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Bioassay and Efficacy of Ethanol Extracts of Selected Plant Materials for the Management of Kola Weevil *Balanogastris kolae* (Coleoptera; Curculionidae) on Stored Kola Nuts

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ABSTRACT: Kola weevil (*Balanogastris kolae)* is one of the major insect pests of stored kola nuts in Nigeria. A bioassay was conducted for contact and residual effects of four plant ethanol extracts on *B. kolae* adult and larvae. Cured kola nuts were treated with the extracts and stored for three months to evaluate their potency in protecting stored kola nuts against *B.kolae* infestation. The extracts were seeds of *Azadirachta indica, Jatropha curcas, Piper guineese and Affiramomum melegueta.* They were applied at 50%, 75% and 100% concentration levels on adult and larvae while kola nuts were treated with 50% and 75% concentrations of the extracts and were stored for three months. Cypermethrin 2.5EC was used as a standard check. Larvae and adult mortality were recorded at 20 minutes intervals for 24hour on bioassay while exit holes, larvae and adult emergence were recorded on stored kola after three months. All the extracts at different concentrations had contact and residual effects on *B. kolae*. *A. indica*, *P. guineense and A. meleguata* gave 80-100%adult and larve mortality of *B.kolae* in all concentrations; their efficacies were comparable to cypermethrin. The *B.kolae* development and emergence from treated stored kola nuts at the various treatment levels decreased with increased concentration of the extracts applied. There were no significant differences ($p>0.05$) among the various treatments on exit holes, larval and adult emergence on stored kola nuts. The ethanol extracts of the four test plants can be used at concentrations of 50% and75% to reduce the menace of kola weevil.

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Kola of the family Sterculiaceae is an important economic cash crop in Africa. They are mostly produced in Africa and are cultivated in large quantity in Nigeria, Ghana, Ivory Coast, Brazil and the West Indian Islands (Eijnatten, 1973; Opeke, 1982 and Oladokun, 1982). Annual production from these countries alone is 250,000 tons, while the world production is about 300,000 tons (AHS, 2002). Kola is an important economic cash crop to a significant proportion of Nigerian populace who are involved in kola farming, trading and industrial utilization. (Asogwa *et al*., 2012). Two species; *Cola nitida* (vent) schott and Endl and *Cola acuminata* (*P. Beav*) Schott and Endl are of major economic importance (Olademokun 1982). *Cola nitida* .are widely cultivated across West Africa and Nigeria accounts for about 70% of the total world production (Quarcoo, 1973; Pala, 1976, Oluokun and Oladokun, 1999). *Cola nitida*, which is regarded as "the true kola of commerce" has featured in the internal trade of West Africa for a number of centuries (Nzekwu, 1961 and Eijnatten, 1969). The importance of kola-nut to the Nigerian economy cannot be overemphasized. Kola nuts are second in value as a commercial crop to Cocoa in the Southern part of Nigeria (Adejompo, 2014). They are used as a masticatory and stimulant in the tropics and has social and traditional significance as it features in many traditional ceremonies in Nigeria (Asogwa *et al.,* 2012). The C. *nitida* and C. *acuminata* being the only two species widely exploited and cultivated are grown on large scale in Nigeria. Out of the two species, *Cola nitida* is being traded internationally, while the consumption of C. *acuminata* is confined to southern Nigeria. Kola nuts are utilized industrially for pharmaceutical production, soft drinks and wine and confectionaries (Beattie, 1970 and Oguuga, 1975). Kola nuts are susceptible to insect pest attack from field to storage. The kola weevils *Balanogastris kolae* and *Sophrorhinus* spp (Coleoptera: Curculionidae) are the most destructive field to store pests of kola nuts in West Africa (Daramola, 1973; Ivbijaro, 1977). Kola weevils can cause up to 100% loss if left uncontrolled in storage and the infestation predisposes the nuts to secondary invasion by microorganisms, especially fungi which further lower the market value and eventually results

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in total destruction of the nuts (Asogwa *et al.*, 2008). .In Nigeria, high levels of infestation have been reported both in the plantations and in storage depending on the sanitary condition of the farm at the time of harvest (Daramola, 1973). Damage by the weevil is done through the feeding activities of the larvae which pupate inside the nut with the adults emerging through circular holes. Breeding persists throughout the year on left over nuts and nuts produced in-between the main harvest seasons (Alibert and Mallamaire, 1955; Daramola, 1978)**.** Current management practice of the weevil relies mainly on application of cypermethrin-based insecticides and Aluminium phosphide pellets during storage and in combination with regular sorting in cases of re-infestation. Chemical control offers easy, cheap and effective control but it is considered unsafe as it is likely to have severe health consequence on consumers since kola nuts only undergo primary processing before consumption. This practice is really disturbing considering the fact that most of the farmers and traders lack basic pesticide education on safety precautions, safe dosage, proper storage and means of disposal. Unfortunately this practice will continue if there are no suitable alternatives or recommended insecticides available to discourage the indiscriminate use of chemical insecticides on kola nuts. Plant-derived insecticides are very effective in insect pest management and are considered safe, biodegradable and environment/user friendly.

In Nigeria, many local plant products such as peppers, ashes, vegetable oils, citrus peals, pawpaw leaves, cedar, neem tree products etc have been adjudged effective for the control of insect pests of stored products (Su, 1977; Ivbijaro, 1983; Sowunmi and Akinnusi, 1983; Ofuya, 1986; Okorie *et al*., 1990; Jackai, 1993 Ogunwolu and Idowu, 1994; Asogwa and Osisanya, 2000; 2003;).

Asogwa *et al*., (2009) reported that *Azadirachta indica* (stem bark*)*; *Cedrela odorata* (stem bark); *Chrysophyllum albidum (*stem bark)*, Khaya spp* (stem bark), and *Chromolaena odorata* (leaf) suppressed development and emergence of kola weevil for 42 days in stored kola nuts Some of these plant derived insecticides have low insecticidal properties and require combination with other plant species for synergistic effect (Oparaeke, 2004).

. Therefore this study evaluates the efficacy of ethanol extracts of four selected plants (*Azardirachata indica, Jatropha curcas*, *Piper guineense* and *Aframomum melegueta*) against Balanogastris *kolae* on stored kola under laboratory conditions

MATERIALS AND METHODS

The study was conducted at the Biology laboratory of the Federal College of Forestry (FCF) Ibadan under ambient temperature of 27 ± 2°C and relative humidity of 70 to 80%. One basket of fresh pods of *Cola nitida* was purchased from Ijare market in Ondo state, Nigeria and processed by skinning. The processed kola were carefully sorted from infested ones, washed and cured for 72 hours in the laboratory before use. The kola weevil **(***Balanogastris kolae*) culture were established in the laboratory from the infested kola nut purchased from local market in Ibadan, Oyo state Nigeria. The infested kola nuts were kept in a plastic container of 6x4 cm and covered with muslin cloth. Adult *B. kolae* emerged after three weeks, the culture was maintained throughout the period of study. Plant materials like *J. curcas*, *A. melegueta* and *P guineense* used were purchased from Ibode a local market in Ibadan while *A. indica* was collected from Forestry Research Institute of Nigeria. *Sources and extraction of Test plant materials.* The plant materials were air-dried for two weeks under ambient light conditions at fluctuating temperature of 25±5ºC, 60-80% relative humidity and L12: D12 photoperiod. Each plant blended with a high-speed mill blender. Two hundred grams (200g) of powdered samples of each plant was weighed and separately placed into extraction chamber with a suitable plug. Two hundred and fifty milliliter (250ml) of ethanol was added to the sample in a separate flask. The extraction was done for 6hours and later the ethanol was distilled off from the flask using a quick fit pressure equalizing funnels.

Toxicity and Residual Bioassay of the Extracts on Balanogastris kolae: The extracts were evaluated for residual action by applying 1ml of each extract at50%, 75%and 100% concentrations on Petri dishes lined with filter paper. Petri dishes were left to drain off before the adult insects and larvae were introduced separately into each dish. Five insects were introduced into the petri dishes and observed for mortality on contact toxicity, the extracts were applied topically on the abdomen of the insects. All treatments were replicated three times. Data on the mortality of larvae for both residual action and contact toxicity were recorded at 20 minutes intervals for 24 hours.

Treatment Applications on Kola for Storage: One hundred and fifty grammes (150g) of kola nuts were soaked separately for 12 hours in plastic bowls containing 50% and 75% concentration of each extract. The kola nuts were removed after 12 hours and spread evenly in a plastic sieve for curing. The nuts were cured for 48 hours in order to reduce the moisture content to a minimal level. Cypermethrin 2.5EC

insecticide was used as reference standard following the description above to compare efficacy. Each concentration served as a treatment and was replicated three times in a Completely Randomized Design. The treated kola nuts were wrapped with *Tectonia grandis* and banana leaves, then put inside earthen pots and stored for three months. The stored kola were opened after three months and data were collected on exit holes, larvae and adult emergence

Data Analysis: Data collected were subjected to analysis of variance (ANOVA) and significant means were separated using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSION

The residual effects of the selected plant extracts on adult kola nut weevil (Balanogastris *kolae*) treated at three different concentration levels is shown in Table 1. Most of the extracts gave an effective kill of the weevil as time progressed and also as the concentration increased. The residual effects of the extracts on the adult weevil were significant ($p< 0.01$) at 50% and 75% concentration 24hours after treatment. However, there were no significant differences among the treatment at 100% concentration. The residual effects of ethanol extracts on *B. kolae* lavae followed the same trend with increased mortality as the time progressed and with increased concentrations (Table 2.).

Table 1 Mean residual action of selected plant extracts on adult *Balanogastris kolae* in laboratory

	Mortality /Time of exposure (minutes)							
Treatment/Con(ml)	**20**	**40**	**60**	**80**	**100**	**120**	**24hrs**	**Mean**
50%								
A.indica	1.00^{c}	0.00^{b}	1.00^{b}	0.00^{c}	1.00^{a}	0.00	0.00	3.00^{b}
J. curcas	0.00	2.00^{a}	2.00^{a}	1.00^{b}	0.00^{b}	0.00	0.00	5.00^{a}
P. guineense	$2.00.^{b}$	1.00^{ab}	0.00	0.00	0.00	0.00	0.00	3.00^{b}
A. meleguata	2.00^{b}	1.00^{b}	1.00^{b}	0.00c	1.00^{b}	0.00	0.00	5.00^{a}
Cypermethrin	2.00^{b}	1.00^{ab}	1.00^{b}	1.00^{b}	0.00_{b}	0.00	0.00	5.00^{a}
	**	**	**	**	**	ns	ns	**
75%								
A.indica	1.00^{b}	1.00	1.00^{b}	1.00^{a}	1.00^{a}	0.00^{b}	0.00	5.00^{a}
J. curcas	0.00^{c}	1.00	2.00^{a}	0.00^{b}	1.00^{a}	1.00^{a}	0.00	5.00a
P. guineense	2.00^{a}	1.00	0.00^{c}	0.00^{b}	0.00^{b}	0.00^{b}	0.00	3.00^{b}
A. meleguata	1.00^{b}	1.00	0.00^{c}	1.00^{a}	1.00^{a}	1.00^{a}	0.00	5.00^{a}
Cypermethrin	1.00^{b}	1.00	2.00^{a}	1.00^{a}	0.00^{b}	0.00^{b}	0.00	5.00^{a}
	**	ns	**	**	**	**	ns	**
100%								
A.indica	1.00^{b}	1.00^{b}	1.00^{b}	1.00^{b}	0.00	0.00	1.00^{a}	5.00
J. curcas	0.00^{c}	2.00^{a}	1.00^{b}	2.00^{a}	0.00	0.00	0.00^{b}	5.00
P. guineense	0.00^{c}	2.00^{a}	2.00^{a}	1.00^{b}	0.00	0.00	0.00^{b}	5.00
A. meleguata	3.00^{a}	2.00^{a}	0.00^{c}	0.00^{c}	0.00	0.00	0.00^{b}	5.00
Cypermethrin	3.00^{a}	2.00^{a}	0.00^{c}	0.00^{c}	0.00	0.00	0.00^{b}	5.00
	**	**	**	**	ns	ns	**	ns

*Mean with the same letter within the column do not differ staticall; ** =Significant at 1% level of probability ($p<0.001$); Ns =non-significant ($p>$.)*

There were significant differences ($p< 0.01$) among the treatments at 50% and 75% extracts concentrations on the residual effects of *B. kolae* larvae after 24 hours of exposure. Similarly, 100% concentration of the extracts showed no significant differences among the extracts after 24 hours of observation. All the extracts showed no contact effect on adult *B. kolae* at 20 minutes of exposure (Table 3). There were significant differences among the treatments at 40 to 80 minutes of exposure at different concentration levels. Hundred percent (100%) mortality was recorded on adult weevil treated with 50% concentration of *Piper guineense* and 75% of *Aframomum melegueta.* At 100% concentration, *Azardirachta indica, Piper guineense* and *Affamomum melegueta*, also recorded 100% adult weevil mortality. *A.melegueta* and *J.curcas* has equal efficacy with synthetic insecticides against *B.kolae* adult at 50% concentration after 24hours of exposure. The contact toxicity of the ethanolic extracts of P. *guineense* was effective on larvae of *B. kolae* starting from 40 minutes after exposure with 50% concentration and above (Table 4.). *P. guineense* and *A, melegueta* gave 100% larval mortality within 24 hours of exposure at all the concentration levels tested. They were comparable with cypermerthrin a synthetic insecticide. *A. indica* recorded 100% larval mortality for contact toxicity at 50% and 100% concentration 24 hours after exposure. *Jatropha curcas* recorded the least effect on the *B. kolae* larvae among all the extracts tested. All the treatments were effective in reducing the infestation of kola weevil on stored cola after three months of storage (Table 5). The 75% concentration of all the extracts were more effective in reducing the number of larvae emergence , number of adult emergence and exit holes on stored cola. Although there were no

significant differences ($p>0.05$) among the treatments on the entire factor of damage assessed and the effects of the different plant extracts tested were not significantly different from the synthetic insecticide (cypermethrin 2.5EC).

Table 2. Mean residual action of selected plant extracts on larvae *Balanogastris kolae* in laboratory

	Mortality/ Time of exposure(minutes							
Treatment/Con(ml)	**20**	**40**	**60**	**80**	**100**	**120**	**24hrs**	**Mean**
50%								
A.indica	0.00	0.00^{c}	0.00^{b}	1.00^{a}	2.00^{a}	1.00a	0.00	4.00^{ab}
J. curcas	0.00	0.00^{a}	1.00^{a}	1.00^{a}	1.00^{b}	0.00b	1.00	4.00^{ab}
P. guineense	0.00	1.00^{b}	0.00	1.00a	2.00a	0.00a	1.00	5.00^{a}
A. meleguata	0.00	0.00^{c}	1.00^{b}	0.00b	2.00^{a}	1.00a	1.00	5.00^{a}
Cypermethrin	0.00	2.00^{a}	1.00^{b}	0.00^{b}	1.00$_{b}$	1.00a	0.00	5.00^{a}
	ns	**	**	**	**	**	**	**
75%								
A.indica	0.00	0.00b	1.00^{a}	1.00^{a}	2.00^{a}	1.00^{a}	0.00	5.00^{a}
J. curcas	0.00	0.00b	1.00	1.00^{b}	2.00^{a}	0.00^{b}	1.00	3.00b
P. guineense	0.00	0.00b	1.00^{a}	0.00^{b}	2.00^{a}	1.00^{a}	1.00	3.00^{b}
A. meleguata	0.00	0.00b	0.00^{b}	1.00^{a}	1.00^{a}	1.00^{a}	1.00	5.00^{a}
Cypermethrin	0.00	1.00a	1.00^{a}	1.00^{a}	1.00^{b}	1.00^{a}	0.00	5.00^{a}
	ns	**	**	**	**	**	ns	**
100%								
A.indica	0.00	0.00^{b}	0.00^{c}	3.00^{a}	2.00^{a}	0.00^{b}	0.00	5.00^{a}
J. curcas	0.00	2.00^{a}	1.00^{b}	0.00^{c}	1.00^{b}	0.00^{b}	0.00	4.00^{b}
P. guineense	0.00	2.00^{a}	1.00^{a}	0.00^{c}	1.00^{b}	1.00^{a}	0.00	5.00^{a}
A. meleguata	0.00	0.00^{b}	3.00^{a}	1.00^{b}	1.00^{b}	0.00^{b}	0.00	5.00^{a}
Cypermethrin	0.00	2.00^{a}	2.00^{a}	0.00^{c}	1.00^{b}	0.00^{b}	0.00	5.00^{a}
	ns	**	**	**	**	**	ns	**

*Mean with the same letter within the column do not differ statically;** =Significant at 1% level of probability ($p<0.001$); ns =non-significant.*

Table 3. Mean contact toxicity of selected plant extracts on adult *Balanogastris kolae* in laboratory

	Mortality/ Time of exposure (minutes)							
Treatment/Con(ml)	**20**	**40**	**60**	**80**	**100**	**120**	**24hrs**	**Mean**
50%								
A.indica	0.00	0.00c	0.00b	1.00a	2.00a	1.00a	0.00	4.00ab
J. curcas	0.00	0.00a	1.00a	1.00a	1.00b	0.00b	1.00	4.00ab
P. guineense	0.00	1.00b	0.00	1.00a	2.00a	0.00a	1.00	5.00a
A. meleguata	0.00	0.00c	1.00b	0.00b	2.00a	1.00a	1.00	5.00a
Cypermethrin	0.00	2.00a	1.00b	0.00b	1.00b	1.00a	0.00	5.00a
	ns	**	**	**	**	**	**	**
75%								
A.indica	0.00	1.00a	0.00b	1.00a	2.00a	1.00a	1.00a	4.00ab
J. curcas	0.00	0.00b	1.00a	1.00a	0.00b	0.00b	1.00a	3.00b
P. guineense	0.00	0.00b	1.00a	0.00b	2.00a	1.00a	1.00a	5.00a
A. meleguata	0.00	0.00b	0.00b	1.00a	2.00a	1.00a	1.00a	5.00a
Cypermethrin	0.00	1.00a	1.00a	1.00a	1.00ab	1.00a	0.00b	5.00a
	ns	**	**	**	**	**	ns	**
100%								
A.indica	0.00	0.00b	0.00c	3.00a	2.00a	0.00b	0.00	5.00a
J. curcas	0.00	2.00a	1.00b	0.00c	1.00b	0.00b	0.00	4.00b
P. guineense	0.00	2.00a	1.00a	0.00c	1.00b	1.00a	0.00	5.00a
A. meleguata	0.00	0.00b	3.00a	1.00b	1.00b	0.00b	0.00	5.00a
Cypermethrin	0.00	2.00a	2.00a	0.00c	1.00b	0.00b	0.00	5.00a
	ns	**	**	**	**	**	ns	ns

*Mean with the same letter within the column do not differ statically;** =Significant at 1% level of probability ($p<0.001$); ns =non-significant.*

The laboratory bioassays of the extracts has confirmed that the mode of action of ethanol extracts of the selected plants on insect could be as a result of contact and/or through residual action. All the plant evaluated showed 60-100% mortality of larvae and adult *B. kolae* at both contact and residual effect at 24 hours of exposure. This has verified the potential of the plant extracts tested for the control *B. kolae* on stored kola. Over 130 plants and plant products have been reported to have insecticidal activity against stored product pests (Bandara and Seneviratne 1993; Caswell (1981). Golob et *al., (*1999) has earlier reported that P. *guineense* powder, oil, and hexane and acetone extracts have proved effective in causing mortality and reducing oviposition of various insects when applied to grains and crops such as maize or cowpea. Ugwu *et al.,(*2012) also reported that leaf powders *A. indica* and *Cymbopogon citratus* were found very effective in protecting *Irvingia wombolu* kernel against *Oryzaephilus mercator* in storage . Similarly, Anikwe

(2013), reported that *Magnifera indica* and *A. indica aqueous extracts* gave significant kill of *S. singularis* in the laboratory. Furthermore, Ugwu (2016) reported that ethanol and hexane seed extracts of *Azadirachta indica*, *Jatropha curcas*, *Piper guineense* and *Eugenia aromatic* were effective against *Callosobrunchus maculatus* (F) on cowpea. . The efficacy of the plant extracts tested in the study increased with increase in concentration. This is in consonance with earlier report by Jembere *et al.,* (1995) and Lajide et al., (1998) that the efficacy of some plant materials like *Ocimum kilim* and *sharium*, *Uvaria afzelli*, *Eugenia aromatica* and *Aframomum melegueta* increase with increased concentration against Sitophillus *zeamais*, *Rhizoptera dominica* and *Sitogroga ceredella. Azadirachta indica*, *P. guineense and A. melegueta* caused 80-100% adult and larve mortality of *B.kolae* in all concentrations levels indicating their high efficacy against *B. kolae*. The biocidal activities of these plants against many insect pests has been reported by several authors. *Azadirachta. indica* has proved to be a very effective biopecitides against several insect species both in the field and in the laboratory. Ivbijaro and Bolaji 1991 and Schmutter, 1995 has reported the potential of neem products for the control of field insect pests of eggplant and okra. Tokyo Aliero (2003) and Nzanza and Mashela (2012) reported that neem extracts are effective for the control of mosquito larvae, aphids, and whitefly. Neem based extracts has been reported to be even more effective than synthetic insecticides against several insect species. Basedow (2002) reported that *A. indica* -based products were effective or even more effective than synthetic insecticides for the control of aphids and white flies. Similarly, Ugwu et *al.,* (2014) reported that *A. indica* seed extracts showed higher efficacy than the cypermethrin in controlling *S. derogata* on okra. *Piper guineense* has also been found to be effective against both field and stored insect pests.

Table 4. Mean contact toxicity of selected plant extracts on larvae *Balanogastris kolae* in laboratory

	Mortality /Time of exposure (minutes)							
Treatment/Con(ml)	**20**	**40**	**60**	**80**	**100**	**120**	**24hrs**	**Mean**
50%								
A.indica	0.00c	1.00^{b}	1.00^{b}	1.00^{a}	0.00^{b}	1.00a	0.00	4.00^{ab}
J. curcas	0.00c	0.00^{c}	1.00^{b}	1.00	1.00^{a}	1.00b	0.00	4.00^{ab}
P. guineense	1.00b	1.00^{b}	0.00c	1.00	1.00a	1.00a	0.00	5.00^{a}
A. meleguata	0.00c	1.00^{b}	2.00^{a}	1.00	1.00^{a}	0.00a	0.00	5.00^{a}
Cypermethrin	2.00a	1.00^{a}	0.00^{c}	1.00	1.00^{a}	1.00a	0.00	5.00^{a}
	**	ns	**	ns	**	**	ns	**
75%								
A.indica	0.00b	0.00b	1.00^{a}	0.00^{a}	1.00^{b}	1.00^{a}	1.00a	4.00^{ab}
J. curcas	0.00b	0.00b	1.00a	0.00^{b}	1.00^{b}	1.00^{a}	0.00b	3.00b
P. guineense	1.00a	0.00b	0.00^{b}	1.00^{a}	2.00^{a}	0.00^{b}	1.00a	5.00^{a}
A. meleguata	0.00b	1.00a	0.00^{b}	1.00^{a}	1.00^{b}	1.00^{a}	1.00a	5.00^{a}
Cypermethrin	1.00a	0.00b	0.00^{b}	1.00^{a}	1.00^{b}	1.00^{a}	0.00b	5.00^{a}
	*	ns	**	**	**	**	**	**
100%								
A.indica	0.00c	2.00a	1.00b	1.00	1.00	0.00b	0.00b	5.00a
J. curcas	0.00c	1.00b	0.00c	1.00	1.00	0.00b	1.00a	4.00b
P. guineense	2.00a	1.00b	0.00c	1.00	1.00	0.00b	0.00b	5.00a
A. meleguata	1.00b	0.00c	2.00a	1.00	1.00	1.00a	0.00b	5.00a
Cypermethrin	1.00b	1.00b	0.00c	1.00	1.00	1.00a	0.00b	5.00a
	**	**	**	ns	ns	**	**	ns

*Mean with the same letter within the column do not differ statically;** =Significant at 1% level of probability (p<0.001); ns =non-significant.*

Idoko and Adesina (2012) reported that sole plant powders application of *P.guineense* caused adults mortality, inhibited oviposition by female beetles on cowpea grains and suppressed F1 progeny emergence of *C.maculatus.* Fasakin and Aberejo (2002) have also reported that pulverized plant material from *P. guineense* inhibited egg hatchability and adult emergence of *Dermestes maculatus* Degeer in smoked catfish (*Clarias gariepipus*) during storage. It has also been reported that extracts of *A. indica, Jatropha curcas* and other local plant materials have potentials in controlling some insects pests in laboratory and small scale insects in the field at the Cocoa Research Institute of Ghana ((Padi, 1997).

The use of plant products has created impact as an imperative element of insect pest management because of their economic viability and eco-friendly nature. They have guarantee as alternatives to chemical insecticides to reduce pesticide load in the environment (Radha and Susheela, 2014).

Table 5. Effects of selected plant extracts on damage and developmental stages of Balanogastris *kolae* on stored kola

Treatment	No. of exit holes	Larval emergence	Adult emergence
5% Concentration			
A.indica	1.33	1.00	1.66
J. curcas	1.00	1.33	1.00
P. guineense	2.00	2.33	1.66
A.meleguata	1.33	1.00	1.66
Cypermethrin	1.00	1.66	1.33
75% Concentration			
A.indica	1.33	1.66	1.66
J. curcas	0.66	1.33	1.00
P. guineense	0.66	1.33	1.33
A.meleguata	0.66	1.00	0.66
Cypermethrin	1.00	1.00	1.66
%CV	64.28	56.68	51.32
Sig. level	ns	ns	Ns

*Conclusion***:** The study has further established the insecticidal potential of ethanol extracts from *A. indica, P. guineense A. melegueta* and *J. curcas* against larvae and adult *B.kolae* on stored kolae and their practicable use in the development of plant-based based insecticide for stored pests. The use of these plant extracts will reduce reliance on conventional chemical products and contribute to safe preservation of kola nuts against storage pests. However further study is required to develop these plant extracts in ready- made formulations.

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