and maize were the most susceptible stored produce to attacks by *Trogodermagranarium*then followed by rice, guinea corn, Soyabean and cowpea. These infestation occur at any point within the marketing channels, general stores as well as retail shops that are already colonized by insects. Insects migrating from other produce are equally prone to infestations. Also traps baited with BFL 225 lure were significantly ($p<0.05$) different in the number of insects caught. insects caught in significant number included, *Sitophilusspp,Callosobruchus spp. Triboliumcastaneum, Prostephanustruncatus, Trogodermagranarium, Cryptolestesturcicus, Cryptolestesferrungineurs etc.* Bullet lure as well as the unbaited traps caught a good number of insects during the study (Tables 4 and 5).

## Conclusion

The infestation of crops produce by insect pests within the processing cycle from the field to the store and the consumer, remains worrisome. This is due to certain aspects of packaging, negligence in warehouses and stores as well as average shelf-life of the products. The application of pheromone-baited traps as a means of checkmating the populations of insect provides different edges over inspections. The applications of insect pheromones in the control of pest involves a careful observation of attractants, early notice, and creation of awareness. It also include isolation and observation for infestation, control measures and the right time to control, population dynamics, evaluation of the effects of control methods etc. The need for insect trap in Integrated Pest Management (IPM) is on the basis that no one method is sufficient in itself to provide adequate protection to crops against pest infestations. Therefore, for an effective pest control and crop protection measure to be put in place, an integrated approach that is ecologically balanced and friendly must be the option.

ACKNOWLEDGEMENT

We hereby acknowledged the following food shop owners who gave us access to their shops for setting the insects traps; Mr. UgochukwuWandare of No. 16 Main Market Road Obudu Cross River State, Nigeria and Mrs. IneIheme of No 36 Portharcourt Street Obudu. We also acknowledged FCE, Obudu for allowing us to use their Crop Science laboratory for the experiment.

ETHICAL CONSIDERATION

The food shop owners requested that no synthetic chemicals be taken to the food shop during the experiment. This request was strictly adhered to.

CONFLICT OF INTEREST

There was no conflict of interest to be declared.

**REFERENCES**

Adler, C., Ojimelukwe, O. and Leon, T.A. (2000). Utilization of phytochemicals against stored product insects. *Integrated Protection of Stored Products, 10BC Bulletin,* **23**: 169-175.

Arthur, F. H, and Philips, T.W. (2002). Stored product insect pests management and control. In Hui, Y.H., Bruisma, B.L., Gorham, J.R., Nip, W.K., Tong, P.S., Ventresca, P. (eds). *Food Plant Sanitation,* New York, Oklahoma: Marcel Dekkar Incorporated, Pp. 341-358.

Banks, H.J. (1994). Illustrated identification keys for *Trogodermagranarium, T. glabrum, T. inoculum,* and *T. Variable* (Coleopteran: Dermestidae) and other Trogoderma associated with stored products. (SIRO Division of Entomology Technical Paper, No. 32. Commonwealth Scientific and Industrial Research Organization, Canberra. 66p.

Barak, A.V. (1982). A new stored product species of *Trogoderma (*Coleopteran*:* Bermestidae) from Bolivia *the ColeopteristsBulletin,* **36** (2), 211-215.

Cox, P. D., and Collins, L.E. (2002). Factors affecting the behavior of beetle pests in stored grains, with particular reference to the development of lures. *Journal of Stored Product Research,* **38**: 95-115.

Duke, S.O., Baerson, S.R., Dayan, F.F., Rimando, A.M., Scheffler, B.E., Tellaz, M.R., Wedge, D.E., Schrader, K.K., Ahey, D.H., Arthur, F.H., De Luccas, A.J., Gibson, D.M., Harrison, H.F., Peterson, J.K., Gealy, D.R., Tworkoshi, T., Wilson, C.L. and Morris, J.B. (2003). United States Department of Agriculture, Agricultural Research Service. Research on Natural Products for Pests Management. *Pest Management Science,* **59**:708-717.

Egbon, I.N. and Ayertey, J.N (2009). Identification of a Sitophilus species to breeding infesting cowpea seeds in Guinea Savanna.*Journal of Agriculture,* 4, 1-4

Faruki, S.I., Miyanoshita, A., Takahashi, K., Musumi, Imamuma, T., Naito, H., Goto, M., and Soma, Y. (2005). Susceptibility of various developmental stages of maize weevil, *Sitophiluszeamais*Motschulsky (Coleoptera: Curculionidae) to methyl, Iodine in brown rice. *Journal of Applied Entomology,* **129**, 12-16.

Fields, P., Dowdy, P. and Marcotte, M. (2009). Structural pest control. The use of an enhanced diatomaceous earth product combined with heat treatment for the control of insect pest in food processing facilities. Leadership in the development of methyl bromidic alternative environmental agriculture.

Heins, C.P. (ed), (1991). Insects and Arachnids of Tropical Stored Products. Their biology and identification. Natural Resources Institute, Chathan, Kent ME 4, 4TB UK. P 246.

Holst, N., Mickle, W.G. and Markham, R.H. (2002). Grain injury models for *Prostephanustruncatus* (Coleoptera: Bostrichidae) and *Sitophiluszeamais (*Coleoptera*:* Curculionidae*)* in rural maize stores in West Africa, *Journal of Economic Entomology* **93**, 1338-1346.

Levinson, H., and Levinson, A. (1994). Origin of grains storage and insect species consuming desiccated food. *Anzeiger fur sch.dlingskundepfanzen-schutzunweltschutz,* **67**, 47-59.

Likwayo, P.W., and Lodges, R.J. (2002). Field monitoring *Sitophiluszeamais* and *Sitophilusoryzae* (Coleoptera: Curculionidae) using refuse flight traps baited with synthetic pheromone and cracked wheat. *Journal of Stored Products Research,* **36** 341-353

Meikle, W.G., Markhan, R.H., Mansen, C., Hoist, N., Degbey, P., Azoma, K., and Korie, S. (2002). Pest management in traditional maize stores in west Arica: a farmer's perspective. *Journal of Economic Entomology,* **95** 1079-1088.

Pascal, R.S., and Smith, J.R. (1995). Biology and Taxonomy of Nearctic species of *Trogoderma.* University of California Publication in *Entomology,* **10** (2): 35-102

Scott, H.G. (1999). Nutrition changes caused by pests in food. In Gorham, J.R. (ed), Ecology and management of food industry pests. Association of official analytical chemists. Food and Drug Administration Technical Bulletin 4, Virginia, USA, Pp. 463-467.

Subramanyam, B.H and Hagstrum, D.N. (2000). Botanicals in: subramanyam, Bh and Hagstrum, D.W. (eds). Alternative to pesticides in stored product IPM. Boston, Kluwer Academic Publishers, Pp. 303-320.

Ukeh, D.A., Udo, I.A., and Ogban, E.I. (2008). Trapping of stored-product insects using flight traps outside traditional African storage granaries. *Journal of Food, Agriculture and Environment,* **6** (2), 399-401.

Ukeh, D.A. and Mordue, A. J. (2011). Plant base repellents for the control of stored product insect. *Biopesticides International,* **5** (1), 01-23.

Wright, E.J., Sinclair, E.A., and Annis, P.C. (2002). Laboratory determination of the requirements for control of *Trogoderma variable* (Coleoptera: Dermestidae) by heat. *Journal of Stored Products Research,* **38***:* 147-155.