Original Research Article

Evaluation of Naturally Termite Resistant Tropical Wood Species

ABSTRACT

Selecting termite resistant wood species for household and construction facilities can increase their durability and reduce the pressure on forest resources. For this evaluation, 100 wood specimens were cut to 20 cm in length, 2.5 cm in thickness, and 5 cm in width and placed in anopen field. Wood density analysis was simultaneouslycarried out in the laboratoryusing wood specimens of equal length (2 cm), thickness (2 cm), and width (2 cm).Results showed that species such as *T. superba*and *H. ciliate* had the highest mean weight loss of 57.62% and 30.27%, respectively, and were highly susceptible to termite attacks compared to *T.ivorensis*, *L. alata*, and *H. utilis*, which were very resistant with only mean weight losses of 0.29%, 0.78%, and 0.81%, respectively.Wood species such as *T. superba*, *P. africanum, T. ivorensis,* and *H. ciliata*had low density compared to *L. alata*, *N. diderrichii*, and *T. tubmaniana*, which had high density.A significant correlation (r = -0.79, p< 0.001) between the weight loss and the density of the selected wood species was observed. It was observed that variations in termite resistance weremainly attributed to the density of the wood.

Keywords: Density, resistance, species, termite, tropical, wood

1. INTRODUCTION

Wood is one of the most important and practical natural resources known to humans because of its distinctive qualities and relative availability (Syofuna*et al.,* 2012). Today, solid wood, wood pulp, and chemicals derived from wood are used in thousands of everyday items that we take for granted. Due to its many benefits over rival materials, including steel, aluminum, brick, concrete, plastics, glass, and ceramics, wood remains a popular choice. Moreover, wood is a renewable resource and environmentally friendly compared to its rivals. Despite all of its benefits, wood suffers from a serious issue called bio-deterioration, which tends to reduce the useful life of the material (Acanakwo*et al.,* 2019).

The problem of bio-deterioration is one of the primary variables influencing consumers' preference for wood over other alternatives such as steel and concrete. This result has prompted research into the inherent toughness of several local commercial wood species(Liu*et al.,* 2015). Natural resistance refers to a wood species' innate capacity to fend off bio-deterioration without the need for artificial preservatives. The presence of extractives in the heartwood region has led to the natural resistance displayed by some species (Mounguengui*et al.,* 2016). Owoyemi *et al.* (2017)reported that regardless of the heartwood's inherent resistance to decay, the sapwood of all known tree species is extremely susceptible to it. Even with proven hardwood species, deterioration is likely to happen if sapwood is not completely removed.

The level of resistance of wood to bio-degrading agents is referred to as its natural durability. As trees grow older and larger, the storage cells in the center of the wood start to die, which causes the sapwood

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region to gradually change into heartwood (Jebrane et al., 2014). While some trees may be mildly resistant to insect attack, others may have no resistance at all. Trees with more harmful natural compounds for termites deposited during metamorphosis have very robust heartwood that is very resistant (Stallbaun et al., 2017).

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Termites are the key pests of wood and wood products in tropical and subtropical areas of the world (Evans et al., 2013). Wood is the main food source for termites, and the vulnerability of wood to termite attack depends on several factors such as hardness, temperature (Gautam and Henderson, 2011), moisture in the wood (Roszaini et al., 2016), wood decayed by fungus, allelochemicals in the wood (Hale et al., 2012), and wood density (Arango et al., 2006). Many different kinds of wood species have built-in defenses that protect them from insects and other pest species. In tropical conditions, where there is no frost season to control insect numbers, this is particularly true. Plants and trees have acquired the ability to produce their own lines of chemical defenses (extractives) that keep invaders out as they have evolved (Pereira et al., 2015.

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The demand for wood-based materials due to the increasing population is increasing rapidly from year to year (Indrayani et al., 2015). As a result, a number of wood species used for different products have been increasingly under threat (Klein et al., 2016). For example, in many African countries, particularly Liberia, people are still highly dependent on wood and wood products, mainly for fencing, household furniture, and building and construction facilities.

Furthermore, damage due to termite attacks is a serious problem in Liberia. It is believed to cause a huge economic loss for the country. Thus, for proper management and utilization of wood products, identifying and using termite-resistant wood species is vital, though this information is lacking. Therefore, the primary objective of the study was to evaluate wood species that are termite-resistant as a basis for providing quality grading options and sustainable forest management.

2. MATERIAL AND METHODS

2.1 Wood species selection and preparation

Ten potential wood species (*Tetraberlinia*tubmaniana, *Petersianthusmacrocarpus, Terminalia superba, Piptadeniastrum*africanum, *Nauclea*diderrichii, *Lophira*alata, *Terminalia*ivorensis, *Hallea* ciliata, *Heritiera*utilis, and *Milicia regia*) that are commonly used in Liberia for fencing, household furniture, and building and construction were selected. A total of 100 wood samples (10 from each species) were collected from representative sawmills and wood workshops throughout the country of Liberia. During the data collection, samples were properly labeled for identification purposes. Following Hadi *et al.* (2015), samples were cut to 20 cm in length, 2.5 cm in thickness, and 5 cm in width to get similar sizes and labeled accordingly. Then, the initial weight of the samples was recorded using a precision electronic balance (0.00 g) in the laboratory.

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2.2 Termite resistance test

The field experiment was conducted at the College of Agriculture and Sustainable Development, Cuttington University, Liberia, field experiment site. It was laid out ona plot of 16 m^2. Wood samples with the stated dimensions were installed at a 30 x 30 cm interval. Each wood sample was pegged up to half of its length (10 cm) into the ground, and the remaining part was kept above the ground for visibility and handling purposes during the sampling period. In every two-month interval, the wood specimens were taken out, carefully cleaned, air dried overnight,and weighed and recorded before they were taken back to the field. This procedure continued for a period of eight months.

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2.3 Wood density test

Wood specimens of equal length (2 cm), thickness (2 cm), and width (2 cm) were cut from each of the selected wood species (100 samples)that were used inthe fieldfor the termite resistance test. The initial weight of each sample was recorded before it was placed in an oven. Then, in order to remove the moisture content present within the wood, samples were placed in the oven at 105°C until their weight became constant.Finally, the oven dry weight of each wood sample was determined as the dry weight of the sample wood divided by the initialvolume of the same wood sample.

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2.4 Data analysis

Weight loss was computed as follows:

$$\text{Weight loss} = (W_1\text{-}W_2)/(W_1) * 100 \qquad \text{Equation (1)}$$

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Where W_1 = weight of sample prior to the test (g) and W_2 = weight of sample after the test (g) following Hadi *et al.* (2015) procedures. An analysis of variance (ANOVA) was performed to see if there were any significant differencesamong the wood species in their density and weight. Means were separated by the Tukey-Kramer HSD test at a 5% alpha level. Resistance to termites was compared using the standard model (resistance class against subterranean termites) by Tsunoda*et al.* (2012) (Table 1). Pairwise correlation analysis was determined using Pearson's product moment to see if any relationship exists between the density test outcomes in the laboratory and the termite resistance tests in the field. All the statistical analysis was performed using SAS JMP Pro 14 software.

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3. RESULTS

3.1 Termite resistance test

Though wood is readily degraded by termites, differences in resistance to termite attacks were observed in this particular study. For example, wood species such as *T. superba*and *H. ciliate* were highly damaged by termite attacksand had the highest mean weight loss of 57.62% and 30.27%, respectively. Wood species such as *T.ivorensis*, *L. alata*,and *H. utilis*fell under class I (very resistant) with only mean weight losses of 0.29%, 0.78%, and 0.81%, respectively (Table 2). The overall termite resistance of the selected wood species was in the order of: *T.ivorensis> L. alata>H. utilis >P. macrocarpus>N. diderrichii> P. africanum> M. regia >T. tubmaniana>H. ciliate > T. superba*.

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Table 1. Resistance class against subterranean termites.

Resistance class	Classification	Mass loss (%)
I	Very resistant	<3.52
II	Resistant	3.52 – 7.50
III	Moderate	7.50 – 10.96
IV	Poor	10.96 – 18.94
V	Very poor	> 18.94

Table 2. Weight loss and resistance class of the selected wood species.

Wood species	Weight loss (g)	Weight loss (%)	Resistance class
H. ciliate	30.27^{b*}	23.37	V
H. utilis	1.17^{d}	0.81	I
L. alata	1.82^{d}	0.78	I
M. regia	5.56^{cd}	3.35	I
N. diderrichii	3.94^{cd}	2.72	I
P. macrocarpus	3.04^{cd}	1.80	I
P. africanum	5.14^{cd}	3.32	I

T. superba	58.86^{a}	57.62	V
T.ivorensis	0.41^{d}	0.29	I
T. tubmaniana	8.44^{c}	4.87	II

*Levels not connected by the same letters are significantly different.

3.2 Wood density test

The density analysis of the selected species was done separately in the laboratory. Results indicated that wood species like *T. superba*(0.3 g/cm^3), *P. africanum*(0.46 g/cm^3), *T. ivorensis*(0.49 g/cm^3),and *H. ciliate* (0.54 g/cm^3)had low density compared to *L. alata*(0.79 g/cm^3), *N. diderrichii*(0.69 g/cm^3), and *T. tubmaniana*(0.69 g/cm^3), which had high density (Fig. 1).

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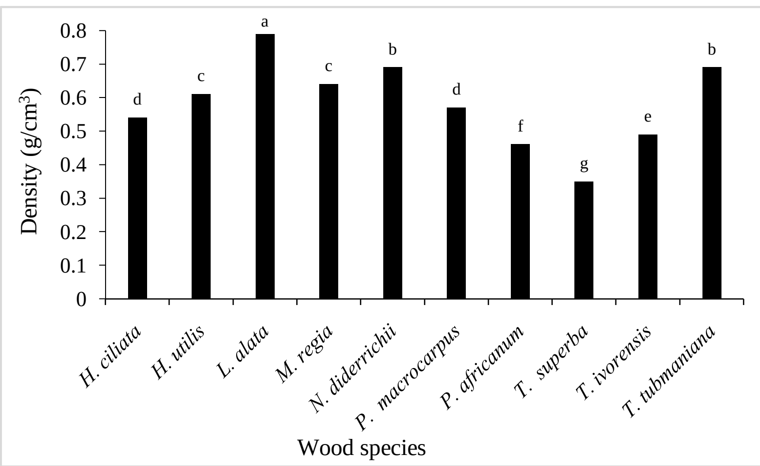

Fig. 1. Wood density (g/cm^3) comparative analysis of the selected ten wood species

3.3 Correlation between wood density and termite resistance

A correlation analysis was performed to see if there was any significant relationship between the weight loss and the density of the selected wood species. Consequently, results from the field were in agreement with the laboratory results and showed a significant negative correlation (r = -0.79, p< 0.001). The differences in the termite resistance properties of the selected wood species were directly related to the results obtained from the laboratory, which showed that the sensitivity of the wood species to termite attacks decreased with increased density.This was clearly observed in species such as*T. superba* and *L. alata*.

4. DISCUSSION

4.1 Termite resistance test

As can be seen in Table 2, wood species such as *H. ciliate* and *T. superba* were far more susceptible to termite attacks than the others. In the first two months of the study, these two wood species were already damaged by termites, especially the half part (10 cm) of the specimen that was pegged into the soil. This result can be explained by the fact that termites have quite selective feeding habits and attack species they have more contact with. Costa *et al.* (2019) found a similar result and concludedthat the preference of termites for a certain type of wood might be different.

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According to Lopez *et al.* (2020), termites have a variety of feeding patterns. These variances may exist across and within groups, and they also have a big impact on the species' evolution. The experiment's mass loss findings demonstrate that the majority of the woods evaluated are naturally very resistant (class I) to termite attacks, with the exception of *H. ciliate* and *T. superba*, which demonstrated the highest percentage of mass loss.

4.2 Wood density test

In this particular study, the density values of the selected wood species ranged between 0.3 g/cm^3 and 0.79 g/cm^3. A similar result, 0.79 g/cm^3, was obtained by Pereira*et al.* (2015) on Tatajuba (*Bagassa guianensis*) and categorized it as resistant to termite attack. According to Costa *et al.* (2019), the dimensional stability, strength, and durability of wood are all significantly influenced by the property of wood density.Similarly, Stallbaun*et al.* (2017) indicated that high density wood tends to limit termites' ability to splinter wood, preventing them from consuming it.However, it is generally acknowledged that in order to evaluate natural resistance, it is important to take into account not only the density of the wood and the quantity of chemical extractives but also their chemical class and the effects they have on diverse species (Marcondes *et al.,* 2013).

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4.3 Correlation between wood density and termite resistance

The results from the laboratory, which revealed that the susceptibility of the wood species to termite attacks decreased with greater density, were directly related to the differences in the termite resistance capabilities of the chosen wood species. In line with this, Peters *et al.* (2015) stated that the susceptibility of wood to termite attacks decreases with increasing density, and natural durability is the most important feature that determines the quality of wood and is partially related to density. Similar findings were indicated by Hale *et al.* (2012), Owoyemi *et al.* (2017), and Roszaini *et al.* (2016), who stated that the higher the density of the wood, the greater the resistance to termite attacks.

In some wood species, such as *H. ciliate* and *T. ivorensis*, no correlation was recorded between the density and the weight loss; rather, the results were randomly observed. Alencar *et al.* (2011) found that there was no correlation between mass loss and density for Sabiá (*Mimosa caesalpiniifolia*) wood, although they did distinguish between phenotypes (with or without aculei) and the position of the wood in the pith-to-bark direction. A study by Peralta *et al.* (2004) also found no significant relationship between wood density and termite resistance in their investigation into the rates at which termites consumed various forest species' wood under field circumstances. Although they came to the conclusion that wood density alone cannot be regarded as the single most important element in determining termite resistance, they did recognize the significance of wood hardness as a deterrent to termite damage.

5. CONCLUSION

Termites severely damaged wood species such as *T. superba* and *H. ciliate*, whereas *T. ivorensis, L. alata,* and *H. utilis* showed high resistance to termite attacks. A strong negative correlation (r = -0.79) was observed, indicating the susceptibility of wood species to termite attacks decreased with an increase in density. Wood species that are resistant to termite attacks have high potential in outdoor applications under severe environmental conditions, in areas where diverse fungi or termites exist.In view of the foregoing, the study has highlighted the resistance of woods species to bio deterioration and degeneration which is highly essential for knowledgeable decision making for both consumers, suppliers and policy makers responsible for reforestations and maintaining sustainable environment as a whole.

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