Insecticidal activities of three weed varieties against the Bamboo Powder Post Beetle *Dinoderus minutus* Fabricius (Coleoptera: Bostrichidae)

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Abstract

The insecticidal activities of crude ethanol extracts of leaves of three weed species, Siam weed, *Chromolaena odorata* Linn., Milk weed, *Euphorbia heterophylla* Linn. and Tree Marigold *Tithonia diversifolia* (Hemsl.) A, Gray on the insect, *Dinoderus minutus* Fabricius, were investigated on bamboo as substrate. Bamboo blocks were treated with different concentrations: control (positive), control (negative), 20% and 25% of each plant extracts. Twenty-five active adult *D. minutus* insects were introduced into each setup of five bamboo blocks in 0.32 L jars for 60 days and were replicated four times in a Completely Randomized design in the laboratory. Data were collected on mortality of *D. minutus* at 5, 10 and 15 days after introduction. The number of holes bored by *D. minutus* on bamboo blocks after 60 days of storage were counted and the percentage weight loss of bamboo block was calculated using standard procedure. The result showed that the highest and the lowest percentage mortality of *D. minutus* were recorded in 25% *T. diversifolia* (94.67±2.67) and control (–) respectively at 15 days after treatment. The number of holes bored by *D. minutus* on bamboo blocks in the control treatments was higher than the number of holes bored on bamboo blocks treated with different concentrations of the three extracts. The mean percentage weight loss of bamboo blocks obtained at 20% and 25% concentrations of each extract was lower than that of the two control treatments. The maximum wood protection (1.33±0.22) against *D. minutes* was recorded at 25% concentration of *T. diversifolia*. The number of *D. minutus* holes on bamboo block correlated positively ($R^2 = 0.538$; $p<0.0001$) with the percentage weight loss of bamboo. The three weeds at 20% and 25% concentrations could be used in the management of *D. minutus* on bamboo.

Keywords: Plant extract; *Dinoderus minutus*; bamboo pest; mortality; weight loss.
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Introduction

Dinoderus minutus, the bamboo borer or bamboo powderpost beetle is a member of the family Bostrichidae in the order Coleoptera. It attacks felled bamboo culms and finished bamboo products to utilise stored starch (Abood, 2008). Loss of about 40% of bamboo stack within 8-10 months to *D. minutus* has been reported (Thapa *et al* 1992). The adult beetles burrow into felled culms through wounds, cracks and cut ends, and make horizontal tunnels along the fibro-vascular tissues of the culms reducing the bamboo to powder which sifts from the beetle holes (Norhisham *et al* 2015).

Chemical treatment using various insecticides and preservatives has been the most widely used method in controlling post-harvest pests of bamboos, including *D. minutus,* (Xin, 1958). Various preservatives such as 5% water solution of copper-chrome-arsenic composition (CCA), 5-6% water solution of copper-potassium dichromate-borax (CCB), 5-6% water solution of boric acid-borax-sodium pentachlorophenate in 0.8:1:1 or 1:1:5 ratios (BBP), 2-3% water solution of borax: boric acid in a 5:1 ratio and 10% or 20-25% water solution of copper sulphate have been recommended and used in the control of *D. minutus*. These are mostly applied by soaking under normal temperatures, cold or heated conditions, or under high pressure (Thapa *et al* 1992; Kumar *et al* 1985; Zhou, 1985).

However, synthetic insecticides have been associated with mild or acute health hazards to humans and animals, and environmental pollution as they are often mis-handled and not properly applied (Fening, 2013). Thus, the use of botanical pesticides have been advocated as a safer, cheaper, accessible and easily processed alternative to synthetic insecticides and have been used traditionally for generations throughout the world (Belmain and Stevenson, 2001). In view of developing a safer and low cost alternative to synthetic insecticides, efforts have been focused on plants-derived materials (Jbilou *et al* 2008) that possess bioactive chemicals and secondary metabolites against insects (Lopez *et al* 2008; Qin *et al* 2010). These compounds act as fumigants (Choi *et al* 2006), contact insecticides (Tang *et al*., 2007), repellents

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(Islam *et al* 2009) and anti-feedants (Gonzalez-Coloma *et al* 2006) or may affect some biological parameters such as growth rate (Nathan *et al* 2008), life span and reproduction of insects (Isikber *et al* 2006).The aim of this study was to determine the effect of leaves of three weed extracts *Chlomolaena odorata,* Linn., *Euphorbia heterophylla,* Linn. and *T. diversifolia* (Hemsl.) A, Gray against *D. minutes* on bamboo.

Materials and methods

The insect stock culture

Adults of *D. minutus* were obtained from the Advanced Entomology Laboratory, Department of Zoology, University of Ibadan (7.44°N, 3.90°E), Nigeria. Cassava chips and bamboo culms used as culture media were heat-sterilized in an oven (Memmert type UL 40) at 60°C for 90minutes (Atijegbe *et al* 2014). The adult *D. minutus* collected were cultured and maintained on the culture media in 1L Kilner jars in the laboratory under recorded temperature and relative humidity of 27°C±3°C and 78±10% using the digital thermometer and whirling psychrometer (740), respectively. Frass generated due to boring and feeding activities of the insects were sieved out weekly using sieve of mesh size 0.25 mm to rejuvenate the culture stock and prevent excessive moisture and growth of mould. Subsequently, insects were collected from the stocked culture for further experiments.

Bamboo substrate preparation

Matured bamboo (*Bambusa vulgaris*) stands were harvested from Forestry Research Institute of Nigeria, Ibadan, Nigeria (FRIN), arboretum. Bamboo culms were cut and splited into blocks of (4.0 x 3.0 x 1.0) cm insize (Norhisham *et al* 2013). The freshly splited bamboo blocks were air dried for 4 weeks and the moisture content determined using the oven drying method as described by (Stumpf, 1998). The dried bamboo were sterilised in a hot-air oven at 60°C for 1 hour (Asmanizar *et al* 2008) to kill any insect that might have infested it from the field and during the drying process.

Collection and preparation of weed samples

Leaves of three weeds species, Siam weed (*C. odorata*), Milkweed (*Euphorbia heterophylla*) and Tree Marigold (*T. diversifolia*) were collected from the arboretum of Forestry Research Institute of Nigeria, Ibadan, Nigeria (FRIN), and identified at the Taxonomy Section, Department of Forest Conservation and Protection, Forestry Research Institute of Nigeria. These leaves were air-dried for 2 weeks under room temperature and milled into powder using a kitchen blender (Model MX-795N).

Crude ethanol extract preparation

The extraction of the crude extracts from the weed species was carried out in the Department of Pharmaceutical Chemistry, University of Ibadan, Ibadan, Oyo State, Nigeria. Each of the milled weed samples wasput in a 1,000-2,000 ml Erlenmeyer flask with 1.5 litres of absolute ethanol as solvent, stirred at intervals and left to macerate for 72 hours. After 72 hours, ethanol solution of each weed sample was removed by filtration and the filtrate was concentrated using a rotary evaporator at 40°C to remove the solvent. The concentrate (crude extract) was further concentrated using vacuum oven set at 30°C and 600 mmHg pressure to further remove any trace of solvent present. The crude extracts were stored in the refrigerator at ultra-low temperature until used (Moreira *et al* 2004).

Boring and feeding deterrence bioassay

Each setup consists of five bamboo blocks in 0.32L plastic jars. The bamboo blocks were treated with 20% and 25% concentration of each extracts. The positive (+) and negative (–) controls were treated with the solvent and without solvent, respectively. The treated bamboo blocks were air dried for 3days for the treatments to dry completely in the Entomology Laboratory of the Department of Forest Conservation and Protection, Forestry Research Institute of Nigeria (FRIN), (7.394°N, 3.871°E), Jericho Hills, Ibadan, Nigeria.

The initial weights of the bamboo blocks were measured using a digital weighing balance [Model: Pioneer PA413 (max 410g x 0.001g)] and a total of 25; male and female adults *D. minutus* were introduced into each jar. All treatments had four replicates and arranged in a completely randomized design (CRD) on the laboratory bench for 60 days. Numbers of dead insects, bored holes and final weight of infected bamboo blocks were parameters taken. The percentage weight loss was calculated using the following formula:

% weight loss:

$$= \frac{\text{Initial weight of bamboo} - \text{Final weight of bamboo}}{\text{Initial weight of bamboo}} \times 100$$

Statistical analysis

Data obtained were subjected to Analysis of Variance (ANOVA) and means were separated using Fisher's least significant difference (LSD) at $p \leq 0.05$.

Results

Mortality of D. minutus on bamboo blocks treated with three botanical extracts

There was a significantly higher mortality of *D. minutus* on bamboo blocks treated with 20% and 25% of *T. diversifolia* than bamboo blocks treated with 20% and 25% of both *C. odorata* and *E. heterophylla* at 5 days post exposure period. However, mortalities of *D. minutus* recorded in *C. odorata* and *E. heterophylla* were not significantly different compared to mortalities in the two control treatments (Table 1). Mortalities of *D. minutus* in 20% and 25% of the three botanical extracts were significantly higher than mortalities at both negative (–)

and positive (+) control treatments at 10 days post-treatment. In addition, *D. minutus* mortalities at both 20% and 25% *T. diversifolia* and 25% *C. odorata* were not significantly different, but significantly higher than *D. minutus* mortalities in 20% *C. odorata* and both 20% and 25% *E. heterophylla*. At 15 days after treatment, there were significantly higher mortalities of *D. minutus* on bamboo chips treated with 20% and 25% *T. diversifolia* than in 20% and 25% *C. odorata* and *E. heterophylla*. The 20% and 25% concentrations of *C. odorata, E. heterophylla* and *T. diversifolia* caused significantly higher mortalities of *D. minutus* than the two control treatments.

Generally, the number of holes bored into bamboo blocks were higher in the two control treatments than on bamboo blocks treated with different concentrations of the botanical extracts at 5, 10 and15 days post exposure periods (Table 2). A significantly lowernumber of holes were obtained at 25% *E. heterophylla*, 25% *T. diversifolia* and 25% *C. Odorata* at 5, 10 and 15 days post exposure periods, respectively than in the control treatments.

Table 1. Percentage mean mortality ($\bar{x}$ ± S.E) of *Dinoderus minutus* on bamboo blocks treated with different concentrations of three botanical extracts at different exposure periods.

Extracts	Extract Concentrations (%)	Period of exposure (days)		
		5	10	15
		Mean mortality ($\bar{x}$ ±S.E) of *Dinoderus minutus*		
C. odorata	20	6.67±2.67b	42.67±3.53c	73.33±1.33cd
	25	13.33±5.81b	52.00±2.31b	82.67±2.67bc
E.heterophylla	20	10.67±2.67b	38.67±1.33c	64.00±2.31d
	25	13.33±1.33b	44.00±2.31bc	74.67±2.67cd
T. diversifolia	20	34.67±2.67a	68.00±4.62a	89.33±1.33ab
	25	36.00±10.07a	76.00±2.31a	94.67±2.67a
Control (+)	0	6.67±1.33b	25.33±1.33d	48.00±4.62e
Control (–)	0	6.67±1.33b	21.33±3.53d	42.67±7.06e

Numbers followed with the same letters in the column are not significantly different (p<0.05). Each treatment mean values was replicated 4 times.

Table 2. Mean number of holes ($\bar{x}$ ± S.E) of *Dinoderus minutus* on bamboo chips treated with different concentrations of three botanical extracts at different exposure periods.

Extracts	Extract Concentrations (%)	Period of exposure (days)		
		5	10	15
		Mean number of holes ($\bar{x}$ ±S.E)		
C. odorata	20	1.67±0.67ab	2.00±0.58ab	2.67±0.33ab
	25	1.00±0.58ab	1.00±0.58b	1.00±0.58b
E.heterophylla	20	2.67±0.88ab	3.67±1.33ab	4.00±1.53ab
	25	0.67±0.33b	1.33±0.33ab	1.67±0.67ab
T. diversifolia	20	2.00±0.00ab	2.67±0.33ab	3.00±0.00ab
	25	1.00±0.58ab	1.00±0.58b	1.33±0.88b
Control (+)	0	3.33±1.86a	4.67±2.73a	5.00±2.52a
Control (–)	0	2.67±0.88ab	3.67±0.88ab	4.00±1.00ab

Numbers followed with the same letters in the column are not significantly different (p<0.05). Each means values are replicated 4 times.

Table 3. Mean weight loss ($\bar{x}$ ± SE) in bamboo blocks treated with different concentrations of three botanical extracts to *Dinoderus minutus* infestation.

Extracts	Extract concentrations (%)	Bamboo weight loss (%)
C. odorata	20	2.82±0.36bc
	25	1.68±0.49c
E. heterophylla	20	3.42±0.70bc
	25	1.78±1.04bc
T. diversifolia	20	2.92±0.78bc
	25	1.33±0.22c
Control (+)	0	7.00±1.69a
Control (–)	0	4.27±0.72b

Damage effect of D. minutus on bamboo blocks treated with three botanical extracts

The percentage weight loss of bamboo blocks at 20% and 25% of the three botanical extracts were not significantly different but significantly lower than weight losses recorded at positive (+) control. The weight loss of bamboo blocks in negative (–) control was significantly lower than weight loss in (+) control but significantly higher than weight losses in both 25% *C. odorata* and *T. diversifolia* (Table 3). There was a significantly positive correlation (R^2 = 0.54; p<0.0001) between the number of holes bored by *D. minutus* on bamboo blocks and the weight loss of bamboo blocks (Figure 1).

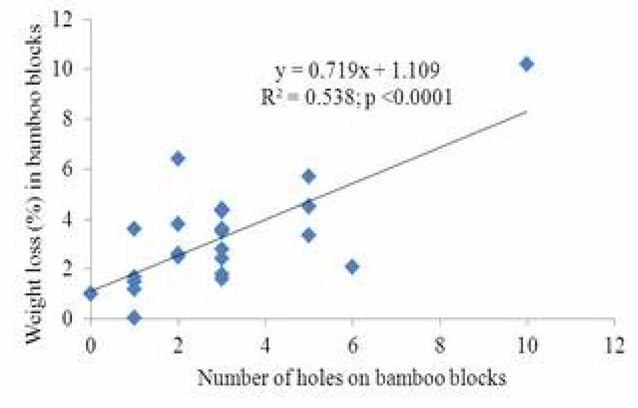

Figure 1: Relationship between the number of holes bored by *Dinoderus minutus* and percentage weight loss of bamboo blocks.

Discussion

Dinoderus minutus is a stored product-pest that has been reported to cause severe damage to bamboo and its products as well as other products like cassava, maize, among others just like other insects from the Family Bostrichidae (Oliveira *et al* 2002). The insecticidal effects of the crude ethanol extracts of three weeds: *C. odorata, E. heterophylla and T.diversifolia* for the treatment of dried bamboo blocks caused substantial levels of mortality on *D. minutus* at all concentrations used compared to the control. The insecticidal activities of *E. Heterophylla* and *T. Diversifolia* had also been reported on *Callosobrochus maculatus* (Adedire and Akinneye, 2004). Insecticidal potency of the extracts of the three weed species in this study may be related to their possession of phytochemical compounds such as alkaloids, cyanogenic glycosides, flavonoids, phytatessaponins and tannins which are toxic to insects (Okeniyi *et al* 2012; Olayinka *et al* 2015). *T. diversifolia* caused higher *D. minutus* mortality compared to *E. heterophylla* and *C. odorata*. This was in agreement with the study of Obembe and Kayode (2013), who reported *T. diversifolia* to be most effective in the control of *C. maculatus* among the four plant extracts tested. It was also reported that leaf extracts of *T. diversifolia* effectively controlled *Sitophilus zeamais* (Onekutu *et al* 2015).

All the three plant extracts used in this study were effective in suppressing the boring activity and the level of damage caused by *D. minutes* on bamboo blocks at 25% concentration. The result showed that less number of holes was recorded in 25% and 20% concentrations compared to control treatments. *T. diversifolia* at 25% concentration was effective in reducing the damage impact of *D. minutus* on bamboo blocks. This confirms the report of Burgueño-Tapia *et al* (2008) that *T. diversifolia* has been identified to possess insect feeding deterrent potential due to the presence of 6-methoxyapigenin and tagitinins A, B, C and F, with diversiform, tirotundin, tithonine and sulphurein. In addition, *E. heterophylla*ca used significant level of *D. minutes* mortality and reduced number of holes bored on bamboo blocks which resulted in reduced bamboo weight loss. It has also been reported that *Jatrophacurcas*, a member of Euphorbiaceae family caused high mortality and feeding deterrence of *D. minutus* on bamboo at higher concentrations (Jyothna *et al* 2015).

In conclusion, this study showed that the crude ethanol extracts of the three weed species possessed insecticidal properties against *D. minutus* on dried bamboo. The extracts were toxic to *D. minutus* and at 25% concentrations were quite effective in suppressing the boring activities of the beetles. Thus, can serve as cheaper and safer alternatives in the treatment of bamboo against *D. minutus* infestation. The challenge of untreated bamboo deterioration, if adequately addressed can help ameliorate the increased pressures placed on the forest woods.

Utilization of weeds with insecticidal properties in the control of *D. minutus* on bamboo and in the control of other stored products and field pests should be greatly encouraged. This will not only help in improving the agricultural yield and the durability of stored products, but also enhances the conversion of these invasive weeds on our agricultural fields into wealth by saving cost on the purchase of synthetic insecticides. This will contribute positively towards proper weed management and achieving a cleaner environment.

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