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Assessment of the Insecticidal Properties of *Anchomanes difformis* (P. Beauv.) Powder on Five Beetles of Stored Produce

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Abstract: Biological activity of *Anchomanes difformis* powder was assessed under prevailing atmospheric condition (28±2°C, 70-75 r.h.) in the laboratory on *Sitophilus zeamais* (Motschulsky), *Tribolium castaneum* (Herbst), *Oryzaephilus mercator* (Fauvel), *Callosobruchus maculatus* (Fabricius) and *Lasioderma serricorne* (Fabricius) at three treatment levels of 0.5, 1.0, 1.5 g of plant powder per 25 g food medium. Percentage beetle mortality was scored at 24, 48 and 72 h after treatment. The plant powder was found to be toxic on all the test beetles at 0.5 g treatments within 24 h of plant powder application except on *L. serricorne.* The highest mortality of 100% was recorded in *C. maculatus* after 72 h at 1.5 g treatment level thus; making *C. maculatus* most susceptible to *A. difformis* powder treatment. In a further evaluation of *A. difformis* on survival and development of *C. maculatus*, oviposition and adult emergence were significantly reduced in treatments compared to control. Generally, the bioactivity of *A. difformis* powder on development of immature stages and emergence of adult *C. maculatus* were more pronounced in 1.5 g treated grains. Thus, application of *A. difformis* plant powder could be employed in integrated pest management for *C. maculatus* control.

Key words: Biological activity, *A. difformis*, oviposition, adult emergence

Introduction

Beetles are of great importance in grain storage systems, their activity on stored produce leads to losses both in quality and quantity. Control of these coleopterans is still dependent on synthetic chemical insecticides and this has almost completely kept at bay, the use of biological control techniques. Although chemical insecticides are effective and poses as solution to insect depredation, thy are however, plagued by many problems such as development of resistance in some major pests, high cost of procurement as well as public awareness of hazards posed to human health and the environment including ozone depleting potential (Golob and Webley, 1980; Credland, 1992; Zhang *et al*., 2000; Adedire and Akinkurolere, 2005). Therefore development of an alternative treatment that is none hazardous to human and environmentally friendly is urgently needed.

The use of plant materials for the protection of stored products is an old practice in developing countries and is very common among poor smallholder farmers in the tropics and subtropics (Golob and Webley, 1980; Delobel and Malonga, 1987; Akinkurolere *et al*., 2006). In the tropics, plant materials such as dried pepper and its inert dust have been in use as powders and admixtures for a long time. These have been found to reduce post-harvest losses of stored grains and grain legumes (Boeke *et al*., 2001).

Anchomanes difformis P. Beauv (family: Araceae) is a large herbaceous plant with stout prickly stem, which grows up to 3 m in height and has large divided leaves (Burkill, 1985). It is abundant in the wild forest of West Africa. Farmers in Southern Nigeria also grow it for making rubefacients and vesicants for external application and internal medication respectively (Burkill, 1985). The plant is considered to be a powerful purgative in Cote d'Ivoire and it is also used as a (snake/scorpion) poison antidote. Any of the plant parts: root, stem or leaves is used to treat urethra discharge, jaundice and kidney pains. *A. difformis* contains strong alkaloids (Adegoke *et al.*, 1968), which have been used as medicine and poison by man for ages. Alkaloids are toxic chemical substances that act on the central nervous system.

This study was carried out to evaluate the lethal effect of the rhizome of *A. difformis* in powdered form against stored product beetles.

Materials and Methods

Source of Insect Population/insect Culture

Adults of *S. zeamais*, *T. castaneum*, *C. maculatus*, *O. mercator* and *L. serricorne* used for this study were obtained from Experimental and Teaching Ranch Warehouse of Huazhong Agricultural University, Wuhan. The insects were later reared in our laboratory of stored-product and urban pests, Huazhong Agricultural University, Wuhan. The culture media and rearing conditions for the test beetles as described by Haines (1987), is shown in Table 1.

Plant Material

Anchomanes difformis used for the experiments were collected from Teaching and Research Farm, Federal University of Technology Akure, Nigeria. The rhizome part of *A. difformis* used was first dried naturally on laboratory benches. When dried, it was pulverized in a Kenwood blender and passed through a uniform size sieve. The plant powder was stored in airtight brown bottle and brought to China for the study.

Bioassay

Contact Toxicity Test

Plant powders at three concentrations namely, 0.5, 1.0 and 1.5 g each was measured into 9 cm diameter Petri-dishes containing 25 g of uninfected food medium and thoroughly mixed manually by agitating the dishes. Ten pairs of newly emerged adult beetles were introduced into each Petri-dish containing varying concentrations of plant powder/food medium complex. A control containing only the appropriate food medium without plant powder treatment was also infested with 10 couples of test beetles. The petri dishes were then covered to prevent insects from escaping. Each treatment was replicated three times and insect mortality was scored at 24, 48 and 72 h after treatment.

Effect of Powder on Fecundity

Clean cowpea (*Vigna unguiculata* (L.) Walp.) seeds treated with different plant powder concentrations as described above were infested with 2 pairs of 0-24 h old adult *C. maculatus*. After 72 h all insects (both dead and alive) were removed and the number of eggs was counted per treatment. The number of adult emergence was assessed 30 days after treatment. Each test was done in three replicates. Control tests were also set up without plant powder treatment.

Table 1: Culture media and rearing physical conditions for test beetles (Haines, 1987)

Insects	Media g g^{-1}	Temperature (°C)	Relative humidity (%)
S. zeamais	Wheat	28±2	70-75
T. castaneum	Whole meal flour and yeast (12:1)	28±2	70-75
C. maculatus	Cowpea	28±2	70-75
O. mercator	Wheat feed and rolled oats and yeast (5:5:1)	28±2	70-75
L. serricorne	Wheat feed and yeast (10:1)	28±2	70-75

Data Analysis

There were 3 replicates in each sets of experiment. ANOVA and Tukey's test were used for mean separation in SPPS for windows soft ware (version 10.0).

Results

Contact Toxicity

Adult mortality of all the test beetles was low after treatment with *A. difformis* powder at 0.5 g (Table 2). The mortality rates of all the storage beetles (*S. zeamais*, *T. castaneum*, *O. mercator*, *C. maculatus* and *L. serricorne)* increased with increase in the concentration of *A. difformis* powder and with exposure period (Table 2-4). Mortality of 100% was recorded within 72 h of exposure to 1.5 g concentration of *A. difformis* powder for *C. maculatus* while mortalities of 65.00, 54.00, 40.00 and 25.00% were recorded after 72 h for *T. castaneum*, *S. zeamais*, *O. mercator* and *L. serricorne* respectively for the same treatment (Table 4). Overall susceptibility of the storage beetles to *A. difformis* powder was ranked in the following order: *L. serricorne* < *O. mercator* < *S. zeamais* <*T. castaneum* <*C. maculatus* respectively with *C. maculatus* being most susceptible.

Effect of A. difformis Powder on Fecundity of Adult C. maculatus

Percentage adult emergence after 30 days and average number of eggs laid by *C. maculatus* after 24, 48 and 72 h following treatment with various concentrations of *A. difformis* powder is represented in Table 5. There is significant difference ($p \leq 0.05$) in the rate of oviposition in treated samples compared to untreated (control) seeds. Fewer eggs were laid (11.68, 16.36 and 23.33) per 24 h intervals in 1.5 g treated samples, while 0.5 g treated samples evoking the least ovicidal effect (39.23, 50.13 and 56.82 eggs). However, after 72 h all the three concentrations (0.5, 1.0 and 1.5 g) tested showed some level of ovicidal effect significantly different from the control. *A. difformis* powder at 1.5 g had significant effect (30.13) on adult emergence, different from all treatments; there was no significant difference in bruchids emergence between 0.5 g and blank control.

Table 2: Effect of 0.5 g *Anchomanes difformis* powder on adults of five stored product beetles

	Percentage corrected mortality±SE at hours post treatment		
Insects	24 h	48 h	72 h
Control	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]
Sitophilus zeamais	1.25±0.72[ab]	7.50±0.43[bc]	11.25±1.09[b]
Tribolium castaneum	1.25±0.72[ab]	10.00±1.44[cd]	16.25±1.30[b]
Callosobruchus maculatus	5.00±1.15[b]	12.50±1.15[d]	27.50±2.89[c]
Oryzaephilus mercator	2.50±1.44[ab]	3.75±1.44[ab]	15.00±1.44[b]
Lasioderma serricorne	0.00±0.00[a]	1.25±0.72[a]	5.00±1.15[a]

Each value is the percentage mean±standard error of three replicates. Means followed by different letter (s) vertically are significantly different at $p \leq 0.05$ by Tukey's test

Table 3: Effect of 1.0 g *Anchomanes difformis* powder on adults of five stored product beetles

	Percentage corrected mortality±S.E at hours post treatment		
Insects	24 h	48 h	72 h
Control	0.00±0.00[a]	0.00±0.00a	0.00±0.00[a]
Sitophilus zeamais	22.25±2.45[cd]	30.00±1.73[c]	43.75±3.32[cd]
Tribolium castaneum	30.00±3.46[d]	42.50±2.02[d]	51.25±0.72[d]
Callosobruchus maculatus	47.00±4.04[e]	65.00±3.46[e]	82.00±4.04[e]
Oryzaephilus mercator	12.50±2.60[bc]	22.50±2.89[c]	35.00±2.89[c]
Lasioderma serricorne	5.00±1.15[a]	12.50±1.44[b]	18.75±1.15[b]

Each value is the percentage mean±standard error of three replicates. Means followed by different letter (s) vertically are significantly different at $p \leq 0.05$ by Tukey's test

Table 4: Effect of 1.5 g *Anchomanes difformis* powder on adults of five stored product beetles

Insects	Percentage corrected mortality±S.E at hours post treatment 24 h	48 h	72 h
Control	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Sitophilus zeamais	25.00±2.31^{c}	38.75±1.15^{cd}	54.82±2.45^{d}
Tribolium castaneum	38.40±4.62^{d}	50.00±5.77^{d}	65.26±2.31^{e}
Callosobruchus maculatus	75.50±3.18^{e}	92.00±4.62^{e}	100.00±0.00^{f}
Oryzaephilus mercator	16.00±0.58^{bc}	28.00±4.62^{bc}	40.00±1.73^{c}
Lasioderma serricorne	7.50±1.44^{ab}	16.25±1.88^{b}	25.13±2.89^{b}

Each value is the percentage mean±standard error of three replicates. Means followed by different letter (s) vertically are significantly different at $p \leq 0.05$ by Tukey's test

Table 5: Percentage adult emergence after 30 days and average number of eggs laid by *C. maculatus* after 24, 48 and 72 h following treatment with various concentrations of *A. difformis* powder

Concentration	Corrected mean number of eggs laid 24 h	48 h	72 h	Emergence (%)
Control	43.33^{b}	58.22^{b}	73.26^{c}	98.62^{d}
0.5	39.23^{b}	50.13^{b}	56.82^{b}	93.33^{d}
1.0	18.42^{a}	26.06^{a}	48.22^{b}.	55.36^{b}
1.5	11.38^{a}	16.36^{a}	23.33^{a}	30.13^{a}

Means followed by the same letter vertically are not significantly different at $p \geq 0.05$ by Tukey's test

Discussion

Rhizome powder of *A. difformis* provided good protection against all the test beetles at 72 h post-treatment. *C. maculatus* was the most susceptible of five cereal beetles tested with 100% mortality within 72 h while *L. serricorne* with 25% mortality is the least susceptible to *A. difformis* (Table 4). Since mortality increased as the exposure period increases, it shows that the toxic volatile components of *A. difformis* have some level of persistence.

Similarly, Chiranjeevi and Sudhakar (1996) reported that in many villages in Africa, farmers often mix plant materials with stored grains against pest infestation. Whole plants or parts of plant rather than their powders are often used, presumably because they are easy to remove from the stored grains (Casewell, 1976; Delobel and Malonga, 1987).

This experiment shows that powders made from *A. difformis* significantly reduce the population of all the storage beetles used in this study. Though *A. difformis* powder showed no insecticidal activity at low concentration in some of the tests at 24 h after treatment, significant ($p \leq 0.05$) mortality occurred 72 h after treatment in all the beetles. It also hampered oviposition and emergence of *C. maculatus*. While feeding on whole or fragmental grains, beetles might pick up a lethal dose of the treatment thus resulting in stomach poisoning. The action of *A. difformis* on these beetles could therefore be linked to contact toxicity and stomach poisoning (Chander and Ahmed, 1985; Adedire and Lajide, 2001). Fine particles of *A. difformis* powder could block the spiracles of the beetles thereby impairing respiration and causing death. The results obtained from this study are in agreement with earlier reports (Ofuya, 1990; Niber, 1994; Lajide *et al*., 1998) that powder of some tropical plants could be admixed with grains in storage in order to protect them from damage by storage beetles. Considering the ease of powder application by farmers, *A. difformis* rhizome powder could be admixed with maize grains or cowpea seeds in order to protect them against some of the most serious pests of stored products.

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