GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 14, NO. 1, 2008: 31 - 36
 ISSN 1118-0579

# ANALYSIS OF INSECT POPULATIONS IN STORED CROPS IN CROSS RIVER STATE, NIGERIA

**DONALD A. UKEH AND IDORENYIN A. UDO**

(Received 26 June 2007; Revision Accepted 21 September 2007)

**ABSTRACT**

A survey of stored cassava, maize, groundnuts and cowpea insect pests and their natural enemies was conducted in Obudu, Cross River State, Nigeria from October 2006 to March 2007. For each product 3 storage facilities were sampled to give a monthly total of 12 locations. 500g of dried cassava tubers, maize, groundnuts or cowpea seeds was measured out from each sample and adult insect pests and beneficial insects were sieved out and identified monthly. Eight insect pest species were found associated with these stored products namely; the maize weevil, *Sitophilus zeamais*, the red flour beetle, *Tribolium castaneum*, the cowpea weevil, *Callosobruchus maculatus*, the lesser grain borer, *Rhyzopertha dominica*, the Indian meal moth, *Plodia interpunctella*, the Angoumois moth, *Sitotroga cerealella*, the kapra beetle, *Trogoderma granarium* and the rusty grain beetle, *Cryptolestes ferrugineus*. The predominant insect species in all crop samples were *T. castaneum* and, *S. zeamais* with mean numbers of 30.6 and 28.2 respectively. *T. castaneum* was recorded in all the crop products sampled, *C. maculatus* was sampled only from cowpea seeds, whereas *T. granarium*, *P. interpunctella* and *C. ferrugineus* were all found in stored groundnut. *R. dominica* and *S. cerealella* were recorded as insect pests of stored cassava, while *S. zeamais* was primarily associated with maize and occasionally found in cassava. The beneficial insects recovered from these stored products were *Anisopteromalus calandrae*, *Theocolax elegans* and *Dinarmus basalis* all Pteromalid Hymenopterans. Results from this study showed that stored commodities are often infested with various insect pests, and frequent sampling and sanitation are required to prevent infestations.

**KEYWORDS**: stored-product insects, cassava, maize, groundnuts, cowpea.

## INTRODUCTION

In many parts of Nigeria, farmers and food merchants commonly store grains after harvest in order to sale at a higher price during periods of scarcity or during planting season to obtain a profit. Stored grain commodities are vulnerable to infestation of many species of arthropods (Golob *et al.*, 2002). More than 600 species of beetles and 70 of moths among the insects, 355 species of mites, 40 species of rodents and 150 species of fungi have been reported to be associated with various stored products (Rajendran, 2005). The activity of stored product pests may be associated with weight losses by direct damage, lowering the nutritional and economic value of the crop and presence of allergens (Arlian, 2002) or toxinogenic fungi (Hubert *et al.*, 2002), in the infested stored grain. Food infecting fungi have been reported to produce many metabolites such as mycotoxin, aflatoxin $_{B1}$, a carcinogenic metabolite of *Aspergillus flavus* which affects the liver (Wild and Hall, 2000), ochratoxin A and citrinin produced by *Penicillium verrucosum* which are known to have nephrotoxic effects (Hubert *et al.*, 2004). The factors triggering an initial infestation in storage ecosystem is not well understood, nor is it clear how environmental and insect demographic factors influence the spatial distribution of insects on a community level in stored grain, and how the spatial distribution patterns of these change during a storage period of several months. The physical environment can play an important role in the establishment of insect populations in grain masses. Small differences in temperature and grain moisture content have been shown to have a substantial impact on development time, mortality, and fecundity of stored product insects in North America (Throne, 1994). In the United States, it has been reported that a major source of the insects that infest new grain in elevators was the previously infested grain present when the new crop is received, grain residues in empty bins, spills and debris around elevators (Arthur *et al.*, 2006). Reed *et al.* (2003) reported the occurrence of *Cryptolestes ferrugineus* (Steph), *Rhyzopertha dominica* (Fab), *Oryzaephilus surinamensis* (L), *Tribolium castaneum* (Hbst), *Sitophilus zeamais* (Motsch) and *S. oryzae* (L) from grain collected from the bottom of elevator silos and from discharge spouts consistently over a two and a half year period. Also, the trucks and railcars used to transport grain to commercial elevators could constitute sources of infestation.

Bio-rational approaches using environmentally friendly methods to protect stored products from insect infestation should have been recommended through integrated pest management (IPM) based on correct pest identification and monitoring (Campbell *et al.*, 2002). In Nigeria, like most African countries south of the Sahara, sufficient information on pest spectrum, their identification and monitoring is not frequently available. The objective of this research was to survey traditional storage structures to describe demographic characteristics of insect communities in them, and to examine the prevalence of natural enemies associated with their prey species.

## MATERIALS AND METHODS

Twelve geographically isolated traditional storage facilities in Obudu Local Government Area of Cross River State were sampled monthly in October 2006 to March 2007 for the prevalence of storage insects. These granaries (baskets or jute bags) housed any of the 4 main commodities namely, cassava (*Manihot esculenta* Crantz), maize (*Zea mays* L.), groundnut (*Arachis hypogea* L.) and cowpea (*Vigna unguiculata* L.Walp), and for each product 3 storage facilities were sampled. The products were stored for 4 weeks before commencement of data collection, and the capacity of each storage facility was 100 kg. Cassava tubers were stored as sliced, maize cobs were dehusked, cowpea threshed but groundnut was stored unshelled in accordance with the local practice by resource poor farmers who produce the bulk of all agricultural products in Nigeria. Using a typical aluminium measuring cup common among the local foodstuff traders, 500g of each stored product was randomly measured out for analysis and weighed using PC 440 electronic balance (Mettler Instrument AG, Zurich, Switzerland) every month. Samples were labelled accordingly and placed in different containers for identification and analysis. In the laboratory, each sample was first sieved through a wire mesh screen size 2 mm (Endecotts Ltd., London, England) for 5 minutes to obtain adult insects. All

**Donald A. Ukeh,** Department of Zoology, University of Aberdeen, Tillydrone Avenue, AB24 2TZ, United Kingdom.
**Idorenyin A. Udo,** Department of Crop Science, University of Calabar, PMB 1115, Calabar, Nigeria.

adult insects sieved out were counted, examined with a Nikon binocular microscope (Nikon House, Surrey, England), and identified to species level following the methods of Halstead (1963) and Haines (1991). The data obtained was subjected to the analysis of variance (ANOVA) using the statistical software package SPSS 15.

## RESULTS

The mean monthly numbers of stored product insects per crop (Table 1) showed no significant differences (p = 0.42) in the means. The mean number of all the insect species found in stored cassava was 51.4, maize 55.2, groundnut 31.2 and cowpea 39.4.

**Table 1**: Mean number of stored products insects per crop per month during study period.

| Crop | No. of samples | Mean monthly no. |
|---|---|---|
| Cassava | 15 | 51.40 ± 1.87 |
| Maize | 15 | 55.20 ± 2.47 |
| Groundnut | 15 | 31.20 ± 1.94 |
| Cowpea | 15 | 39.40 ± 2.41 |

Table 2 showed the mean number of insect pests associated with each stored product collected over the study period. The predominant insect species in all crop samples were the red flour beetle, *T. castaneum* and the maize weevil, *S. zeamais* with mean numbers of 30.6 and 28.2 respectively. *T. castaneum* was recorded in all the crop samples, the cowpea bruchid *Callosobruchus maculatus* (Fab.) was sampled only from cowpea seeds, whereas the kapra beetle *Trogoderma granarium* (Everst), the Indian meal moth *Plodia interpunctella* (Hubner) and the rusty grain beetle *C. ferrugineus* were all sampled from stored groundnut. The lesser grain borer *R. dominica* and the Angoumois grain moth *Sitotroga cerealella* (Oliv.) were recorded as insect pests of stored cassava, while *S. zeamais* was primarily associated with maize and occasionally found in cassava.

**Table 2:** Mean number of adult insect species associated with stored-products during sampling period

| Crop | *S. zeamais* | *S. cerealella* | *R. dominica* | *T. castaneum* | *C. maculatus* | *T. granarium* | *C. ferrugineus* | *P. interpunctella* |
|---|---|---|---|---|---|---|---|---|
| Cassava | 4.80 ± 0.77 | 5.00 ± 0.61 | 20.40 ± 1.26 | 10.60 ± 0.72 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 |
| Maize | 23.40 ± 1.53 | 7.00 ± 1.04 | 6.40 ± 0.77 | 9.80 ± 1.15 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 |
| Groundnut | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 4.00 ± 0.82 | 0.00 ± 0.00 | 6.00 ± 0.89 | 14.80 ± 1.31 | 6.40 ± 0.82 |
| Cowpea | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 6.20 ± 1.06 | 24.20 ± 1.92 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 |
| Total | 28.2 | 12 | 26.8 | 30.6 | 24.2 | 6 | 14.8 | 6.4 |

The beneficial insects recovered from the crop samples were *Theocolax elegans* (Westwood), *Anisopteromalus calandrae* (Howard) and *Dinarmus basalis* (Rondani) (Hymenoptera: Pteromalidae). The mean number of *T. elegans* was 4.8 and 4.2 in cassava and maize respectively, while *A. calandrae* was 5.8 in cassava and 4.4 in maize. *D. basalis* had a mean number of 1.37 in groundnut and 9 in cowpea. In comparison to the host density, the density of the parasitoid wasps was low during the study period. The population trends of the insect pests associated with cassava is shown in Figure 1, maize in Figure 2, groundnuts in Figure 3 and cowpea in Figure 4.

In cassava, the populations of *R. dominica* increased rapidly from November 2006 reaching a peak in March 2007, followed by *T. castaneum* while *S. cerealella* and *S. zeamais* were the least. In maize, the peak of *S. zeamais* infestation was in February 2007 with a decrease in March 2007 (Figure2), but the population of *S. cerealella* remained relatively low throughout the study period. The populations of *C. ferrugineus* and *T. granarium* on groundnut increased from November 2006 and reached the peak in March 2007, while the highest numbers of *P. interpunctella* and *T. castaneum* insects was in February 2007 (Figure 3). In cowpea, the population of *C. maculatus* rose steadily from November 2006 till March 2007 while *T. castaneum* population although very low followed a similar pattern (Figure 4).

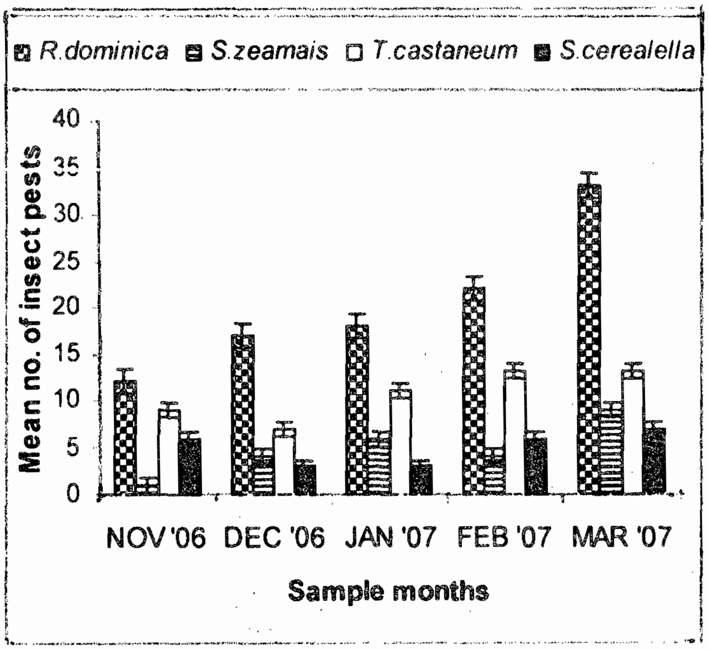


**Figure 1**: Monthly population trends of the insect pests of stored cassava tubers (Mean ± SE) during study period.

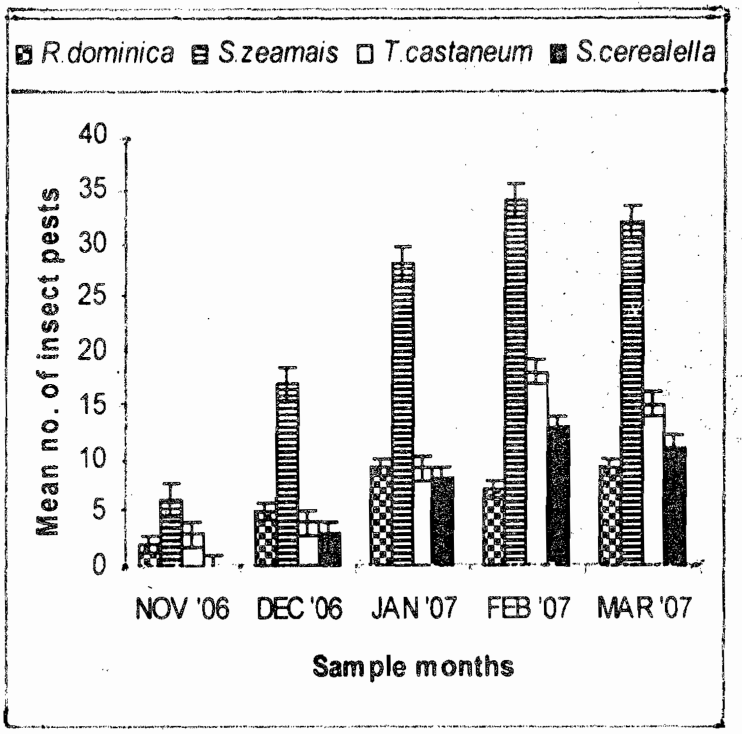


**Figure 2**: Monthly population trends of insect pests of stored maize (Mean ± SE) during the study period.

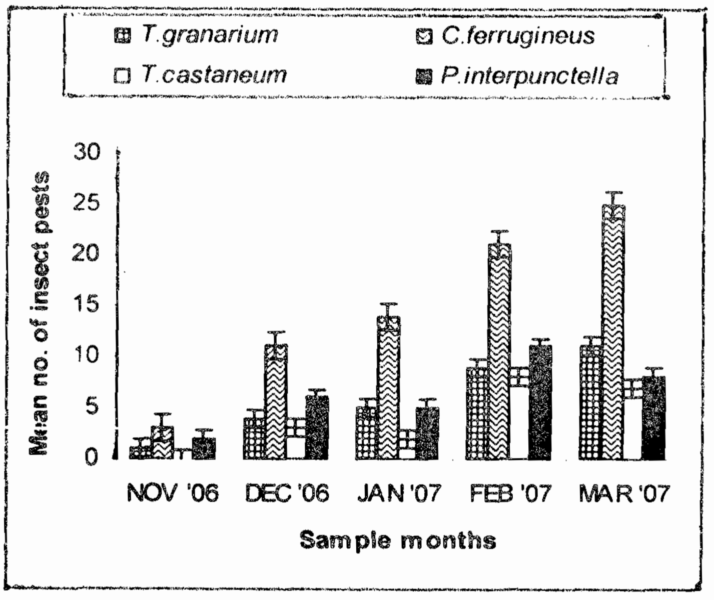


**Figure 3**: Monthly population trends of insect pests of stored groundnuts (Mean ± SE) during study period.

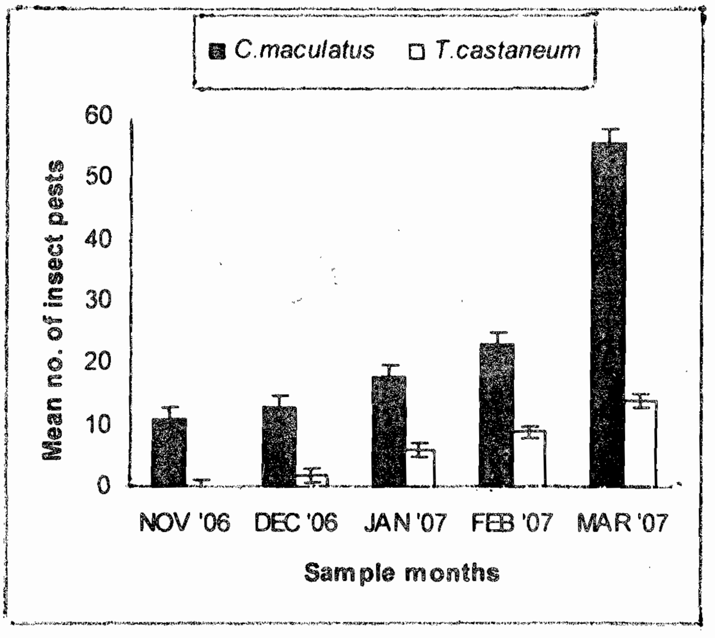


**Figure 4**: Monthly population trends of insect pests of stored cowpea (Mean ± SE) during study period.

**DISCUSSION**

In this study, the naturally infested cassava, maize, groundnut and cowpea storage facilities in which both emigration and immigration of insects likely occurred were analysed. The results showed that *T. castaneum* was the most abundant insect pest and occurred in all the crop samples throughout the monitoring period, followed by *S. zeamais*, *R. dominica* and *C. maculatus* in decreasing order. In all, eleven insect species were encountered and identified signifying that a fairly high insect diversity was observed throughout the study period. The species composition of samples in this study was similar to those found in other surveys of insects in stored maize facility in Madison, Wisconsin, USA (Nansen *et al.*, 2004), millet, maize, cowpea and sorghum facilities in northern Namibia (Stejskal *et al.*, 2006). The sources of infestation of *S. zeamais* and *C. maculatus* are the field prior to harvest, other granaries and abandoned granaries (Arthur *et al.*, 2006). Hence larvae and pupae of these pests are already present when the harvested crops are stored in the granaries. Unlike *S. zeamais*, there is little evidence that *R. dominica* infests ripening grains in the field (Hagstrum, 2001); therefore infestation in storage emanated from either a failure to destroy residual populations from the granaries or from dispersing individuals exploiting unprotected stored grains. This rapid colonization behaviour, strong flight ability and broad polyphagy, coupled with the fact that *R. dominica* has been trapped in diverse environments, including wood-lands substantial distances from grain stores (Cogburn, 1988), suggests the movement of this insect pest between potential natural habitats and grain storage facilities. This movement by *R. dominica* is enhanced by the male-produced aggregation pheromones and host plant volatiles in storage houses (Landolt, 1997; Bashir *et al.*, 2001). Males produce the aggregation pheromone upon location of a suitable food source for feeding and breeding (Edde *et al.*, 2007).

Both the male-produced aggregation pheromones and female-produced sex pheromones of a particular insect species have been reported as attractive to both sexes of the insect in the field and the laboratory resulting in local accumulations on food hosts. (Oehlschlager *et al.*. 1983; Phillips, 1997; Mbata, *et al.*, 2000; Bashir *et al.*, 2001; Olsson *et al.*, 2006; Edde, *et al.*, 2007). Hence, it could be the insects got attracted to stored products in response to the volatiles or odour plumes from the products alone, and in combination with the pheromones emitted by con-specifics' feeding and mating activities while on the stored products.

In contrast to the erratic pattern of field insects, the seasonal pattern of stored products insect density in granaries showed a steady increase throughout the warm months of November to March. The greatest density occurred immediately after the warmest months (January and February) and the lowest density corresponded with the beginning of dry season (November). Cross River has a humid tropical climate with total annual rainfall of 1500-3000 mm, humidity of 65-90%, while ambient temperatures during the study period were 22.2°C-23.8°C minimum, and 27°C-38.2°C maximum. An index of environmental suitability indicated that between 25 °c - 30 °c and 65 %-75 % temperature and RH respectively is the optimal environment for growth and multiplication of most stored products insect populations (Throne, 1994).

Our study showed that beneficial insects were observed in the masses of the stored commodities. Laboratory studies have documented that certain parasitoids observed in this study are capable of suppressing the population growth of associated host insect pest species (Flinn *et al.*, 1996). Studies by Iloba *et al.* (2007) and Amevoin *et al.* (2007) both showed the suppression of *C. maculatus* of stored cowpea by *D. basalis* adults in Nigeria and Togo respectively. Similarly, the parasitic wasp *A. calandrae* has been reported to suppress up to 81% the host populations of *S. zeamais* and *R. dominica*. Other host ranges of *A. calandrae* include the immature stages of *Lasioderma serricorne* (Fab.), *T. granarium*, *C. chinensis* (L.) and *S. oryzae* (L.) (Mahal *et al.*, 2005). *T. elegans* is another cosmopolitan pteromalid wasp that parasitizes the larvae and pupae of stored product grain beetles including *S. zeamais* and *R. dominica* (Flinn *et al.*, 1996). The female parasitoids lay eggs by inserting its ovipositor through the seed coat into the larval or pupal stages of the hosts. The hatching parasitoids larvae suck the host fluids while undergoing three larval instars, before reaching the pupal stage and finally emerging as adults. Emerging adults cause the death of the host insect (Islam, *et al.*, 2003).

This study showed that 4 important stored product crops namely, cassava, maize, groundnuts and cowpea were pre-disposed to insect infestation soon after harvest. The insect pests complex of these crops were *T. castaneum*, *S. zeamais*, *C. maculatus*, *R. dominica*, *S. cerealella*, *P. interpunctella*, *T. granarium* and *C. ferrugineus*. While the beneficial insects were *A. calandrae*, *T. elegans* and *D. basalis* indicating the potential for pest bio-control in Nigeria. Regular sampling and adequate sanitation could alleviate some of the problems associated with insect pest infestations in stored agricultural commodities in the country.

## REFERENCES


Amevoin, K., Sanon, A., Apossaba, M. and Glitho, I.A., 2007. Biological control of bruchids infesting cowpea by the introduction of *Dinarmus basalis* (Rondani) (Hymenoptera: Pteromalidae) adults into farmers' stores in West Africa. J. Stored Products Research 43: 240-247.

Arlian, L.G., 2002. Arthropod allergies and human health. Annual Review of Entomology 47: 395-434.

Arthur, F.A., Hagstrum, D.W., Flinn, P.W., Reed, C.R. and Phillips, T.W., 2006. Insect populations in grain residues associated with commercial Kansas's grain elevators. J. Stored Products Research 42:226-236.

Bashir, T., Birkinshaw, L.A., Hall, D.R. and Hodges, R.J., 2001. Host odours enhance the responses of adult *Rhizopertha dominica* male-produced aggregation pheromone. Entomologia Experimentalis et Applicata 101:273-280.

Campbell, J. F., Muellen, M. A. and Dowdy, A. K., 2002. Monitoring stored-product pests in food processing plants with pheromone trapping, contour mapping and mark-recapture. J. Economic Entomology 95: 1089-1101.

Cogburn, M. W., 1988. Detection, distributional and seasonal abundance of *Sitotroga cerealella* and *Rhyzopertha dominica* as indicated by pheromone-baited adhesive traps. Proceedings of the XVIII International Congress of Entomology, 3-9 July 1988, University of British Columbia, Vancouver, Canada.

Edde, P.A., Phillips, T.W., Robertson, J.B. and Dillwith, J.W., 2007. Pheromone output by *Rhyzopertha dominica* (Coleoptera: Bostrichidae), as affected by host plant and beetle size. Ann. Entomol. Soc. Am. 100(1): 83-90.

Flinn, P.W., Hagstrum, D.W. and McGaughey, W.H., 1996. Suppression of beetles in stored wheat by augmentative releases of parasitic wasps. Environmental Entomology 25: 505-511.

Golob, P., Farrell, G. and Orchard, J.E., 2002. Crop post-harvest: science and technology. Volume 1. Principles and practice. Blackwell Publishing, Oxford, 554pp.

Hagstrum, D. W., 2001. Immigration of insects into bins storing newly harvested wheat on 12 Kansas farms. J. Stored Products Research 37: 221-229.

Haines, C.P., 1991. Insects and Arachnids of Tropical stored products: Their biology and identification (A training manual). Natural Resources Institute, Chatham, UK, 246pp.

Halstead, D. G. H., 1963. External sex differences in stored products Coleoptera. Bull. Entomol. Research 54: 119-134.

Hubert, J.,Stejskal, V., Kubatova, A., Munzbergova, Z., Vanova, M. and Zdarkova, E., 2002. Mites as selective fungal carriers in stored grain. Exp. Appl. Acarology 29: 69-87.

Hubert, J., Stejskal, V., Munzbergova, Z., Kubatova, A., Vanova, M. and Zdarkova, E., 2004. Mites and fungi in heavily infested crops in the Czech Republic. J. Economic Entomology 97: 2144-2153.

Iloba, B.N., Umoetok, S.B.A. and Keita, S., 2007. The biological control of *Callosobruchus maculatus* (Fabricius) by *Dinarmus basalis* (Rondani) on stored cowpea (*Vigna unguiculata* Walp) seeds. Research J. Applied Sciences 2(4): 397-399.

Islam, W., Ahmed, K.N. and Malek, M. A., 2003. Suppression of residual populations of pulse beetle, Callosobruchus maculatus (F.) by parasitoid Dinarmus basalis (Rond.) (Hymenoptera: Pteromalidae). Bangladesh J. Entomology 13: 103-110.

Landolt, P.J., 1997. Sex attractant and aggregation pheromones of male phytophagous insects. American Entomol., 43: 12-22.

Mahal, N, Islam, W., Parween, S., and Mondal, K.A.M.S.H., 2005. Effect of *Anisopteromalus calandrae* (Hymenoptera: Pteromalidae) in controlling residual populations of *Rhyzopertha dominica* (Coleoptera: Bostrichidae) in wheat stores. International J. Tropical Insect Science 25(4): 245-250.

Mbata, G. N., Shu, S. and Ramaswamy, S. B., 2000. Sex pheromones of *Callosobruchus subinnotatus* and *C. maculatus* (Coleoptera: Bruchidae): congeneric responses and role of air movement. Bull. Entomol. Research 90: 147-154.

Nansen, C., Phillips, T.W. and Palmer, M.W., 2004. Analysis of insect community in stored-maize facility. Ecological Research 19: 197-207.

Oehlschlager, A.C., Wong, J.W., Verigin, V.G. and Pierce, H.D., 1983. Synthesis of two macrolide pheromones of the rusty grain beetle, Cryptolestes ferrugineus (Stephens). J. Organic Chemistry 48: 5009-5017.

Olsson, P.O. C., Ryne, C. Wallen, R., Anderbrant, O. and Lofstedt, C., 2006. Male-produced sex pheromone in *Tribolium confusum*: Behaviour and investigation of pheromone production locations. J. Stored Products Research 42: 173-182.

Phillips, T. W., 1997. Semiochemicals of stored product insects: Research and applications. J. Stored Products Research 33(1): 17-30

Rajendran, S., 2005. Detection of insect infestation in stored foods. Advances in food and nutrition research 49: 163-232.

Reed, C.R., Hagstrum, D.W., Flinn, P.W. and Allen, R.F, 2003. Wheat in bins and discharge spouts, and grain residues on floors of empty bins in concrete grain elevators as habitats for stored-grain beetles and their natural enemies. J. Economic Entomology 96: 996-1004.

Stejskal, V., Kosina, P. and Kanyomeka, L., 2006. Arthropod pests and their natural enemies in stored crops in northern Namibia. J. Pesticide Science 79: 51-55.

Throne, J. E., 1994. Life history of Immature maize weevils (Coleoptera: Curculionidae) on Corn stored at constant temperatures and relative humidities in the Laboratory. Environmental Entomology 23(6): 1459-1471.

Wild, C.P and Hall, A.J., 2000. Primary prevention of hepatocellular carcinoma in developing countries. Mutat. Research 462: 381-393.