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Effects of some indigenous plant seed-powders on the house-hold pest, *Blattella orientallis* L (Blattodea: Blattidae)

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Abstract
Seed-powders of 3 indigenous plants (*Piper guineense, Aframomum melegueta* and *Dennettia tripetala)* on the German cockroach nymphs after 24 hours exposure, and using different dosages of 0.0, 10.0, 20.0, 30.0, and 40.0% w/v (powders: distilled water), have revealed significantly higher mean nymph mortalities ($P < 0.05$) when treatment effects were compared to the normal controls (water). The toxicity trials showed *P. guineense* as recording highest mean nymph mortalities (16.5±2.8), after 24hrs exposure, followed by *A. melegueta* (15.0±2.7), and *D. tripetala* (5.5±1.7) compared to (0.00 ± 0.0) of the normal control. Also, *P. guineense* recorded higher percent effectiveness (66.88%) in control of pest population, followed by *A. melegueta* (50.63% and *D. tripetala* (6.88%) respectively; but it was hundred percent (100%) effectiveness when compared against snipper (the positive control). Similarly, the mean lethal dose that killed 50% (LD_{50}), as well as the mean lethal time for killing 50% of the pest/cockroach population (LT_{50}) were found to be: 28.0% w/v, at 21min, and 40.0% w/v at 31min for *P. guineense*, *A. melegueta* respectively; but nil (zero) for *D. tripetala*, showing the latter as a relatively weak and less effective plant seed-powder. Additionally, the mean number of nymph-to-adult emergence records after 48 hrs were found to be 6.0 or 0.36% (range of 0.06-0.15%) for *P. guineense*, in other words highly suppressed emergence;11.0 or 1.10% (range 0.10-0.36%), or moderately suppressed for *A. melegueta*; but it was 34.0 or 11.56% (range 2.04-3.06%) for *D. tripetala* (still the less effective, and also with relatively high adult emergence). These findings have shown the relative capacities, of these plant seed-powders for control of this household pest. Most importantly, being indigenous, and hence readily available, they may serve as better, cheaper, safer and preferred control alternatives (especially *P. guineense*, and *A. melegueta)*, to the use of conventional insecticides.

Keywords: Plant Seed-Powders, House-Hold Pest, *Blatella* Orientallis, Toxicity Trials, Nymph Mortalities, Adult Emergence]

Introduction

Seed powders of certain plants are traditionally utilized worldwide as natural pesticides to manage domestic pests, thus serving as eco-friendly alternatives to the use of synthetic chemicals. This study on 3 indigenous plant seed powders (*P. guineense, A. melegueta* and *D. tripetala*) is hereby undertaken, following the successes recorded by previous works (Oparaeke et al., 2005; Toschihiro & Haruyasu, 2006,) with similar plants on other noxious pests. And therefore, serve as a baseline for this investigation on the efficacy of these selected indigenous plants against the German cockroach, a notorious household pest.

Cockroaches are one of the most common household pests in the world, and belong to the animal kingdom Arthropoda, class Insecta; order Blattodea & family Blattidae. Several species exist namely; *Blatta orientalis* (Oriental cockroach). *Periplaneta americana* (American cockroach), *Periplaneta australasiae* (Australian cockroach), *Blattela germanica* (German cockroaches) amongst many others (Vatandoost, 2021). They are found everywhere, and feed on diverse thrash and sewage materials, etc., and are notoriously difficult to contain or control. German cockroaches (*Blattella* species) are vectors involved with bacteria disease-transmissions via their feet & other body parts (Vatandoost, 2021); spreading dysentery, typhoid fever, and cholera, and also cause allergies, nauseating smells/odors (Kathy 2016). They may additionally, trigger asthmatic attacks and/or feed on bodily wastes and even bite sleeping humans thereby causing anxiety and depression (Jacobs 2007).

Chemical control involving baits, dusts, sprays etc., are conventionally used currently to curtail their menaces but Kassie et al., (2020), Ileke and Oni (2011) etc., do not consider such chemical measures as viable options due to their several drawbacks viz: resistance development, pest resurgences, toxicity and environmental concerns, amongst several others. Plant-based insecticides e.g. pyrethrum, nicotine, rotenone etc., have consequently, been utilized over centuries now for their control; for instance, insecticides from black piper (*Piper nigrum)* have been found effective against bean weevils (Kassie 2020). Pyrethroids and several essential oils from plant leaves, seeds and barks are similarly, found to possess insecticidal and larvicidal properties (Cheng et al., 2003).

In this study, the 3 plant seed powders of Alligator pepper (*Aframomum melegueta*), Pepper fruit (*Dennettia tripetala*) and Guinea cubeb (*Piper guineense*) are being investigated for their efficacy in control of the domestic cockroach (*Blatella spp*). The alligator pepper (*A. melegueta)* alias "grain of paradise" is a perennial plant endemic to western Africa, and a member of the ginger family; and contains aromatic ketones such as 6-paradol, 6-gingerol and 6-shogaol responsible for the seeds' peppery flavour (Sugita et al., 2013). Pepper fruit (*D. tripetala*), another tropical fruit native to West Africa, and of the Annonaceae family, is similarly recognized for their fruity green or purple pods; and as a spicy fruit (Ikpi & Nku, 2008). Their peppery flavour and insecticidal properties make them to be commonly employed to ward off insects, pests and weevils (Odeyemi et al., 2008). The Guinea cubeb (*Piper guineense*), also native to West Africa, serves a wide variety of uses: medicinal, cosmetic and insecticidal (Anyanwu & Nwosu, 2014).

Henrietta et al., 2017 studied the nutritional, phytochemical and therapeutic characteristics of these 3 plants (*P. guineense, A. melegueta* and *T. tetrapeta*) and found them to be of great potential. Consequently, they are hereby investigated, to determine their impacts in the control of cockroach nymphs. The goal here is specifically, to determine if these 3 plant seed powders have insecticidal and toxic capabilities to control the German cockroach; determine their lethal doses (LD_{50}) and lethal time (LT_{50}) in killing 50% of the pest population, and their impacts on the progeny development (or nymph-to-adult emergence) in this notorious household pest. The findings here, may proffer notable solutions and also contribute towards the development of effective and yet cheaper, and more readily available alternative control options that guarantee bio-friendliness and environmental safety against cockroaches; for the overall benefit of individuals, groups/populations, Government and even the global community at large.

Materials and Methods

Collection of Plant Materials for the experiments/bioassays

Fresh seeds of the 3 plants namely, Alligator Pepper (*A. melegueta*), Pepper Fruit (*D. tripetala*), and Guinea Cubeb (*P. guineense*) were purchased from Igwuruta market in Ikwerre Local Government Area of Rivers State, Nigeria for this research project; and all experiments were conducted in the laboratory of the Biology Department, Ignatius Ajuru University of Education, Rumuolumeni, Port Harcourt, Rives State, Nigeria (4.8068^0 N, 6.9343^0 E)

Preparation of Plant seed powder

Fresh seeds of these indigenous plants were spread on trays and oven dried in the laboratory, except for the alligator pepper seeds that were purchased dry. After drying, 30g from each was milled into a fine powder with the aid of an electrical blender (model: multifunctional BLG-412) and collected into several 10ml plastic containers and stored away in air-tight conditions in readiness for the laboratory experiments. Fifteen grams (15 g) fine powder of each of the three plant samples was reweighed for the toxicity experiments, while the remainders were kept for later proximate analyses and phytochemical screening studies.

Collection and preparation of test organism

The German cockroach (*Blattella spp*) was reared in 4 (nos.) hard-paper cartons of 30x30x30cm each, kept in the laboratory under normal 12:12 (light: dark) photoperiod, and normal temperature and relative humidity conditions of 25 ± 3°C and 75 ± 5% respectively. Fifth instar nymphs were used in the laboratory experiments because they were the most abundant life stage; and they were usually chilled in the refrigerator at 4^{o}C for a minimum of 10 minutes (to immobilize them) before use in experiments.

1) Toxicity trials

The toxicity trials followed the method of Rahman et al., (2007). A set of 10 immobilized cockroach nymphs were tested against 1-mililiter of each seed powder solution, (and the control or mere distilled water) applied topically at the dorsal region of nymph thorax, using a micro capillary tube. Different concentrations (0.0 or the control, 10.0,

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20.0, 30.0, 40.0% w/v) of each test solution respectively were used. All nymphs were thereafter transferred to 9-cm diameter plastic Petri dishes containing bread crumps as food for their sustenance. The experiments were conducted in completely randomized design (CRD) and replicated twice. The nymphs were monitored for mortalities at intervals of 15, 30, 60 mins and 24 hrs for 3 days. Mean mortalities were compared using Duncan multiple range test (DMRT).

2) Determination of LD_{50} and LT_{50} Values of the Plant Seed Powders

Following the method as described in (1) above, the lethal dose (LD_{50}) and the lethal time taken to yield 50% mortality (LT_{50}) in cockroach nymph populations were investigated and determined for the different plant seed powders. 1-mililiter of the different concentrations viz: 0.0 the control, 10.0, 20.0, 30.0 and 40.0% w/v of each plant seed powder was separately tested against 10 cockroach nymphs respectively and replicated twice. **LD_{50} for each seed-powder** was calculated as the **lethal dose** of the test extract that killed 50% of the nymph population, while the **lethal time (LT_{50})** was the mean or average-time taken to yield/effect 50% mortality in the nymph population.

3) Determination of Percent effectiveness of the plant seed-powders.

Rahman et al's (2007) methodology with toxicity trials as described in (1) above was adopted here, but was slightly modified to allow for inclusion of a second control (i.e. 'snipper' – a standard insecticide). Consequently, the performances of the plant seed-powders were tested against both the normal control (i.e. mere distilled water) as well as against the standard insecticide ("snipper"). To obtain 4 different concentrations of this snipper or standard insecticide solutions, (comparable to the 10.0, 20.0, 30.0 and 40.0% w/v of the plant seed-powder solutions), 1-mililiter of the standard insecticide (Snipper) was diluted with 10ml, 20ml, 30ml and 40ml of distilled water, for this 2nd control. Performances of the seed-powders to the first control (i.e. mere distilled water) and to the second control (or the standard insecticide/snipper) were then compared in order to determine the percent effectiveness of the seed-powders (or exactly how the seed-powders fared).

4) Effect of plant seed powders on Progeny Development of Cockroach Nymphs

To determine the plant seed-powder effects on progeny development in the cockroach nymphs, a set of ten (10) unsexed cockroach nymphs were tested against the 3 different plant seed-powders respectively; and each set was replicated twice. Then records were taken on the number dead and number alive within 24hours. Also, the number(s) alive after 48 hours, as well as total number of nymph-to-adult emergence(s) after 48hours were recorded. The **Percent (%) development** in this study reflected the extent to which each plant seed-powder, influenced progeny development in the cockroach, and this was calculated as follows: **total adult emergence x emergence of adult cockroach / 100**

Results

1) Toxicity trials using the plant seed-powders against the Cockroach nymphs

The results of toxicity trials with the plant seed-powders on the nymphs of the German cockroach are presented in Table 1. Higher concentrations (30-40% w/v) and prolonged exposures (60mins – 24 hrs) generally yielded significant mortalities in the pest populations ($P<0.05$) (particularly true for *P. guineese* and *A.melegueta*).

Table 1: Toxicity of plant seed powders on German cockroach (*Blattella* spp) nymphs exposed to different treatment concentrations within 24 hours

		Mean mortality ± S.E.			
Treatment	**Conc (w/v)**	**15 mins**	**30 mins**	**60 mins**	**24 hrs**
Control (1-mililiter, d-water)	0.0	0.0 ± 0.0 c	0.0 ± 0.0 c	0.0 ± 0.0 c	0.0 ± 0.0 c
Piper guineense	10.0	1.0 ± 0.5 b	4.0 ±1.4 b	5.5 ± 1.7 b	8.5 ± 2.0 b
	20.0	3.0 ± 1.2 b	7.5 ± 1.9 b	9.5 ± 2.2 b	10.5 ± 2.3 b
	30.0	4.0 ± 1.4 b	10.5 ±2.3 b	13.5 ±2.6 a	14.5 ±2.7 a
	40.0	4.5 ±1.5 b	16.0 ± 2.8 a	16.5 ±2.8 a	16.5 ± 2.8 a
Control (1-mililiter, d-water)	0.0	0.0 ± 0.0 c	0.0 ± 0.0 c	0.0 ± 0.0 c	0.0 ± 0.0 c
Aframomum melegueta	10.0	0.5 ± 0.5 b	2.0 ± 1.0 b	3.0 ± 1.2 b	5.0 ± 1.6 b
	20.0	1.0 ± 0.5 b	2.5 ± 1.1 b	5.0 ± 1.6 b	7.5 ± 1.9 b
	30.0	4.5 ± 1.5 b	3.5 ± 1.3 b	4.5 ± 1.5 b	6.5 ± 1.8 b
	40.0	4.4 ± 1.5 b	8.5 ±2.1 b	12.5 ± 2.5 a	15.0 ±2.7 a
Control (1-mililiter, d-water)	0.0	0.0 ± 0.0 b	0.0 ± 0.0 b	0.0 ± 0.0 b	0.0 ± 0.0 b
	10.0	0.5 ± 0.5 b	0.5 ± 0.5 b	0.5 ± 0.5 b	1.0 ± 0.7 b

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Dermettia tripetala	20.0	0.0 ± 0.0 b	0.0 ± 0.0 b	0.0 ± 0.0 b	0.0 ± 0.0 b
	30.0	0.0 ± 0.0 b	0.0 ± 0.0 b	0.0 ± 0.0 b	1.5 ± 0.9 b
	40.0	0.0 ± 0.0 b	0.0 ± 0.0 b	0.0 ± 0.0 b	5.5 ± 1.7 a

w/v = weight of powder/volume of water

Different alphabets indicate significant differences (P<0.05) among treatment groups and exposure times

2) Determination of LD_{50} and LT_{50} Values of the Plant Seed Powders

The results of the LD_{50} and LT_{50} trials are presented in **Table 2** below.

Table 2: The Lethal dose (LD_{50}) and Lethal time (LT_{50}) of Plant Seed-powders on the German cockroach

Treatment	Dose	15min	30min	60min	24 hrs	Total Response	Percent (%) Response*	LD_{50}	LT_{50}
Control (d-water)	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	10.0	1	4	5.5	8.5	19	23.75		
Piper guineense	20.0	3	7.5	9.5	10.5	30.5	38.13	28.0	21.4
	30.0	4	10.5	13.5	14.5	42.5	53.13		
	40.0	4.5	16	16.5	16.5	53.5	66.88		
	30.0	4	10.5	13.5	14.5	42.5	53.13		
Control (d-water)	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	10.0	0.5	2	3	5	10.5	13.13		
A. melegueta	20.0	1	2.5	5	7.5	16	20.0	40.0	31.6
	30.0	4.5	3.5	4.5	6.5	19	23.75		
	40.0	4.5	8.5	12.5	15	40.5	50.63		
Control (d-water)	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
	10.0	0.5	0.5	0.5	1	2.5	3.13		
D. tripetala	20.0	0	0	0	0	0	0.0	-	-
	30.0	0	0	0	1.5	1.5	1.88		
	40.0	0	0	0	5.5	5.5	6.88		

***Total Response X 100 / N   where N = 80 (i.e. total no. of nymphs tested or 10nymphs x4 time-intervals x2 replicates=80)**

The Result showed that 50% reduction (or 50% mortality) in pest population was only possible with *P. guineense*, and *A. melegueta*. The LD_{50} values were determined as 28.0% w/v for *P. guineense*, and 40.0% w/v for *A. melegueta* was (Fig. 1 & Fig. 2). There was no record of 50% reduction in pest population with *D. tripetala,* when different concentrations of this treatment sample (seed powder) were tested against the cockroach; indicating that, *D. tripetala* was relatively weak and ineffective, when compared to *P. guineense* and *A. melegueta*. At dose level response, *P. guineense* and *A. melegueta* seed powders caused 50% mortality of German cockroach within 24hours of exposure (Table 2). The lethal time (LT_{50}) to effect 50% mortality in pest population was recorded as 21.4 mins for *P. guineense*, and 31 .6 (aprox 32.0) for *A. melegueta* (Fig. 2).

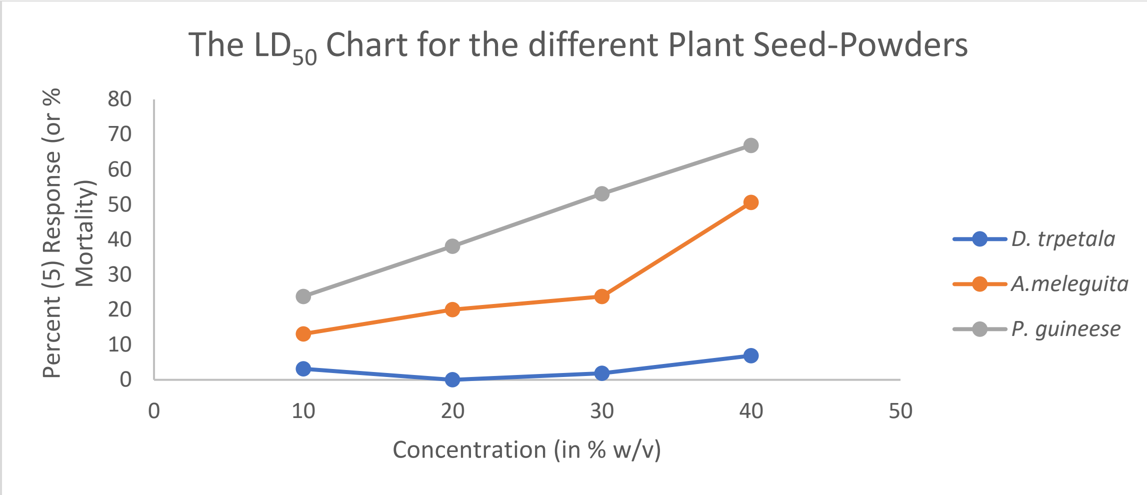

Fig 1. Plant seed-powder concentration versus percent mortality in pest population (LD_{50} for *P. guineense* was 28% w/v; while it was 40% w/v for *A. melegueta* and 0.0% for *D. tripetala* respectively)

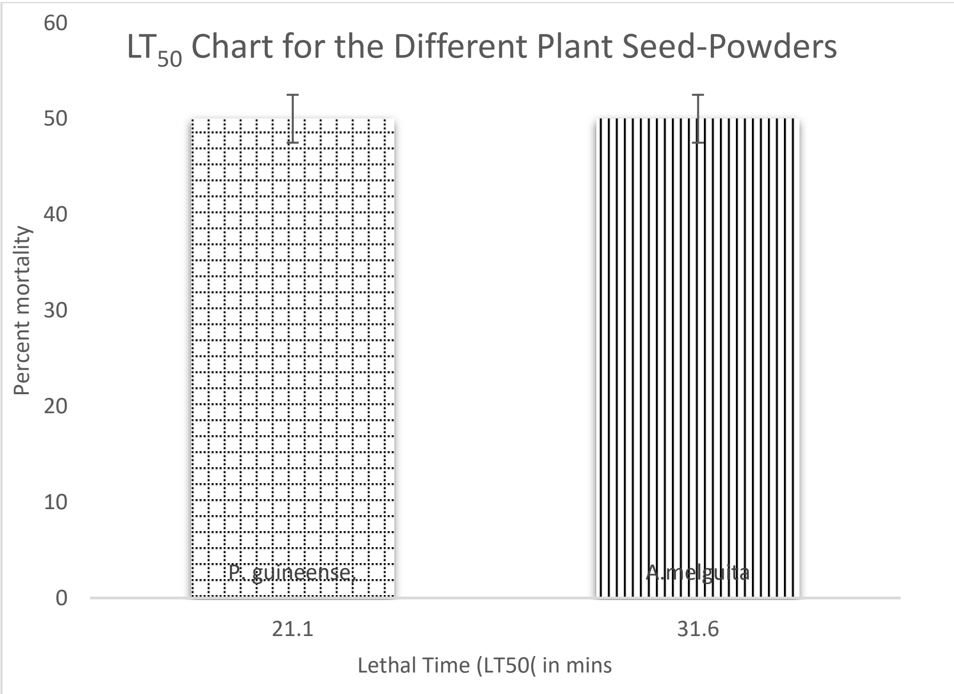

Fig. 2: Percent Mortality versus Time chart for the Plant Seed-Powders (The Lethal time taken to cause 50% mortality (50% reduction) in pest population (LT_{50}) for *P. guineese* = 21.1 min; while it was 31.6 min for *A. melegueta* and 0.0 for *D. tripetala)*

3) Percent effectiveness of plant seed powders

Table 3 presents a comparative account of percent effectiveness values for all plant seed-powders, versus the active control or the standard treatment (i.e. snipper, - a synthetic insecticide) at different concentrations and for different exposure durations within 24hrs.

Table 3: Comparing percent effectiveness of plant seed powders against the synthetic insecticide (snipper)

Treatment	Conc (w/v)	15 mins	30 mins	60 mins	24 hrs	Total mortality	Percent (%) effectiveness
Normal Ctrl (d-water)	0.0	0	0	0	0	0	0
Piper guineense	10	1	4	8.5	8.5	19 b	23.75
	20	3	7.5	10.5	10.5	30.5 a	38.13
	30	4	10.5	14.5	14.5	42.5 a	53.13
	40	4.5	16	16.5	16.5	53.5 a	66.88
Normal Ctrl (d-water)	0.0	0	0	0	0	0	0
A. melegueta	10	0.5	2	5	5	10.5 b	13.13
	20	1	2.5	7.5	7.5	16 b	20.0
	30	4.5	3.5	6.5	6.5	19 b	23.75
	40	4.5	8.5	15	15	40.5 a	50.63
Normal Ctrl (d-water)	0.0	0	0	0	0	0	0
D. tripetala	10	0.5	0.5	1	1	2.5 c	3.13
	20	0	0	0	0	0 c	0.0
	30	0	0	1.5	1.5	1.5 c	1.88
	40	0	0	5.5	5.5	5.5 c	6.88
Standard Ctrl (Snipper)	10	20	20	20	20	80 a	100.0
	20	20	20	20	20	80 a	100.0
	30	20	20	20	20	80 a	100.0
	40	20	20	20	20	80 a	100.0

Different alphabets indicate significant differences (P<0.05) amongst treatment groups and exposure times.
There were significant inhibitory differences (P<0.05) amongst treatment groups
The highest mortality (80) was recorded with snipper (100%). Therefore the % effectiveness was determined from the standard i.e. 80 mortality = 100% effectiveness

The results indicated that the plant seed-powders could actually inhibit cockroach activity; although snipper (the synthetic insecticide) yielded much higher mortalities relative to the tested seed-powders viz: 100% for snipper, compared to 23.7 - 66.88%, 13.13 - 50.63% and 0.0 - 6.88% for *P. guineense*, *A. melegueta* and *D. tripetala* respectively. This showed snipper as being highly toxic, as against the three plant seed-powders (or bioinsecticides). There was some evidence of higher mortality associated with *P. guineense* and *A. melegueta,* than *D. tripetala*; proving that *P. guineense* (and also, *A. melegueta.* to a lesser extent) may serve as an effective bio-insecticide against cockroach. Again, higher mortalities were observed to be associated with higher concentrations, and prolonged exposures of cockroach to the insecticide. Significant differences (P<O.O5) were recorded amongst the treatment groups.

4) Effects of plant seed-powders on development of German cockroach nymphs

Table 4 present the results of plant seed powder effects on progeny development (i.e. nymph-to-adult emergences) in the cockroach. Relatively fewer nymph-to-adult emergences occurred with *P. guineense* and *A. melegueta* seed powders, compared to the significantly higher incidences (P<0.05) recorded with *D. tripetala* and the control (water). Similarly, significantly more deaths (P<0.05) were recorded with *P. guineense* and *A. melegueta* compared to *D. tripetala* results and the control.

Table 4: Mean effect of the plant seed powders on the development of the German Cockroach

Treatment	Conc (w/v)	No dead 24hrs	No alive 24 hrs	No Alive 48 hrs	Emerged Adults 48 hrs	Percent (%) Development*
Control (d-water)	0.0	0.0 b	20.0 a	20.0 a	18.0	13.86
Piper guineense	10.0	8.5 a	11.5 a	9.0 a	2.5 b	0.15
	20.0	10.5 a	9.5 a	8.5 a	1.0 b	0.06
	30.0	14.5 a	5.5 b	4.5 b	1.0 b	0.06
	40.0	16.5 a	3.5 b	2.0 b	1.5 b	0.09
Control (d-water)	0.0	0.0	20.0 a	20.0 a	19.0	14.63
A. melegueta	10.0	5.0 b	15.0 a	11.0 a	3.0 b	0.32
	20.0	7.5 a	12.5 a	9.0 a	3.5 b	0.36
	30.0	6.5 a	13.5 a	10.5 a	3.0 b	0.32
	40.0	15.0 a	5.0 a	4.0 b	1.0 b	0.10
Control (d-water)	0.0	0.0	20.0 a	20.0 a	20.0 a	15.40
D. tripetala	10.0	1.0 b	19.0 a	10.0 a	9.0 a	3.06
	20.0	0.0 b	20.0 a	8.5 a	11.5 a	3.91
	30.0	1.5 b	18.5 a	11.0 a	7.5 a	2.55
	40.0	5.5 b	14.5 a	9.5 a	6.0 b	2.04

There were significant differences ($P<0.05$) recorded between samples or the plant seed powders.
***Percent development** was calculated as: **Total adult emergence x emergence of adult cockroach / 100**

The Total number of the nymphs alive, as well as the total nymph-to-adult emergences after 24-48 hours were viz: 30.0, 24 and 6 for P. guineense; 41, 35 and 11 for *A. melegueta*; and 53, 39 and 34 for *Dennetlia tripetala* respectively.

No mortality was recorded for the control; as all (60) remained alive after 24 -48 hours exposure to the different seed powder concentrations. However, it is noteworthy that as high as 51.0 nymph-to-adult emergences were recorded.

Percent development (i.e. nymph-to-adult emergences) after exposure to different concentrations of plant seed-powders were viz: 0.06% — 0.15%, 0.10% — 0.36% and 2.04% - 3.91% for *P. guineense*, *A. melegueta*. and *D. tripetala* respectively. In other words, more nymph-to-adult emergences, notably occurred with *D. tripetala* and the control.

These results show that nymph-to-adult emergence (or progeny development) in this cockroach could be prevented with these bioinsecticides (particularly with *P. guineense, A. melegueta)*; as they seemingly possess insecticidal capacity to inhibit metamorphosis or alter metabolic processes associated with progeny development in the cockroach.

Discussion

Though agrochemical use, on one hand have led to maximized food production, it has on the other-hand brought about several deleterious consequences of pollution, biotoxicity, pest resistance, amongst others; hence, necessitating increased interest in use of alternative strategies for less risks to environment, human health etc. (Campos et al., 2019)

Botanical insecticides, are vital and valuable natural pesticides of plant origin with huge potentials, and tremendous promise for sustainable protection against pests and disease agents of households, field crops, stored produce and general agriculture due to their catalogue of benefits viz: ready availability, low costs, biodegradability, low toxicity, no toxicity to natural enemies and non-target organisms etc., This study on 3 indigenous plants-seed extracts of *P. guinense, A. melegueta* and *D. tripetala*, have proven efficacious against household cockroaches; hence confirming their inherent insecticidal attributes; and it also agrees with the previous accounts by Carlini and Grossi-de Sa, (2002); Clemente et al. 2003; Vinha et al. (2012); Ukoroije and Bob-Manuel, 2019; Ukoroije and Otayor, 2020.

These plant seed-plant were all observed to be visibly toxic when tested against the cockroach nymphs, yielding significant mean mortalities ($P<0.05$) in the pest population after 24hours of exposure; the values were 16.5±2.8; 15.0±2.7 and 5.5±1.7 for *P. guineense, A. melegueta and D. tripetala* respectively, when compared to the control (0.00). Also, prolonged exposures (e.g. 24hrs) was found to be more effective and toxic than brief durations of 15-, 30- or 60-minutes exposure.

Previous works by Toshihiro and Haruyasu (2006), on the single use, and the combined effects of powders of Alligator pepper; *Aframomum melegueta*, Pepper fruit; *Dennettia tripetala*, and Ginger; Zingiber officinale against stored cowpea weevils *Callosobruchus maculatus* proved efficacious and provide a base-line for this current study on household cockroaches. Toshihiro and Haruyasu (2006) report also confirmed that alligator pepper, *Afi-amomum melegueta*, pepper fruit, and *Dennettia tripetala* had secondary metabolites that are ariti-feedants, oviposition deterrents, larvicidal, and also regulate insect development. The effectiveness of these herbs has also been demonstrated to increase with dose/concentration (Ukeh et al., 2009)

In this study, *P. guineense, A. melegueta* and *D. tripetala* demonstrated insecticidal activity (or toxicity) against nymph cockroaches. The lethal dose (LD_{50}) and the lethal time (LT_{50}) that killed 50% of the pest population, was recorded as: 28.0% w/v, at 21.4 (21 mi 4sec) for *P. guineense; and* 40.0% w/v at 31.6 (31mm, 6sec) for *A. melegueta* respectively. *D. tripetala* was a relatively weaker seed-powder (bioinsecticide) and so could not record 50% reduction/mortality in the pest population. The LD_{5O} results from this work, has generally revealed that percent mortality was dependent on the combined effects of concentration, substrate, and time; with higher concentrations yielding 50% mortality in a shorter time duration.

Comparison of plant seed powder effects against diluted Snipper (synthetic insecticide) effect on cockroach nymphs revealed higher percent mortalities (i.e. 100% mortalities for all diluted concentrations) compared to relatively lower mortality ranges of: 23.75%-66.88%, 13.l3%-50.63% and 0.0%-6.88% for *P. guineense, A. melegueta* and *D. tripetala* respectively. Although, it showed some evidence of high effectiveness with *P. guineense* and *A. melegueta* than with *D. tripetala*. It also proved that *P. guineense* (and *A. melegueta*, to some extent) may serve as effective bio-insecticides against cockroaches; and additionally, that higher effects are dependent on higher concentrations and prolonged exposures.

In this study *P. guineense* and *A. meleguela* supported only few nymph-to-adult emergences in the cockroach, compared to the multiples found with *D. tripetala* and the control. More nymphs than adults were recorded with *P. guineense* and *A. melegueta c*ompared to more adults than nymphs, with *D. tripetala* and the control (water). Similarly, the total number of nymphs alive at 24 hours, and at 48 hours, and the total adults alive at 48 hrs were correspondingly 30.0, 24.0 and 6.0 for *P. guineense*; 41, 35 and 11, for *A. melegueta;* but 53.0, 39.0 and 34.0 for *D. tripetala* respectively. No mortality was recorded at 24 and 48 hours with the control (water). The percent development of the cockroach exposed to different powder concentrations ranged from 0.06% — 0.15% for *P. guineense*; 0.10% 0.36% for *A. melegueta* and 2.04% - 3.91%.for *D. tripetala* respectively. The results demonstrated that the insecticide materials in plant seed powders can prevent metamorphosis of cockroach, by altering the metabolic and anatomical processes and thereby cause death in the cockroach.

The findings of Udo (2005) and Asawalam et al. (2007), on plant spices also indicated that a higher quantity of *Piper guineense* on the maize weevil, *Sitophilus zeamais* caused substantial deaths and even lowered the pest's progeny generation. Ukeh et al., (2009) similarly, observed that *A. melegueta* extracts displayed repellant activity towards adult *S. zeamais*. *Piper guineense* odors were also found to significantly repel adult *Sitophilus zeamais* (Ukeh et al., 2009; Akinbulumi et al., 2017). Akinbulumi et al., 2017; Ukeh et al., 2009). Furthermore, Oparaeke et al. (2005) work, similarly revealed that *P. guineense and A. meleguêta* considerably reduced or suppressed pest abundance and pod damages on post-flowering cowpea, hence aided improved grain yields. Also, Shadia et al., 2013 showed that emergence of adult cockroach could be prevented with botanical plants, but stressed that the inhibitory effects may vary for different plants.

The efficacy of botanical insecticides in controlling/preventing insect infestations, from the foregoing (and also directly from this undertaken study with *P. guineense, A. melegueta* and *D. tripetala*) can therefore, not be overemphasized; as also supported from the quantum of publications on the subject. Some are reported to even offer broad-spectrum solutions (insecticidal and/or repellant actions) e.g. the plant piper species (Soraya et al., 2018). Botanical insecticides (or bio-insecticides) are therefore of tremendous significance especially for resource-poor farmers in third world nations, in ensuring safe and effective house-keeping, and in field and storage crop protection,

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and in general environmental preservation and management. Most importantly, they are most often indigenous and hence readily available; low-cost, biodegradable, non-toxic and with no ugly resistance development cases, as associated with the use of conventional chemicals. Consequently, it makes them, the most preferred and acceptable alternatives for environmental management, food security and sustainable agriculture, compared to the use of harmful and deleterious chemical insecticides. Accordingly, the nature, distributions and practical use of these plant-based insecticides have lately become a subject of extensive research.

Conclusion

The study has clearly shown that the investigated plants (particularly *P. guineense* and *A. melegueta)* have biocidal abilities that may conveniently be depended upon to serve as potential bioinsecticides in our immediate environment and globally also. They proved effective against the notorious domestic pest, the German cockroach, and show promise for effective protection of the household, environment and general agriculture. The study has also brought to light an unequivocal truth that some naturally-occurring plants do possess biological attributes (i.e. insecticidal, larvicidal, repellant potentials etc.,) that are yet to be uncovered; and so, it hereby serves only as a baseline, for more further and future investigations. Such follow-up studies may involve whole plant extracts (or plant bark and body washes), plant oils (from leaves, seeds etc.,) for more likely successes and socio-economic gains. Their myriads of benefits (ready availability, low costs, non-toxicity to natural enemies and non-target organisms, amongst others) makes them the most appropriate and viable, and hence the more preferred control option, to the use of synthetic, hazardous chemicals

Recommendations

This study has greatly expanded our knowledge and understanding on subject; consequently, we hereby recommend, thus:

- Encourage cultivation and conservation of these plants
- Identify and investigate more plant species for their innate/inherent attributes (insecticidal, inhibitory and/or repellent potentials)
- Execute full scale plant examinations (using seed-powders, plant body extracts, plant oils from seeds, leaves etc.,)
- Carry out proximate analyses and phytochemical screenings to detect bioactive components in such plants, that may ultimately lead to synthesis or development of novel bioinsecticides against pest species

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