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# Efficacy of *Lepidagathis alopecuroides* Extracts as Wood (*Bombax buonopozense*) Preservative against Termites (*Macrotermes malaccensis*) Attack

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***Authors' contributions***

*This work was carried out in collaboration between all authors. The experiment was designed by author FGO which was supervised by author OKO. Author OSE executed the work and equally drafted the manuscript which was read and corrected by author FGO. All authors finally read and approved the final manuscript as presented.*

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## ABSTRACT

Cold and hot extracts of *Lepidagathis alopecuroides* were obtained using water, petroleum spirit and methanol as extracting solvents. The extracts were diluted to different concentrations (0.025, 0.035, 0.045 and 0.055 mg/L) and a control (0.00 mg/L). The extracts were then applied on completely dried pieces of *Bombax buonopozense* wood and stuck in the ground near an anthill and allowed to stand for six weeks. The protection of the wood was measured by the rate of non-

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consumption of the wood. It was observed that the protection of the wood from termites attack by the extracts were concentration dependent. In the cold extract, methanol gave 95.23 ± 7.55% protection at the highest concentration (0.055 mg/L) followed by the value at 0.045 mg/L (65.08 ± 9.20%) as against the control value of 10.50 ± 0.00%. Cold petroleum spirit extract at the highest concentration gave 86.60 ± 9.34% protection while, the cold water extract at the highest concentration gave 88.88 ± 16.32% protection. In the hot extraction, extracts from methanol gave 46.20 ± 10.21% at the highest concentration; petroleum spirit gave 57.38 ± 7.71% protection while, hot water extract gave 53.19 ± 7.25% protection. The results showed that cold extracts of *Lepidagathis alopecuroides* from the various solvents were more potent in the wood (*Bombax buonopozense*) protection than the corresponding hot extracts. We can infer that some of the active components in the plant are volatile. The plant *Lepidagathis alopecuroides* can be recommended as potent, new wood preservative.

*Keywords: Termites; Lepidagathis alopecuroides; Bombax buonopozense; protection; extracts.*

## 1. INTRODUCTION

Wood is one of the oldest known materials used in the construction of structures with a wide variety of applications [1,2]. Wood possesses some physical and mechanical properties which qualifies it for use as structural material, hence it has found utility in the building and construction of houses, roofing, doors and window panels, furniture, building of bridges, fuel, electrical poles, etc [3,4].

Woods are used in both outdoor and indoor services and are subjected to different environmental conditions, yet when properly preserved, have the ability to withstand these conditions for many years [5]. However, it is only those woods that are durable that are considered for structural and construction purposes especially in Nigeria [6].

Woods are subject to biodegradation and deterioration. One of the major agents of degradation of woods is termite attack. Termites feed on cellulose which is a common constituent of wood and wood products [5]. When termites feed on wood, the structural capacity and appearance is reduced and eventually destroyed [7] and therefore rendered useless. Termites attack on wood is a chronic problem all over the world, especially in tropical regions of sub-Sahara Africa and this has led to serious financial and material losses [8]. The activities of termites also help in the improvement of soil fertility. However, they cause a lot of damage to both living plant and dry wood which is used for construction purposes and other indoor and outdoor uses [9]. They travel long distances underground by building forage tunnels to search for cellulose in wood.

Although termites normally eat dead vegetation, their tunnels may weaken plant stems, causing them to collapse or giving access to fungus and other diseases. They attack phloem of trees and thereby cause them to wither collapse or die. They make mud runways to reach dead wood and in the process may cover some smaller plants with the mud which may cause the death of these plants. In the event of construction, or agricultural use of land, it requires the use of machinery to level and explosives to blow up very large anthills thus increasing thus increasing the cost of mechanized farming, road construction and building-site clearance. To obtain the wood for their food they make extensive tunnels through the structures, weakening them and eventually causing their collapse. Since the insects make no openings to the outside, or do so only at an advanced stage of the invasion, the owner is frequently unaware of their presence until it is too late [10].

For many years, different industries have developed different synthetic chemicals as wood protectants or preservative against pests or degrading agents all over the world [11]. Most of these synthetic products have worldwide acceptance because they give long time protection of the wood against different insect infestation [12]. However, these synthetic products or pesticides are in turn detrimental to the environment due to their persistence and toxicity to plants and animals. Virtually all synthetic pesticide have residual (accumulative) effects on food crops and animals on contact and this has led to different legislative efforts to restrict the use of most of these preservatives [13].

For example, the government of most countries required that pesticides must be approved legally before it is sold or used by individuals and corporate bodies [14]. Furthermore, European union for example has approved that pesticides that are carcinogenic, mutagenic or toxic to reproduction, those that are endocrine-disrupting, and those that are persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumulative are not good for the general safety of the environment and human lives and are therefore banned [15]. In the US, the EPA regulates pesticides by the amendment of the Food Quality Protection Act of 1996. Also the United States Department of Agriculture (USDA) and the United States Food and Drug Administration (FDA) have set limits in the concentration of pesticides in crops [16].

*Lepidagathis alopecuroides* is a native of coastal countries of West Africa. It belongs to the family Acanthaceae. Local fishermen applies finely ground parts of the leaves of this plant on mudflats of tidal water at low tide period to stupefy mudskippers and other mud dwelling fishes in parts of Rivers and Cross River states, Nigeria [17]. When put in contact with the fish, the extract determines a quick kill. According to [18], the plant possesses some antimicrobial activity and therefore finds its use by the locals for the treatment of abdominal pains and diarrhea. It also possesses larvicidal action against mosquito's larvae [19].

This study was conducted to examine the efficacy of *Lepidagathis alopecuriodes* extracts on the prevention of termite attack on the wood *Bombax buonopozense* an important wood plant in the Niger Delta Nigeria.

## 2. MATERIALS AND METHODS

Leaves and stems of *Lepidagathis alopecuriodes* were collected from Mgbara-Egbema in Ohaji-Egbema Local Government Area of Imo State, Nigeria and transported to the Department of Chemistry, Rivers State University of Science and Technology, Port Harcourt, Rivers State. The samples were air-dried to constant weight for a period of two weeks, ground to powder with a blender and stored in tightly closed bottles.

A trial solution was prepared by soaking 100 g of the ground sample in distilled cold water in a 250 ml conical flask. The conical flask was covered with aluminum foil and allowed to stand for 48 hours. Similarly, test samples were prepared using 25 g *Lepidagathis alopecuriodes* soaked in 100 ml of cold water, petroleum spirit and methanol respectively and allowed to stand for 48 hours at room temperature. For the hot extracts, 25 g sample each in a thimble were placed in the soxhlet apparatus and extracted with petroleum spirit and methanol respectively. The hot water extract was obtained by refluxing 25 g of the sample in 100 ml of water for 48 hours. The extracts obtained from both the cold and hot extractions were serially diluted to obtain the concentrations (0.025, 0.035, 0.045 and 0.055 mg/L). The control (0.00 mg/L) was the pure solvent in each case.

Lengths of the wood, *Bombax buonopozense* already cut into 2 inches by 2 inches by 12 feet (popularly known as 2 by 2 used for roofing) were purchased from Mile 3 Timber Market, Port Harcourt. The wood was further cut into one foot, weighed and labeled. Each length of wood was subsequently demarcated into 6 inch units with a marker pen.

One half portion of the wood was smeared with the plant extracts from the different solvents (water, petroleum spirit and methanol) and extraction methods (cold and hot) with a brush and allowed to dry for 24 hours. The control samples were smeared with the pure solvents and left to dry for 24 hours also.

The anthill selected was 3.6 metres high, 2.8 metres long and 2.1 metres wide, situated behind the Food Science and Technology Department and midway between the Faculty of Science and Faculty of Engineering of the Rivers State University of Science and Technology Port Harcourt. The treated woods were transported to the experimental site, leaving eight untreated pieces in the laboratory. This was done to ascertain the weight difference for a completely dry sample in order to determine the water content of the wood.

At the anthill site, the treated woods were staked in the ground, starting from a distance of two feet, with the treated half of the wood completely buried. The woods were arranged in rows and columns one foot apart and were exposed to termite attack for a period of six weeks. The choice of the six weeks was based on other works [7,20]

The experiment consisted of four treatment levels and a control with three replicates. During the experimental period, temperature and humidity readings were taken twice a week for six weeks because pilot measurement of temperature and humidity taken every day for the first week did not vary.

**Fig. 1. The anthill at the experimental site**

At the end of the sixth week (the experimental period), the woods were removed from the ground and transferred to the laboratory for further analysis.

**Fig. 2. Standing woods (treated) and fallen woods (untreated)**

The following mathematical assessments were conducted to ascertain the percentage of wood protection by the different solvent extracts and methods:

a) Wood protection = weight of fresh *Bombax buonopozense* wood – (weight of water + weight loss due to *Macrotermes* specie).
b) Weight loss due to *Macrotermes* specie infestation = weight of fresh wood – (weight of water + weight of wood after infestation)
c) Percentage protection = $\frac{\text{weight loss due to infestation of wood}}{weight\ of\ wood\ before\ Macrotermes\ infestation} \times 100$

The results obtained were further subjected to analysis of variance (ANOVA) to determine if differences existed in the infestation of termites on the woods smeared with the different extracts from the solvents and the applied concentrations. Probit analysis [21] was also done on the data to obtain different protection levels of the extracts at 95% confidence intervals.

## 3. RESULTS AND DISCUSSION

The temperature and humidity of the inside and outside of the anthill are given in Table 1. Temperature and humidity in the tropics are good factors for the activity of termites. Termites thrive better in the humid and temperate regions than the arid and semi-arid regions and are completely absent in the Antartica [22,23].

**Table 1. Weekly mean of temperature and humidity of the anthill during the six weeks period**

| Week | Temperature | | Humidity | |
|---|---|---|---|---|
| | Inside | outside | Inside | Outside |
| 1 | 27.5 | 29.0 | 70.0 | 63.5 |
| 2 | 26.5 | 28.5 | 71.0 | 59.25 |
| 3 | 26.0 | 27.5 | 76.25 | 68.75 |
| 4 | 29.0 | 30.5 | 69.0 | 61.50 |
| 5 | 30.0 | 32.0 | 64.0 | 58.50 |
| 6 | 30.3 | 33.33 | 58.67 | 53.83 |

The efficacy of the cold and hot extract of *Lepidagathis alopecuriodes* against termite infestation on *Bombax buonopozense* wood is shown in Tables 2 and 3. The efficacy of the different solvent extracts of *Lepidagathis alopecuriodes* on the wood *(Bombax buonopozense*) protection is shown in Table 4. The application of different extracts of *Lepidagathis alopecuroides* from different solvents using different methods (hot and cold) on the wood *Bombax buonopozense* showed a concentration dependent prevention of the wood from termite attack. The above observation corroborates the findings of [11] when they exposed wood treated with *Lagenaria breviflora* to termites attack.

Different extracts from plants and plant parts have been used by different authors as wood preservative or protectant against termite invasion and other wood attackers. [11], used the fruit pulp extracts of *Lagenaria brevflora* to prevent termites attack on *Triplochitin scleroxylon* wood. *Moriange oleifera* seed oil extract was used to prevent termites attack on *Gmelina arborea* wood after twelve weeks of exposure [7]. [24], used ethanolic extracts of *Tridax procumbens, Parkia biglobosa* and tar oil to prevent different woods (*Triplochiton scleroxylon, Gmelina arborea and Ceiba pentandra*) against termites and fungi attack. [5], observed that neem extracts applied at different concentrations prevented termites from attacking the wood of *Khaya senegalensis*.

The application of extracts of *Lepidagathis alopecuroides* from different solvents on the wood, *Bombax buonopozense* showed a concentration dependent protection of the wood from *Macrotermes specie* attack. The preventive efficacy of *Lepidagathis alopecuroides* may be connected with the different phytochemical components it possesses [18]. These phytochemicals may be poisonous to the termites when consumed and therefore, they are scared away from consuming or feeding on the contaminated wood. However, the applied extracts did not offer 100% protection throughout the experimental period. This might be as a result of biodegradation of the components over the time which would render the wood susceptible to attack or that higher concentrations of the extracts are required.

According to [25], when insects feed on chemicals which are toxic, the mode of action of the substance or chemical alters the body physiological and biochemical mechanisms which culminates in toxicity and death of the insects in some cases. When wood is smeared or soaked in extracts, the extracts penetrate the internal parts of the wood. In other words, the wood absorbs the extracts and this goes a long way to offer protection against insect invasion [26].

In this study, cold extracts offered more protection to the wood than the hot extracts in all the solvents used. This may have resulted from the difference in the chemical components extracted in the different methods [27,28]. The cold extracts may have retained more potent volatile components than the hot extracts which were responsible for wading off attacks by the termites. This assertion corroborates the findings of other authors [7,26]. These authors reported that the nature of the preservative chemical applied affects the wood absorption and also that the protection of wood by chemicals from termite attack is concentration dependent.

According to [29], there are certain factors or parameters that are required in the treatment of wood. Such factors are: the solution viscosity and temperature, duration of time before degradation of the product, the depth which the chemical penetrates or is absorbed by the wood, the treatment method, the application method and the concentration of the chemical. In addition, this study was able to establish that the method of extraction of the plant components is a key factor in the choice of wood preservative

**Table 2. The efficacy of cold extracts of *Lepidagathis alopecuriodes* treated *Bombax buonopozense* wood against *Macrotermes* specie**

| Concentration (mg/L) | Cold methanol<br>% protection | Cold petroleum spirit<br>% protection | Cold water<br>% protection |
|---|---|---|---|
| 0.00 | 10.50 ± 0.00$^{d}$ | 9.00 ± 0.00c | 9.01 ± 0.00$^{c}$ |
| 0.025 | 18.15 ± 7.26$^{c}$ | 75.93 ±7.80$^{ab}$ | 73.73 ± 9.80$^{b}$ |
| 0.035 | 21.78 ± 8.60$^{c}$ | 79.90 ± 6.12$^{ab}$ | 71.45 ± 9.40$^{b}$ |
| 0.045 | 65.08 ± 9.20$^{b}$ | 72.43 ± 5.20$^{b}$ | 86.33 ± 11.05$^{a}$ |
| 0.055 | 95.23 ±7.55$^{a}$ | 86.60 ± 9.34$^{a}$ | 88.88 ± 16.32$^{a}$ |

*Means with the same superscript in the same column are not significantly different*

**Table 3. The efficacy of hot extracts of *Lepidagathis alopecuriodes* treated *Bombax buonopozense* wood against *Macrotermes* specie**

| Concentration (mg/L) | Hot methanol<br>% protection | Hot petroleum spirit<br>% protection | Hot water<br>% protection |
|---|---|---|---|
| 0.00 | 2.60 ± 0.00$^{c}$ | 0.00 ± 0.00$^{d}$ | 0.00 ± 0.00$^{c}$ |
| 0.025 | 32.78 ± 6.44$^{b}$ | 4.33 ±2.03$^{c}$ | 21.93 ± 9.30$^{b}$ |
| 0.035 | 35.38 ± 8.20$^{b}$ | 18.85 ± 5.01$^{b}$ | 21.00 ± 9.01$^{b}$ |
| 0.045 | 45.85 ± 5.33$^{a}$ | 54.93 ± 12.61$^{a}$ | 22.00 ± 5.20$^{b}$ |
| 0.055 | 46.20 ±10.21$^{a}$ | 57.38 ± 7.71$^{a}$ | 53.19 ± 7.25$^{a}$ |

*Means with the same superscript in the same column are not significantly different* especially when it has to do with phytochemicals similar to the observation of [30] when they used different solvent and different techniques on the antioxidant activity of selected medicinal plants and that of [31] when they used different extraction methods on *Linum usitatissimum*.

From the result obtained in Table 4; for the cold extracts, it showed that cold water extract gave the greatest protection to the wood, followed by cold petroleum spirit and finally cold methanol extracts. However, in the hot extraction the reverse was observed. The trend followed was methanol > water > petroleum spirit. This observation is an indication that the method of extraction is an important factor in determining the extraction method to be used in the treatment of wood against termite infestation and destruction [32]. It should also be noted that the most suitable extraction method varies from plant to plant [30]. A particular solvent and extraction method which might be good for one plant might not be good for another due to the nature of the components and their solubility and volatility in that particular solvent [27].

**Table 4. The efficacy of cold and hot extracts of *Lepidagathis alopecuriodes* in various solvents against *Macrotermes* specie on *Bombax buonopozense***

| Solvent (Protectant) | Cold extract | Hot extract |
|---|---|---|
| Methanol | $60.69 \pm 9.16^a$ | $32.56 \pm 6.67^b$ |
| Petroleum spirit | $69.09 \pm 6.12^a$ | $27.01 \pm 6.29^b$ |
| Water | $70.20 \pm 7.11^a$ | $29.68 \pm 6.19^b$ |

*Means with the same superscript in the same row are not significantly different*

The phytochemical screening or examination of *Lepidagathis alopecuroides* showed that the plant possesses tannins, saponins, flavonoids, cardiac glycosides, steroids and alkaloids and also the components varied depending on the solvent used for the extraction [18]. This plant has been found to be toxic to different species of mosquitoes [19], mudskippers, *Periophthalmus papillio* [17], *Clarias gariepinus* [33] and hybrid catfish [34]. The mortality of these organisms according to the authors resulted from the toxic components present in the plant.

The probit protection for the wood *Bombax buonopozense* due to cold and hot extracts of *Lepidagathis alopecuroides* is shown in Table 5 and 6. The protection offered by the plant extracts from the various solvents showed that the cold water extract will offer 50% protection to the wood against termites attack with 0.016 mg/L concentration of *Lepidagathis alopecuroides* extract. Cold extracts of petroleum spirit and methanol required 0.011 and 0.035 mg/L respectively to offer the same level of protection to the wood against termites attack. The values of 0.059, 0.063 and 0.088 mg/L of water, petroleum spirit and methanol extracts of *Lepidagathis alopecuroides* respectively offered 95% protection to the wood.

The concentration of the different solvent extracts required to offer protection is an indication of the concentration of the phytochemicals or chemical components present in each of the extracts. The solubility of phytochemicals or chemical components depends on the solvent used and the nature of the components [35]. According to [36,37, extracts of medicinal plant are sources of natural chemicals that could be used to control termites and this is attributed to the presence of phytochemicals of diverse chemical structures that possess repellent, antifeedant, or toxic effects on termites during feeding tests.

The efficacy or potency of the various extraction solvents is shown in Table 7. In the hot extractions, water extracts offered the greatest protection to the wood against termite attack, followed by methanol and finally petroleum spirit. However, in all the extraction conditions (cold and hot), it was observed that the cold extracts of *Lepidagathis alopecuroides* was more potent in the protection of the wood (*bombax buonopozense*) against termites attack.

**Table 5. Probit protection with associated 95% confidence intervals (lower and upper limits) of *Bombax buonopozense* wood with cold extracts concentrations (mg/L) of *Lepidagathis alopecuriodes* treatment against *Macrotermes* specie**

| Extraction method | Probit protection (%) | | |
|---|---|---|---|
| | 50 | 90 | 95 |
| Cold water | 0.016 (0.012 - 0.025) | 0.05 (0.04 - 0.06) | 0.059 (0.047 - 0.086) |
| Cold petroleum spirit | 0.011 (- 0.1 - 0.021) | 0.051 (0.04 - 0.08) | 0.063 (-) |
| Cold methanol | 0.035 (-) | 0.078 (-) | 0.088 (-) |

**Table 6. Probit protection with associated 95% confidence (lower and upper limits) of *Bombax buonopozense* wood with hot extracts concentrations (mg/L) of *Lepidagathis alopecuriodes* treatment against *Macrotermes* specie**

| Extraction method | Probit protection (%) | | |
|---|---|---|---|
| | 50 | 90 | 95 |
| Hot water | 0.07 (-) | 0.13 (-) | 0.14 (-) |
| Hot petroleum | 0.05 (-) | 0.08 (-) | 0.09 (-) |
| Hot methanol | 0.05 (0.04 – 0.012) | 0.09 (0.061- 0.22) | 0.10 (0.08 – 0.26) |

The correlation matrix of temperature, humidity and protection is shown in Table 8. The correlation of temperature and humidity on *Lepidagathis alopecuroides* protection of the wood (*Bombax buonopozense*) showed a non-significant positive correlation between temperature and protection, indicating that temperature increase is a positive factor in wood protection. There was a non-significant negative correlation between temperature and humidity and also between humidity and protection. The negative correlation is an indication that low temperature and low humidity deter wood protection against termites attack.

**Table 7. Summary of efficacy of the solvent extracts of *Lepidagathis alopecuriodes***

| Extraction method | Solvent used | | |
|---|---|---|---|
| | Methanol | Petroleum spirit | Water |
| Cold | 44 | 42 | 45 |
| Hot | 33 | 27 | 29 |

**Table 8. Correlation of temperature and humidity on *Lepidagathis alopecuriodes* extracts treated against *Macrotermes* specie on *Bombax buonopozense***

| | Temperature | Humidity | Protection |
|---|---|---|---|
| Temperature | 1.000 | | |
| Humidity | - 0.860 | 1.000 | |
| Protection | 0.172 | - 0.086 | 1.000 |

## 4. CONCLUSION

The results of this study revealed that *Lepidagathis alopecuroides* extracts has the capacity of preventing termites attack on wood. It also showed that the protection efficacy of the plant extracts is concentration dependent. The result also indicated that cold extracts of the leaves were more effective in the prevention of termites from consuming the wood. The protection of the wood by the various extracts showed that methanol extracts was the most effective as against petroleum spirit which was the least. Thus, *Lepidagathis alopecuroides* can be a very promising botanical for wood protection against termite invasion or attack, since it is biodegradable, environment friendly, renewable, abundant and cheap to obtain. Toxicity of the chemicals from plants depended on the extracting solvent and the nature or form of extraction used. Finally the plant *Lepidagathis alopecuroides* can be used as an alternative source of wood protection or exploited to develop new wood preservatives. Though this study has opened a new avenue of exploiting natural resources, yet the protection efficacy of the plant extracts of *Lepidagathis alopecuroides* seem to be limited to time. However, this study has opened more light to the use of botanicals in the prevention of termite attack on woods especially when the protection is required for a short time. Further studies should be carried on a short and long term basis using this plant on other woods so as to use it as commercial termiticide if found to be effective.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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