ANTITERMITIC PROPERTIES OF *Vitellaria paradoxa* (C. F. Gaertn.) STEM BARK EXTRACTS ON *Daniellia oliveri* (Rolfe) Hutch. & Dalziel AND *Vitex doniana* Sw. WOODS

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ABSTRACT

Bioactive effect of V. paradoxa stem bark n-hexane and ethyl acetate extracts on D. oliveri and V. doniana woods was investigated. Stem bark of* V. paradoxa *was collected, air dried and pulverised prior to extraction. D. oliveri and V. doniana wood were purchased and processed into 10 x 2 x 2 cm dimensions. Extraction was sequentially done by dissolving 600 g of stem bark into n' hexane and ethyl acetate, respectively and the mixtures allowed to macerate for 24 hours. Crudes were filtered and evaporated.* V. paradoxa *stem bark was screened for the presence of photochemical constituents. Absorption and retention of extracts in woods were calculated. Treated woods were laid out in a completely Randomized Design with 6 treatments and controls. Termite activities on test woods were recorded as incidence of attack and severity of attacked determined by percentage weight loss. Results indicate that alkaloids and cardiac glycoside were higher (0.12 % and 0.16 %) in stem bark ethyl acetate extract and lower (0.04 % and 0.07%) in stem bark n' hexane extract. The presence of tannins and favonoids were recorded as 0.03 % and 0.01% in ethyl acetate and n' hexane extracts while, phenol (0.11 %) and saponins (0.01%) were present in ethyl acetate, but were absent in n' hexane extracts. V. doniana wood treated with 7.50% n' hexane and 15 % ethyl acetate stem bark extracts were not attacked until the 7th week of the experiment. Percentage solvent absorption in woods ranged from 73.37 - 63.40 % and 81.21- 65.29 % in D. oliveri, while it was from 73.54 - 65.29 % and 92.92 - 71.43 % in V. doniana. Extracts retension in D. oliveri wood ranged from 49.90 - 71.18 % and from 48.19 - 78.52 % whereas, it was 20.89 - 33.00 % and from 15.67 - 38.70% in V. doniana woods. Percentage weight loss in D. oliveri wood was from 52.82 - 83.82% and from 27.14 - 43.82 % in V. doniana. Termigaurd was the most effective treatment with least (7.23 - 10.40) % percentage weight loss followed by 3.75 % V. paradoxa stem bark hexane extract and 7.50 V. paradoxa stem bark ethyl acetate extract. V. paradoxa stem bark extracts are potential biocide which may be combined with other plant extracts for profitable application in wood preservation.

Keywords: Absorption, extracts, *V. paradoxa*, retention, phytochemical, weight loss

INTRODUCTION

Wood is one of the main renewable bio-resources used by mankind since creation. It is used for various purposes such as making of weapons and farm tools, construction purposes and as fuel for house and industrial energy among others (Sonowal and Gogoi, 2010). Although wood can be used for a very long time, it is subject to biodegradation caused by fungi, bacteria, ants and termites. Termites play significant impact on deteriorating or degrading wood and wood products from both plantations and urban forestry. Termites' activities can also cause the death of healthy trees (Calderón-Cortés *et al.*, 2018).

Termites as dominant invertebrates in tropical soils have a major influence on soil chemical and physical structure (Khan *et al.*, 2018). Termites are perhaps the most influential soil-dwelling ecosystem engineers in the tropics (Bignell, 2006). Their biogenic structures: soil sheeting, nests and foraging holes, regulate the availability of resources for other organisms through recycling. Termites play paramount role in the digestion and disintegration of organic matter by regulating nutrient dynamics or global cycling, through the ingestion and redistribution of minerals through associations with symbionts. Termites are known to be the most important instruments for primary breakdown of surface mulches under conservation agriculture (Khan *et al.,* 2018). They are also one most important agent in the mineralization of organic matter that leads to the production of greenhouse gases. Termites' activities on organic matter emit large quantities of methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O) into the atmosphere. Soil-feeding termites emit more methane than wood-feeding termites (Brauman *et al.,* 1992; Bignell *et al.,* 1997). Soils from termite mounds are normally nutrient-rich, in particular of calcium, magnesium, potassium and sodium and available phosphorus (Van Huis *et al.,* 2017).

Despite the beneficial roles of termites to ecosystem and human, the economic loss from their activities on wood and wood products is unprecedented. Termites are extremely destructive and pests of crop plants. They cause damage to green foliage, forests, seedlings, wooden structures, pasture, fibers plus household cellulose-based materials, and postharvest stored products (Pearce, 1997; Upadhyay, 2013). The damage caused by termites slow down food security and reduces livelihoods of smallholder farmers (Demissie *et al.,* 2019).Termites are responsible for huge yield losses and are often a major constraint in reforestation, especially in the semi-arid and sub-humid tropics (*Logan et al.,* 1990). They are amongst the few organisms that are capable of digesting cellulose which contributes to their ecological and evolutionary success (Watanabe *et al.,* 1998; Nakashima *et al.,* 2002); and have become economic pests of wood and wood products in human homes, building materials, forests, and other commercial products.

Activists of termites on wood which has constitutes threat to buildings in many tropical countries is a very serious concern. Though the annual losses due to termites' attacks in Nigeria are presently not certain because of the difficulties in collating such information, their activities are causing so much loss. This has led to the increase in acknowledgement of the importance of termite damage to buildings due to regular repairs of wooden services. This has resulted in the use of Solignum and other synthetic chemicals in their control. Synthetic chemicals have harmful effects on human and the environment. Biopesticides are regarded safer alternatives to chemical pesticides in pest management (Nuruzzaman *et al.,* 2019; Vimala *et al.,* 2019). This knowledge has stimulated much attention among researchers, and has been advocated as potentially good alternatives to synthetic pesticides.

Vitellaria paradoxa (C.F. Gaertn.) belong to the family sapotaceae. The plant is locally abundant in the derived savannah zones in Nigeria (Ndukwe *et al.,* 2007). Studies on *V. paradoxa* have proved that the species contains biocidal substances against some fungi and bacteria (Ahmed *et al.,* 2009; Garba and Salihu, 2011; Fodouop *et al.,* 2017). However, no scientific work has been done on termicidal activity of *V. paradoxa.* This study, therefore evaluates the antitermitic properties of *V. paradoxa* stem bark extracts on *D. oliveri* and *V. doniana* wood samples.

MATERIALS AND METHODS

Sample Collection and Preparation

Stem bark of *V. paradoxa* was collected from Federal University of Agriculture, Makurdi (FUAM) campus. The sample was air dried and pulverised prior to extraction. *Daniellia oliveri* and *Vitex doniana* wood were purchased from Timber shed in North bank Makurdi, Benue State, Nigeria and processed into 10 x 2 x 2 cm (length x width x breadth) dimension as test samples. A synthetic chemical known as 'Termigaurd' was purchased from a sales store at North bank Makurdi, and used as control.

Extraction procedure of *V. paradoxa* stems bark

Crude extraction of stem bark sample was carried out in the Chemistry Laboratory at FUAM. Extraction of sample was done sequentially by dissolving 600 g of stem bark (w/v) into n' hexane and ethyl acetate, respectively and the mixture were allowed to macerate for 24 hours. The extracts were filtered and evaporated according to Ekhuemelo *et al.* (2018).

Phytochemical screenings of *Vitellaria paradoxa* stem bark and sawdust

The phytochemical evaluation of the n-hexane and ethyl acetate extracts of *V. paradoxa* stem bark was performed using standard procedures (AOAC, 2010).

Treatment of Wood samples

The test wood samples were correctly labeled, weighed (W1) and soaked in the different treatments for 24 hours. After soaking, the treated wood blocks were removed from the treatment solutions, drained, and reweighed (W2) to determine the levels of gross absorption and retention of the extracts.

Absorption and retention of extracts is calculated and expressed volumetrically using formulae (Eqns. 1 and 2) adopted by Yildiz *et al*. (2010), Hien *et al*. (2012) as:

$$PA\ (\%) = \frac{(w2-w1)}{w1} x100 \ldots \ldots . . \ldots [1]$$

$$PR\ (kgm-3) = \left(\frac{G*C}{V}\right) * 10 \ldots . \ldots \ldots [2]$$

Where:

PR = Percentage Retention

A = Percentage Absorption

G = (W2-W1) = amount of the treatment absorbed by the test wood blocks (g),

W1 = the oven dried weight of the conditioned wood blocks before treatment (g),

W2 = the weight after treatment,

V = volume of wood test block (cm^3).

C = grams of preservative in 100g of treating solution/concentration of extract.

Experimental Design

The treated wood samples were laid down in a Completely Randomized Design with 6 treatments, each containing six wood samples (each species containing three wood samples) in the field located beside Aper Aku auditorium north core of Federal University of Agriculture, Makurdi. Six treatments of n-hexane, ethyl acetate of *V. paradoxa* bark extracts, at concentration levels of 15 %, 7.5 % and 3.75 % each, Termigaurd (+control), and non-treated woods (- control) were used. The experiment was replicated three times. Two samples each of the wood species were used for each treatment giving a total of twenty-four test samples for a replicate. A total of seventy- two wood test samples were used for the three replicates. The treated samples were buried for eight weeks to allow enough time for termite activities. Samples were checked and assessed weekly by visual observation of wood samples on the field for the rate of termite attack.

Data collection

Inspection and evaluation of the specimens were done by visual assessment after weekly for any sign of termite attack for a period of eight weeks. In every inspection, the specimen was removed from the ground, cleaned and damage was assessed and recorded.

Experimental layout

Figure 2 shows a plot of 6 by 12 meters that was mapped out in a termite infested area. Thirty-six holes of 10cm depth were dug along the length of the mapped-out area at every 1 by 3 meters apart. This was done and replicated three times. Twelve wood samples were laid for each wood species in one replicate, and 6 wood samples for each treatment in a replicate.

Figure 1: Field Layout of the Experiment

Plate 1 shows *D. oliveri* and *V. doniana* wood samples soaked in n' hexane and ethyl acetate extracts of *V. paradoxa* at various levels of concentrations 15, 7.5 and 3.75% respectively and in synthetic chemical and untreated wood samples as control.

Plate 1: Wood samples soaked in crude extracts for treatment

Incidence of Termite Attack

The incidence of termite attack was recorded as follows:

+ = attack and

- = no attack

Severity of termite attack

The severity of termite attack was determined by percentage weight loss calculated mathematically as:

$$\%\ \text{weight loss} = \left(\frac{w1-w2}{w1}\right) x100 \ldots \ldots \ldots [3]$$

Where: w1 = Conditioned weight after preservative treatment (g); w2 = Final weight after exposure to termite (g)

Efficacy of treatments was assessed by observing decrease in mean weight of treated wood samples from the beginning to the end of the experiment.

Data Analysis

One way Analysis of Variance (ANOVA) was used to determine means of treatment on wood samples. Follow up test was carried out using Duncan Multiple Range Test (DMRT) where significant differences exist.

RESULTS

The results of quantitative phytochemical screening of *V. paradoxa* stem bark results are shown in Figure 3. The results shown that alkaloids and cardiac glycoside were higher (0.12 and 0.16%) in stem bark ethyl acetate extract and lower (0.04 % and 0.07 %) in stem bark n' hexane extract. The value of tannins and favonoids were 0.03 % and 0.01 % in ethyl acetate and n' hexane extracts while phenol (0.11 %) and saponins (0.01 %) were present in ethyl acetate they were absent in n' hexane extracts.

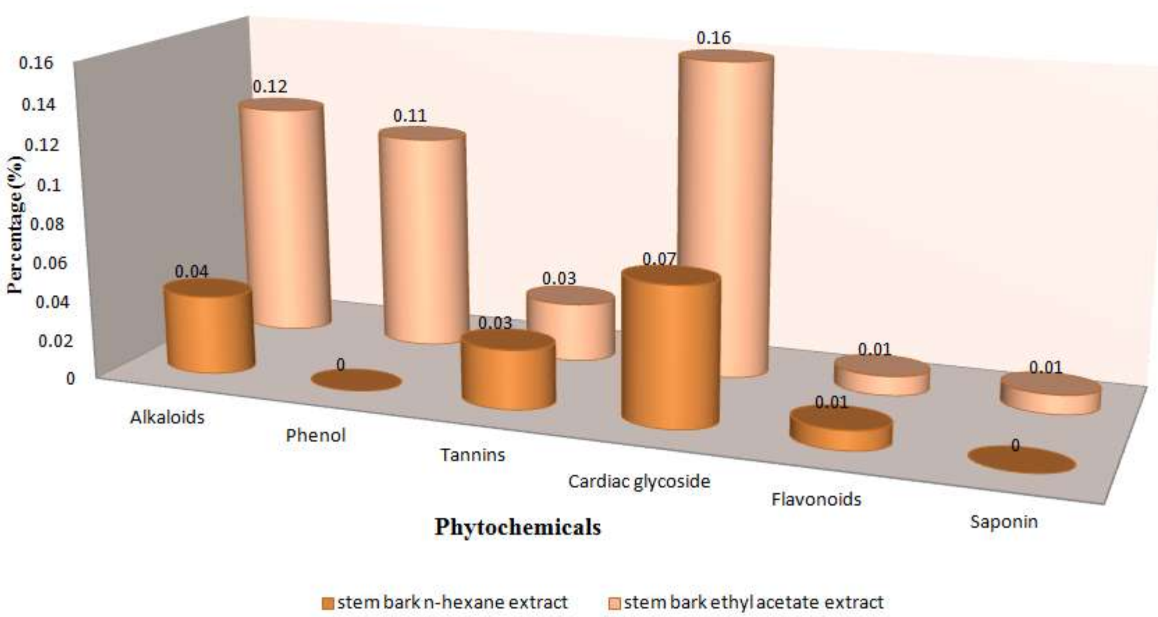

Figure 2: Quantitative phytochemical screening of *V. paradoxa* stem extracts

Table 1 shows results of incidence of termites attack on *D. oliveri and V. doniana* wood samples treated with stem bark of *V. paradoxa* extracts. *Vitex doniana* wood treated with 7.50 % n' hexane and 15 % ethyl acetate n' hexane stem bark extracts were not attacked until the 7th week of the experiment. The result further showed that, *D. oliveri* and *V. doniana* wood samples treated with 7.50 % n' hexane, and by 15 % and 7.50% ethyl acetate stem bark extracts were not attacked by termites till the 5th week. However, both *D. oliveri and V. doniana* treated with Termigaurd were not attacked throughout the experiment. The untreated *D. oliveri* and *V. doniana* wood samples were attacked in the 2nd and 5th week respectively.

Table 1: Incidence of termites attack on *D. oliveri and V. doniana* woods treated with stem bark of *V. paradoxa* extracts

Treatment	Conc. (%)	*Daniellia oliveri*								*Vitex doniana*							
		wk 1	wk 2	wk 3	wk 4	wk 5	wk 6	wk 7	wk 8	wk 1	wk 2	wk 3	wk 4	wk 5	wk 6	wk 7	wk 8
N' Hexane stem bark extract	15.00	-	-	-	+	+	+	+	+	-	-	-	-	+	+	+	+
	7.50	-	-	-	-	+	+	+	+	-	-	-	-	-	-	+	+
	3.75	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+
Ethyl acetate stem bark extract	15.00	-	-	+	+	+	+	+	+	-	-	-	-	-	-	+	+
	7.50	-	+	+	+	+	+	+	+	-	-	-	-	+	+	+	+
	3.75	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	+
Control																	
Non treated		-	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+
Termigaurd		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Key: - *no attack, + attacked; wk - week*

Table 2 shows the results of mean percentage solvent absorption by *D. oliveri* and *V. doniana* wood samples. Percentage solvent absorption in wood samples ranged from 73.37 - 63.40 % and 81.21- 65.29% in *D. oliveri* while it ranged from 73.54 - 65.29 % and 92.92 - 71.43 %in *V. doniana* for both n' hexane and ethyl acetate extracts, respectively. For both *D. oliveri* and *V. doniana* woods, Termigaurd treated had the least percentage absorption of 57.43 and 58.45, respectively. The solvent absorption in both cases was highest in wood samples treated with 15% concentration of extracts. There was no significance different among percentage solvent absorption at p>0.05 in both test wood species.

Table 2: **Percentage solvent Absorption by *D. oliveri* and *V. doniana* wood samples Treated with *V. paradoxa* stem bark extracts**

Conc. (%)	Stem bark Hexane extract		Stem bark Ethyl acetate extract	
	Daniellia oliveri **Mean± Std.**	***Vitex doniana*** **Mean± Std.**	***Daniellia oliveri*** **Mean± Std.**	***Vitex doniana*** **Mean± Std.**
3.75	65.80±108.96[a]	61.23± 36.26[a]	73.50±127.95[a]	75.65± 28.62[a]
7.50	63.40±127.48[a]	66.78±17.12[a]	65.29±76.47[a]	71.43± 33.24[a]
15.00	73.37±196.97[a]	73.54± 61.06[a]	81.21±84.74[a]	92.92± 39.54[a]
Control				
+ Termigaurd	57.43±48.02	58.45±34.35		

Means with the same alphabet as superscripts within each column are not significantly different.

Results of percentage retention of extracts in *D. oliveri* and *V. doniana* wood samples are presented in table 3. Extracts retained in *D. oliveri* wood ranged from 49.90 - 71.18% and 48.19 - 78.52%; it was highest in 15% and lowest in 7.50% for both *V. paradoxa* stem bark hexane and ethyl acetate extracts. In *V. doniana* wood samples, percentage retention ranged from 20.89 - 33.00% and 15.67 - 38.70% for both hexane and ethyl acetate extracts, respectively; and highest in 15.00% concentration of extracts. However, percentage retention of Termigaurd treated woods was moderate (37.18 - 36.09) % in both wood species. There was no significance different among percentage solvent retention at p>0.05 in both treated wood species.

Table 3: Percentage Retention of *Daniellia oliveri* and *Vitex doniana* Treated Wood Samples

Conc. (%)	Stem bark Hexane extract		Stem bark Ethyl acetate extract	
	***Daniellia oliveri* Mean± Std.**	***Vitex doniana* Mean± Std.**	***Daniellia oliveri* Mean± Std.**	***Vitex doniana* Mean± Std.**
3.75	55.04±16.34[a]	20.89± 5.44[a]	63.85± 19.19[a]	18.76± 4.29[a]
7.50	49.90±19.12[a]	26.35± 2.57[a]	48.19±11.47[a]	15.67± 4.99[a]
15.00	51.18± 29.54[a]	33.00± 9.16[a]	78.52±12.71[a]	38.70± 5.93[a]
Control				
Termigaurd	37.18±7.21	36.09±6.99		

Means with the same alphabet as superscripts within each column are not significantly different.

Results of percentage weight loss in *D. oliveri* wood were from 52.82 - 83.82% and 62.78 - 79.79% while it was from 30.22 - 41.77% and 27.14 - 43.82 % in *V. doniana*. Termigaurd was the most effective treatment with least (7.23 - 10.40) % percentage weight loss. There was no significant difference among percentage weight loss at p>0.05 in both test wood species.

Table 4: Percentage weight loss of *V. paradoxa* extracts of stem bark on *D. oliveri* and *V. doniana* wood Samples

Conc. (%)	Stem bark hexane extract		Stem bark ethyl acetate extract	
	***Daniellia oliveri* Mean± Std.**	***V. doniana* Mean± Std.**	***D. oliveri* Mean± Std.**	***V. doniana* Mean± Std.**
3.75	52.82±18.07[b]	30.22± 15.60[abc]	77.07± 29.74[b]	32.63± 11.36[abc]
7.50	83.82± 28.03[b]	41.77± 23.74[abc]	62.78± 32.41[b]	27.14±18.91[abc]
15.00	59.59± 21.29[ab]	33.67± 4.87[abc]	79.79± 28.75[b]	43.82± 20.38[abc]
Control				
+ Termigaurd	10.40±2.91[a]	7.23±17.26[a]		
- Non- treated	64.59±39.64[b]	39.29±8.69[abc]		

Means with the same alphabet as superscripts within each column are not significantly different.

Most *Daniellia oliveri* samples treated with *V. paradoxa* **s**tem bark extracts and the untreated were all severely (4) attacked after week 8 of the study while 3.75% n- hexane *V. paradoxa* **s**tem bark extract treated samples were moderately attacked. *Vitex doniana* woods treated with 3.75 and 15 % *V. paradoxa* **s**tem bark n- hexane extracts, 3.75 and 7.50 % ethyl acetate extracts and the untreated samples were moderately (2) attacked (Table 5). Samples treated with 7.50% n- hexane extract and 15% ethyl acetate extracts were moderate/severely (3) attacked. All samples treated with Termigaurd were slightly (1) attacked.

Table 5: Visual rating of severity of termite attack on *D. oliveri* and *V. doniana* treated wood samples in week 8

***Vitellaria paradoxa* Extracts**	**Concentration (%)**	**Visual rating of Treated wood samples**	
		Daniellia oliveri	***Vitex doniana***
Stem bark n- hexane extract	3.75	3	2
	7.50	4	3
	15.00	4	2
Stem bark ethyl acetate extract	3.75	4	2
	7.50	4	2
	15.00	4	3
+ Control (Termigaurd)	Chemical treatment	0	0
- Control	Untreated	4	3

Keys: 0 = No attack; 1=Slight attack (1-20% damage); 2=Moderate attack (21-40% damage);
3=Moderate/severe attack (41-60% damage); 4=Severe attack (61-80% damage);
5=Very severe attack (81-99% damage); 6=100% Failure

DISCUSSION

Alkaloids, cardiac glycoside, tannins, favonoids, phenol and saponins were present in the stem of *V. paradoxa.* This finding corroborates with the study of Boyejo *et al.,* (2019) who reported the presence of alkaloids, flavonoids, saponins, tannins, phlobotanins and phenolic compounds in the acetone, ethanol and water extracts from the leaves, barks and roots of *V. paradoxa.* This makes saponins natural antibiotics. Saponins also reportedly function as prevention for bioactivity against insects. Numerous researchers have shown the efficiency of plants extracts as source of bio-preservative on the activities of fungi and termite attacks on wood (Singh and Kumar, 2008; Sotande *el al.,* 2011; Djenontin *el al.,* 2012; Addisu *el al.,* 2014; Fariwa *el al.,* 2015).

D. oliveri wood was more susceptible to termites attack compared to *V. doniana* wood. This agrees with the finding by Ekhuemelo and Musa, (2015) that *D. oliveri* wood vulnerable and susceptible to fungi, pinhole borers, termites, *Lyctus* and marine borer's attacks (Schmelzer *et al*., 2012). This implies that the wood needs protection before being used.

Percentage solvent absorption was higher in *D. oliveri* wood in comparison to *V. doniana* wood. It was observed that wood treated with 15 % concentration of extract had highest percentage of solvent absorption. Funke *et al.,* (2015) observed that the rate of solvent absorption in wood is dependent on the concentration of a solution. Therefore, absorption of wood sample increases directly as the concentration level of solvent increases. The difference in the rate of absorption could be attributed to viscosity of the biopesticides or by some other properties of wood such as pores, cell lumen among others. It could also be the differences in absorption as a result of extractives deposited in the wood samples (Faruwa *et al.,* 2015). The high rate of extractives absorption and the penetration in wood species does not necessary imply a better resistance of the treated wood to attack by biodegradation agents like termite. However, the resistance of treated wood to biodegrading attacks could be determined mainly by the active ingredient in preservative chemical or extracts (Adeduntan, 2015).

Percentage solvent retention was higher in *V. doniana* wood as compared to *D. oliveri* wood. The anatomical structure of different wood species could be responsible for this variation in pesticides retention. The amount of biocide held in the cellulose material probably differs due to dissimilarities in anatomical structures of the different wood species (Ogbogu, 1996). Similar to percentage absorption in this study, solvent retention in wood was highest in woods treated with 15 % concentration of extract in both species. This trend could be due the volume of the extract.

As previously reported for incidence of termites attack, *D. oliveri* wood samples had higher percentage weight loss compared to *V. doniana* wood. However, termiguard performed best in the control of termites on treated wood samples followed by 3.75 % *V. paradoxa* stem bark hexane extract and 7.50 % *V. paradoxa* stem bark ethyl acetate extract. All woods treated with termiguard were slightly attacked. This implies that the synthetic chemical still remains active as wood preservative. However, *V. paradoxa* stem bark extracts have also proved to be permissive biocide which may be combined with other plant extracts for purposeful application.

CONCLUSION

This study revealed that untreated woods of *D. oliveri* and *V. doniana* were highly susceptible to termite attack. Alkaloids, cardiac glycoside, tannins, favonoids, phenol and saponins were present in the stem of *V. paradoxa*. Percentage solvent absorption was higher in *D. oliveri* wood in comparison to *V. doniana* wood, while, percentage solvent retention was higher in *V. doniana* wood as compared to *D. oliveri* wood. Termiguard performed best in the control of termites on treated wood samples followed by 3.75 % *V. paradoxa* stem bark hexane extract and 7.50 *V. paradoxa* stem bark ethyl acetate extract. *V. paradoxa* stem bark extracts have proved to be potential biopesticide which may be combined with other plant extracts for application in wood preservation.

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