

# Comparative Efficacy of Insecticidal Plants on the Management of Groundnut Bruchid (*Caryedon Serratus*)

Simon Idoko Okweche

Department of Forestry and Wildlife Resources Management, University of Calabar, PMB  
1115, Calabar, Nigeria.

Phone: +2347034967125

Sylvia Bassey Umoetok

Department of Crop Science, University of Calabar, PMB 1115, Calabar, Nigeria

Phone: +2347034966700

Ukatu, Patrick Odey

Department of Crop Science, University of Calabar, PMB 1115, Calabar, Nigeria

Received: March 9, 2016      Accepted: March 21, 2016      Published: June 31, 2016

doi:10.5296/jas.v4i3.9681      URL: <http://dx.doi.org/10.5296/jas.v4i3.9681>

## Abstract

Laboratory study was conducted to determine the efficacy of insecticidal plant extracts *Azadirachta indica* A. (Juss), *Lantana camara* L. (Verbenaceae), *Eupatorium odoratum* L. (Asteraceae), *Tephrosia vogelii* Hook, *Afromomum melegueta* K.M. (Schumann) and *Ocimum gratissimum* (L) leaves against groundnut bruchid beetle (*Caryedon serratus*), and a synthetic insecticide (Cypermethrin) (10EC) under ambient condition of temperature and relative humidity (30 °C and 72%). One hundred grams of shelled groundnut was weighed into jute bags and treated with powders of the insecticidal plants. Both treated and untreated bags of groundnut were then infested with newly emerged adult of *C. serratus* (20 per bag) and covered. The experiment was laid out in Completely Randomized Design (CRD) and replicated four times. Parameters assessed included number of egg oviposited, number of eggs hatched (eclosion) and number of adults that emerged from each treatment, total developmental period (egg – adult), sex ratio of the emerged adults and finally percentage germination of the treated seeds. Data collected were analyzed using analysis of variance and treatment means were separated using Duncan multiple range tests at  $P \leq 0.05$  level of significance. Results showed that *A. indica*, *L. camara*, *T. vogelii*, *A. melegueta* and *O. gratissimum* treated seeds significantly recorded lowest mean number of eggs, reduced

damage by *C. serratus* and increased germination percentage compared with *E. odoratum* and control. In conclusion, *A. indica*, *L. camara*, *T. vogelli*, *A. melegueta* and *O. gratissimum* the potentials as alternatives to synthetic insecticides in the management of *C. serratus* by resource poor farmers.

**Keywords:** *Caryedon serratus*, damage, groundnut, germination percentage, Insecticidal plants, synthetic insecticide

## 1. Introduction

A major arable crop cultivated in the tropical and subtropical regions of the world is the leguminous crop - groundnut (*Arachis hypogea*) of the family Fabaceae. Groundnut (*Arachis hypogea*) which is commonly stored as staple for man has several benefits - the grains are cheap source of protein to man (Alabi *et al.*, 2003) and in recent times, largely depends on it because of the rising cost of meat, fish and egg and other protein products. Groundnut is rich in vitamins, minerals and oil. Its other importance is in the livestock industry, fibre production (Rachie, 1985) and restoration of soil fertility/erosion control (Okigbo, 1978). Reasonable losses of between 20 – 50% have been reported on stored groundnut due to attack by groundnut bruchid (*Caryedon serratus*) and may sometimes reach 100% if not controlled (Alabi *et al.*, 2003). Apart from direct damage to the grains, losses may also occur as a result of contamination with the insect waste materials such as faeces, nitrogenous wastes and exuviae (Emoisairue *et al.*, 2004). Effort has been made by farmers in the management of groundnut bruchid amongst which includes the use of synthetic and non-synthetic insecticides.

Currently, insect control in stored products relies primarily upon the use of gaseous synthetic fumigants and residual insecticides, both of which may pose serious hazards to humans and the environment. Residues of methyl bromide, one of the two synthetic fumigants still used in the disinfestations of stored foods, have been found to exhibit carcinogenic effects in rats (Dansie *et al.*, 1984). Of recent, many researchers have turned to the use of botanicals and plant products in the control of pest due to the hazardous effects of synthetic insecticides on the environment (Omongo, *et al.*, 1997). The protection of stored products by the use of plant materials is a common practice among smallholder farmers in Africa. Repellent, anti-feedant, and insecticidal substances have been identified in a large variety of plant species, long before the “industrial insecticide revolution” in the 1930’s and 1940 when compounds such as nicotine and pyrethrum were the only effective insecticides (Mahdi, 2008). Azadirachtin, a component of *A. indica* is presently considered as a promising alternative to synthetic insecticides, and is currently used by developed and developing countries for the control of both field and stored insect pests (Rajapakse *et al.*, 2002; Rajapakse and Ratnasekera, 2009, Okweche, *et al.*, 2013). The aim of the experiment was to investigate the efficacy of *A. indica*, *L. camara*, *E. odoratum*, *T. vogelii* against the groundnut bruchid (*Caryedon serratus*), in comparison it with synthetic insecticide (Cypermethrin) (10EC).

## 2. Materials and methods

### 2.1 Legume Grains

Shelled groundnut used for the trial was obtained from Abuochiche market in Bekwarra local

government area of Cross River State and stored in jute bags in the Crop Science Departmental Lab, University of Calabar till when needed.

### 2.2 *Caryedon serratus*

The method of Ousman *et al.* (2007) was adopted in the mass production of *C. serratus*. The mass production of *C. serratus* took place in the Crop Science Laboratory, University of Calabar, Nigeria, under ambient temperature and relative humidity ( $28 \pm 5$  °C and 66.6%), respectively. Hundred newly emerged adults of *C. serratus* of mixed sexes (male and female) were obtained from a laboratory stock culture and reared on 100 g each of *A. hypogea* in perforated plastic containers and covered with muslin cloth. After one week, when oviposition had been noticed, the parent stocks of *C. serratus* were removed by sieving the grain with a 2.00 mm sieve. The grains with the oviposited ova were left under laboratory conditions till emergence of F1 progeny. The F1 progenies from the cultures were then used for the experiment.

### 2.3 Plant materials

The plant materials used for this study were collected from forestry plantation of the Department of Forestry and Wildlife Resources Management, University of Calabar. The plant materials were shade-dried for three weeks until a constant weight was maintained. They were ground and sieved into powder using 0.20 mm mesh sieves preserved in plastic air-tight bottles under refrigeration until needed.

### 2.4 Phyto-chemistry of plant materials

The 5 g of each powdered plant material was weighed using an electronic weighing balance and mixed in 25 ml of distilled water, steamed for 35 minutes on a bath at 60 °C and then filtered using filter paper (Whatman). The filtrates were then centrifuged at 2500 rpm for 15 min, the supernatants were discarded and the residues stored in sterile bottles at 5 °C according to Harbone (1973). The samples were later tested for alkaloids, glycosides, saponins, reducing sugar, tannins, steroids, resins and acidic compounds.

### 2.5 Experimental design

A total of 32 jars (with diameter 0.09 m, volume 3.69 m<sup>3</sup>) were used for the experiment. Twenty newly emerged *C. serratus* adults of less than 24 hrs old (10 males and 10 females) were introduced into each of the jars containing 30 g of grains (*A. hypogea*) containing 1 g each of the botanicals (*A. indica*, *E. odoratum*, *L. camara*, *T. vogelii*, *A. melegueta*, *O. gratissimum*). The Cypermethrin (10EC) was applied at the rate of 0.1 g per 30 g of each legume grain which serves as standard control and an untreated jar which serves as control group was set up with the grains and *C. serratus* with no botanical (experimental control). Each jar was covered with a muslin cloth to allow air movement and prevent insects from escaping. The experiment was laid out in a completely randomised design (CRD) and each treatment was replicated four times at 24 hr intervals and was randomly assigned to positions at a temperature of 26 °C and relative humidity of 75%. The set up was allowed for four days with daily monitoring.

Data were collected on the total number of egg oviposited, number of eggs hatched (eclosion)

and number of adults that emerged from each treatment. The total developmental period (egg – adult) and the sex ratio of the emerged adults were also recorded and analyzed using analysis of variance. Germination percentage of the seeds was assessed by placing the seeds in a germination medium and assessed at 5, 7 and 10 days after germination trial. Dead insects in each jar was collected and counted and the percentage insect mortality was calculated thus:

$$\text{Percent insect mortality} = \frac{\text{number of dead insects} \times 100}{\text{total number of insects}}$$

The results were then subjected to analysis of variance using Statview software and means separated using New Duncan Multiple Range Test (NDMRT) at 5% level of significance

### 3. Results

The phyto-chemical studies of eight powdered plant materials used in this study indicated that alkaloids were highly present in *L. camara*, *T. vogelii*, and *A. melegueta*; it was also found to be present in low concentrations in *A. indica*, *E. odoratum* and *O. gratissimum*. Similarly, glycosides were found to be abundantly present in *O. gratissimum*, and highly present in *A. indica*, *A. melegueta* while in moderate concentrations in *T. vogelii* and in slightly present in *L. camara*, and *E. odoratum*. More so, saponins were present in abundant concentration in *A. melegueta*, high in *O. gratissimum*, *T. vogelii*, and *E. odoratum* while moderately present in *A. indica*, and *L. camara*. Tannins were found to be abundantly present in *A. melegueta*, high in *T. vogelii*, moderately present in *A. indica* and *L. camara*, *O. gratissimum* and *E. odoratum*. Reducing sugars were moderately present in *T. vogelii*, *A. melegueta* and *O. gratissimum* and slightly present in *A. indica* and *E. odoratum* while absent in *L. camara*. Furthermore, steroids were found in abundant in *A. melegueta* and high in *T. vogelii* while slightly present in *A. indica*, *L. camara*, *E. odoratum* and *O. gratissimum*. Resins were found in very low concentrations in all the tested plants and completely absent in *T. vogelii* while Acidic compounds were found in low concentrations in *L. camara*, *E. odoratum* and completely absent in other tested plants (Table 1).

The insecticidal plants and synthetic insecticide were found to have effects on oviposition and development of the bruchid (*C. serratus*) on groundnut. The results showed that *A. indica*, *A. melegueta*, *O. gratissimum* and Cypermethrin, were the most effective insecticides which were significantly ( $P < 0.05$ ) different from other treatment and the control which recorded the highest mean number of 50.10 eggs. *E. odoratum*, *L. camara* and *T. vogelii* with mean numbers of 8.45, 5.20, and 5.20 were significantly ( $P < 0.05$ ) different from the control where no insecticide was applied. Similar trend was observed in the mean number of eggs hatched with control having the highest number of 42.8 eggs hatched and the least recorded in *A. indica*, *A. melegueta*, *O. gratissimum* and Cypermethrin (Table 2). All the bruchid exposed to Cypermethrin had 100 percent mortality at 18 hours after application which was not significantly different from *A. indica*, *A. melegueta*, *O. gratissimum*, *Eupatorium odoratum*

Table 1. Phytochemical Compositions of the Biopesticidal Plants

Parameters	<i>Azadirachta indica</i>	<i>Lantana camara</i>	<i>Eupatorium odoratum</i>	<i>Tephrosia vogelii</i>	<i>Aframomum melegueta</i>	<i>Ocimum gratissimum</i>
Alkaloids	+	+++	+	+++	+++	+
Glycosides	+++	+	+	++	+++	++++
Saponins	++	++	+++	+++	++++	+++
Reducing sugar	+	-	+	++	++	++
Tannins	++	++	++	+++	++++	++
Steroids	+	+	+	+++	++++	+
Resins	+	+	+	-	+	+
Acidic compounds	-	+	+	-	-	-

**KEY** + = slightly present, ++ = moderately present, +++ = highly present, ++++ = abundantly present, - = absent

 Table 2. Insecticidal effect of treatments on oviposition and development of *Careydon serratus*

Treatment	No of eggs laid (Mean)	No of egg hatched (Mean)	No of dead bruchids (Mean)
A. indica	0.45 ± 0.02c	0.11 ± 0.74c	19.00 ± 2.17 a
E. odoratum	8.45 ± 2.13b	4.3 ± 1.23b	3.32 ± 0.87c
L. camara	5.20 ± 2.02b	2.4 ± 0.14b	9.14 ± 1.75b
T. vogelii	5.20 ± 2.02b	1.7 ± 0.76b	15.10 ± 2.11ab
A. melegueta	0.45 ± 0.02c	0.11 ± 0.74c	19.00 ± 2.17 a
O. gratissimum	0.45 ± 0.01c	0.11 ± 0.74c	20.00 ± 2.32 a
Cypermethrin	0.45 ± 0.01c	0.11 ± 0.74c	20.00 ± 2.32a
Control	50.10 ± 4.45a	42.8 ± 4.23a	1.00 ± 0.02c

Sample means followed by the same alphabets are not significantly different from each other (DMRT 0.05)

Table 3. Effect of insecticidal plants and synthetic insecticide on percent mortality of *C. serratus*

Powder	Mortality (hours)			
	6	12	18	24
<i>A. indica</i>	60	65	98	100
<i>E. odoratum</i>	10	20	40	50
<i>L. camara</i>	35	50	70	85
<i>T. vogelli</i>	44	60	70	80
<i>A. melegueta</i>	50	68	98	100
<i>O. gratissimum</i>	50	78	99	100
Cypermethrin	80	95	100	100
Control	0	0	0	5

recorded 50 percent mortality at 24 hours after application which was the least efficacious. *Lantana camara* and *T. vogelli* recorded were effective at 24 hours after application recording 80 and 85 percent respectively. Control experiment had the least percent mortality (5%) after 24 hours while *E. odoratum* recorded 50 % mortality after 24 hours of introduction of the bruchids (Table 3).

A significantly higher developmental period 23.2 days was recorded in *E. odoratum* and control experiment compared with *L. camara* and *T. vogelli* with developmental periods of 19.2 and 18.3 days respectively. The result showed a non-significant ( $P > 0.05$ ) effect on the sex ratio with males and females having similar result (Table 4). Table 5 shows the result of percentage germination of groundnut treated with the various insecticides. An average of 97% germination was recorded from Cypermethrin, *A. indica*, *A. melegueta*, *O. gratissimum*, *L. camara* and *T. vogelli* treated seeds while 65% was recorded from *E. odoratum* treated seeds and the control experiment respectively

#### 4. Discussion

Long term use of synthetic insecticides have culminated into serious health and environmental issues (Nathan and Kalavani, 2006) which redirect the researchers to look for some safer alternatives and ecologically acceptable pesticides with no or less residual effect and resistance development property, for the control of important insect pests. The results of the present study indicate that, *A. indica*, *A. melegueta*, *O. gratissimum*, *L. camara* and *T. vogelli* can be used successfully against groundnut bruchid.



Table 4. Insecticidal effect of treatments on developmental period and sex ratio of *Careydon serratus* on groundnut seeds

Treatment	Eggs laid (X) (Male : Fem)	No of adult (X) emergence	Developmental period (days)	Sex Ratio (M:F)
<i>A. indica</i>	0.45±0.02 <sup>c</sup>	0.00±0.00 <sup>c</sup>	0.00±0.00 <sup>c</sup>	1:0
<i>E. odoratum</i>	8.45±2.13 <sup>b</sup>	7.11±1.23 <sup>b</sup>	23.2±3.23 <sup>a</sup>	5:4
<i>L. camara</i>	5.20±2.02 <sup>b</sup>	5.11±0.24 <sup>b</sup>	19.2±1.68 <sup>b</sup>	3:3
<i>T. vogelii</i>	6.16±1.45 <sup>b</sup>	5.23±1.12 <sup>b</sup>	18.3±2.14 <sup>b</sup>	4:4
<i>A. melegueta</i>	0.45±0.01 <sup>c</sup>	0.00±0.00 <sup>c</sup>	0.00±0.00 <sup>c</sup>	0:0
<i>O. gratissimum</i>	0.45±0.01 <sup>c</sup>	0.00±0.00 <sup>c</sup>	0.00±0.00 <sup>c</sup>	0:0
Cypermethrin	0.45±0.01 <sup>c</sup>	0.00±0.00 <sup>c</sup>	0.00±0.00 <sup>c</sup>	0:0
Control	50.10±4.45 <sup>a</sup>	50.32±7.23 <sup>a</sup>	23.2±4.15 <sup>a</sup>	10:9

Sample means followed by the same alphabets are not significantly different from each other (DMRT 0.05)

Table 5. Effect of plant powders and synthetic insecticide on germination percentage.

Treatment	5 DAT	7 DAT	10 DAT
<i>A. indica</i>	75±5.54a	98±6.65a	98±6.65a
<i>E. odoratum</i>	60±3.22b	60±3.22b	65±4.34b
<i>L. camara</i>	78±6.66a	97±6.54a	97±6.54a
<i>T. vogelii</i>	77±4.74a	97±6.54a	97±6.54a
<i>A. melegueta</i>	80±3.58a	95±6.00a	99±6.14a
<i>O. gratissimum</i>	76±3.12a	97±6.54a	99±6.54a
Cypermethrin	70±3.7ab	95±4.40a	95±4.40a
Control	60±3.22b	65±3.30b	65±3.30b

Sample means followed by the same alphabets are not significantly different from each other (DMRT 0.05)

Of the six insecticidal plants used for the protection of stored groundnuts, *E. odoratum* was less effective on the survival of *C. serratus* adults. The reason why the plant is used in spite of their lack of effectiveness is not clear. Their common feature is a strong smell, which is believed to repel or kill insects, but this is obviously not always the case. However, Shivan *et. al.*, (2009) had reported a significant population and damage by *H. amigera* on cabbage in *E. odoratum* treated plants compared with *L. camara* and *T. vogelli* recording lower population of same pest. Neem extracts and neem based insecticides are reported effective on

a wide range of insect pests on field crops (Baidoo *et al.*, 2006, Okweche, *et al.*, 2013). The use of compounds such as neem (*Azadiractha indica*) extract or extract from *T. vogelii* has been attempted in stem-borer in Africa and elsewhere (Ploaszek, 1998). It has been reported that, several centuries before synthetic insecticide became available, farmers in India protected their crops with natural insecticides found in neem fruits and leaves (Polaszek, 1998). The insecticidal properties of neem products as reported by many authors (Schmutterer, 1990; NRC, 1992; Emosairue and Ukeh, 1996) have therefore been confirmed in this study. Emosairue and Ukeh (1996) reported that the behavior of insect towards a neem- treated seeds is a manifestation of repellence and phagodeterrence due to antifeedant effects. Ukeh *et al.* (2007) reported that neem has high contact toxicity on insect pest resulting in complete death of the pests or rendering them inactive. Recently, evidences on neem efficacy on insect pests of cowpea and some other crops in Nigeria have mounted and many cowpea researchers have given useful information on the potentials of neem in insect pests control (Amatobi, 2000; Oparaeke, 2005).

The report on chemical constituents of *L. camara* showed that the plant contains some active ingredients known as terpenes which is effective against insect pest and mosquito larvae (Sarath, *et al.*, 2004; Adenikan, 2013). Powders or extracts of *T. vogelii*, *A. indica* and *L. camara* have been shown in the past to be toxic to insects to insects such as *Callosobruchus maculatus* (Ukeh, *et al.* 2009), maize stem borers (Okweche, *et al.* 2013). It was considered at that time that *T. vogelii* itself had a potential as an economic source of rotenone, however, the rapid development of the chemical industry interrupted the spread of insecticides of vegetable origin (Golob *et al.*, 1999). The nature of the active compound of *T. vogelii*, *A. indica* and *L. camara*, which could possibly be the one responsible for its anthelmintic properties, will be the subject of further investigation by the authors. Its mode of action, persistence and spectrum of activity against other stored products insects, as well as the optimal size of particles and level of application necessary to afford complete protection of stored grain, will also be determined.

The effectiveness of *A. melegueta* and *O. gratissimum* in causing mortality could be attributed to the presence of essential oils in the leaves and stems (Afolabi *et al.*, 2007). The phytochemical analysis of the six biopesticides used revealed that they contained terpeneol, alkaloids, glycosides, steroids, flavonoid as active ingredients. The active ingredients may be responsible for the noticed biopesticidal effectiveness. This finding is in line with that of Eke *et al.* (2013) that aromatic compound such as terpeneol, glycosides, saponin and flavonoid has ovicidal, toxic and deterrent effects on stored product coleopterans. Out the six species of plant used against the bruchid, the extract of three plants (*A. indica*, *T. vogelii*, *L. camara*, *A. melegueta* and *O. gratissimum*) could induce mortality of *C. serratus*. It is doubtless that these plants will provide eco-friendly compounds for vectors control as these plants are widely used as spice and in therapeutics, it will not cause any harm to the flora and fauna. These plant products matched the efficacy of Cypermethrin whose undesirable side effects emanating from its use pose problems to the human environment and danger of mammalian toxicity; hence, *A. indica*, *T. vogelii*, *L. camara*, *A. melegueta* and *O. gratissimum* are recommended to farmers for the preservation of groundnut seeds against infestation of



bruchid beetles during storage. The practice of mixing plants or parts of plants to stored grain appears to be more a token of allegiance to tradition than an effective control measure.

## References

- Afolabi C. A., Ibukun E. O., Afor, E., Obuotor, E. M., & Farombi, E. O. (2007). Phytochemical constituent and antioxidant activity of extract from the leaves of *Ocimum gratissimum*. *Sci. Res. Essay* 2:163-166.
- Alabi, O.Y., Odebisi, J. A., & Jackai, L. E. N. (2003). Field evaluation of cowpea cultivars (*Vigna unguiculata* (L) Walp.) for resistance to flower bud thrips (*Megalurothrips sjostedti* Trybom) Thysanoptera: Thripidae) *International Journal of Pest Management*, 49 (4), 287- 291. <http://dx.doi.org/10.1080/0967087031000123706>
- Amatobi, C. I. (2000). Cashew plant extract as a promising aphicide in cowpea insect pest management. *Abstracts of paper and poster presentations*. World Cowpea Res. Conf.111. IITA-Ibadan, Nigeria, p.11.
- Baidoo, P. K. Adam J. I., & Sarpong-Nsiah, M. (2006).The role of extracts of *Azadirachtaindica* (A. Juss) and *Lantana camara* (L) in the reduction of damage done to maize plants by Lepidopterous stem-borers. *International Journal of Food and Agricultural Research*, 3(1), 66-70
- Dansi L, Van Velson F. L., & Vander Heuden C. A (1984). Methyl bromide: carcinogenic effects in the rat fore stomach. *Toxicol. Appl. Pharmacol.* 72, 262-271
- Eke, F. N.; Onah, I. E.; Atama, C. F.; Ivoke, N., & Eyo, J. E. (2013). Effectiveness of botanical powders against *Callosobruchus maculatus* (Coleoptera: Bruchidae) in some stored leguminous grains under laboratory conditions. *African Journal of Biotechnology*, 12(12), 1384-1391
- Emosairue, S. O. & Ukeh, D. A. (1996).Field trials of Neem products for the control of okra flea beetles (*Podagrica* sp.) in South-Eastern Nigeria. *African Journal of Plant Protection*, 37, 22-26.
- Emosairue, S. O.; Nwofia, G. E., &Umuetok. S.B.A. (2004). Observation on the Insect complex associated with cowpea (*Vigna unguiculata*) (L.) Walp in Umudike, South- eastern. *Nigeria Journal of Sustainable Agricultural Environment*, 6(1), 38-43.
- Golob, P. et al. (1999), The Use of Spices and Medicinals as Bioactive Protectants for Grains. Rome: Food and Agriculture Organization of the United Nations. Retrieved August9, 2006, from <http://www.fao.org/docrep/x2230e/x2230e11.htm>
- Harbone J. B (1973). *Phytochemicals Methods*. London: Chapman and Hall.
- Mahdi S. H. A., & Rahman, M. K (2008). Insecticidal effect of some spices on *Callosobruchus maculatus* (Fabricius) in black gram seeds. *Univ. J. Zool. Rajshahi Univ*, 27, 47-50.
- Nathan, S. S., & Kalaivani, K. (2006). Combined effects of azadirachtin and

nucleopolyhedrovirus (SplNPV) on *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) larvae. *Biological Control*, 39, 96-104.

Okigbo, B. N. (1978). *Grain legumes in the agriculture of the tropics*. In Pests of Grain legumes Ecology and control (Edited by Singh S.R. Van emden H.E. and Taylor T.A) Academic Press, Inc., New York.

Okweche, S. I, Ukeh D. A., & Udo, I. A. (2013) Comparative efficacy of pesticidal plant products and Carbofuran in the management of maize stem borers in Nigeria. *Biopesticide International*, 9(1), 23-30.

Omongo, C. A., Adipala, E., Ogenga Latigo, M. W., & Kyamanywa, S. (1997). Insecticide application to reduce pest infestation and damage on cowpea in Uganda. *African Journal of Plant Protection*, 4(2), 91-100.

Oparaeke, A. M. (2005). Studies on insecticidal potential of extracts of *Gmelina arborea* products for control of field pests of cowpea, *Vigna unguiculata* (L) Walp. The pod borer *Maruca vitrata* and the coreid bug, *Clavigralla tomentosicollis*. *Journal of Plant Protection Research*, 4 (1).

Ousman A, Ngassoum M. B, Essia-Ngang J. J., Ngamo L. S. T., & Ndjouenke, R. (2007). Insecticidal activity of spicy plant oils against *Sitophilus zeamais* in stored maize in Cameroon. *Agric. J.* 2:192-196.

Polaszek, A. (1998). *African Cereal Stem Borers: Economic Importance, Taxonomy, Natural Enemies and Control*. Wallingford, UK: CABI, 530.

Rajapakse, R. H. S., & Disna R. (2009). Pesticidal potential of some selected tropical plant extracts against *Callosobruchus maculatus* (F) and *Callosobruchus chinensis* (L) (Coleoptera: Bruchidae). *Tropical Agricultural Research and Extension, Sri Lanka*, 11.

Rajapakse, R. H. S., Rajapakse, H. L. de Z., & Disna R. , (2002). Effect of botanicals on oviposition, hatchability and mortality of *Callosobruchus maculatus* L. *Entomon*, 27(1), 93-98.

Sarath, M., Varun, N., & Minija, J. (2004). Herbal larvicides to control mosquito larvae. *Natural Product Radiance*, 3(1) 24-26.

Schmutterer, H. (1990). Properties and potential of natural pesticides from the Neem tree, *Azadirachta indica*. *Annual Review of Entomology*, 35, 271-97.

Shivan R. Y., & Sachinkumar R. P. (2009) Field efficacy of plant extracts on larval populations of *Plutellaxylostella* L. and *Helicoverpa armigera* Hub. and their impact on cabbage infestation. *Journal of Biopesticides*, 2(1), 32-36.

Ukeh, D. A, Birkett, M. A., Bruce, T. J. A., Allan, E. J, Pickett, J. A., & Mordue, A. J. (2009). Behavioural responses of the maize weevil, *Sitophilus zeamais*, to host (stored-grain) and non-host plant volatiles. *Journal of Pest Management*, 66(1), 44-50.

Ukeh, D. A., Emosairue, S. O., Udo I. A., & Ofem, U. A. (2007). Field Evaluation of Neem

---

(*Azadirachta indica* A. Juss) products for the management of lepidopterous stem borer of maize (*Zea mays* L.) in Calabar, Nigeria. *Research Journal of Applied Science* (Medwell) 2(6) 653-658.

### **Copyright Disclaimer**

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/3.0/>).