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Feeding preference of drywood termite *Cryptotermes cynocephalus* Light (Kalotermitidae) against common furniture wood species in the Philippines

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Abstract

Drywood termites are known as household pests attacking furniture and other wood products. A free-choice and no-choice feeding test were conducted to determine the feeding preference of *Cryptotermes cynocephalus* Light to common furniture wood species in the Philippines, viz., *Gmelina arborea* Roxb, *Swietenia macrophylla* King and *Acacia mangium Willd*. The analysis of mass loss, wood consumption rate, and wood utilization rate revealed a distinct feeding preference of *C. cynocephalus*. The preferred order of wood species was found to be as follows: *Swietenia macrophylla* – *Acacia mangium* – *Gmelina arborea*, with the latter being the least favored among the three.

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Introduction

Cryptotermes spp. occur in all zoogeographic regions (Scheffrahn and Krecek 1999; Ibrahim and Adebote, 2012). This group was considered a household pest (Cassalla *et al.,* 2016). In the United States, the cost estimate of the total economic impact from drywood termites and their control varies from 5 to 20 percent of the total $1.5 billion to $5 billion spent on wood-destroying insect control annually (Lewis *et al.,* 2000) but worldwide losses aren't fully documented (Su and Scheffrahn, 2000). There are only two species of this group that are quite common pests in the Philippines, viz., the native *Cryptotermes cyanocephalus* Light (Light, 1921) and *Cryptotermes dudleyi* Banks (Acda, 2004; Garcia *et al.,* 2012), attacking wooden structures including furniture (Rojo, 2017; Rojo, 2020). These termites are difficult to detect and observe because of their cryptic habit (Grace, 2009), thus making drywood termite control challenging (Grace, 2013). The presence of fecal pellets is an indication of drywood termite infestation (Rojo, 2018).

There has been a decreasing supply of wood from natural forests due to overexploitation and insufficient management interventions (Murty, 2009) in the Philippines logging-ban within the old-growth natural forest was imposed in 1991 (Bugayong, 2006); thus, the supply of wood for local plywood manufacturer mostly came from tree farms (plantation forest). *Gmelina arborea* Roxb, *Swietenia macrophylla* King, and *Acacia mangium* Willd are among the species widely grown on tree farms (Harrison *et al*., 2005). Both *S. macrophylla* and *G. arborea* were generally utilized for furniture making (Israel and Bunao, 2017) and apart from furniture, *A mangium is* also suitable for interior construction work like framing and flooring (Tumbull *et al*., 1998). However, Moya and Berrocal (2015) stressed that wood produced from the tropical plantation condition has low natural durability and is thus susceptible to fungal and insect attacks. Ghaly and Edwards (2011) argued that palatability, repellency and opportunity are the foremost relevant parameters affecting the natural resistance of wood against termite attacks. However, there have been limited studies investigating the wood preference for drywood. This study presents the feeding preference of *C. cynocephalus* against *G. arborea, S. macrophyla* and *A. mangium.* The result provides information to furniture manufacturers and users regarding the susceptibility of those three common wood species to termite attacks.

Material and methods

Specimen collection

The study was conducted at the University of the Philippines Los Baños, Department of Forest Products and Paper Science (UPLB-FPPS) laboratory. Three wood species commonly used in furniture, viz., *G arborea*, *S. macrophylla* and *A. mangium* were used. The wood samples were collected from Central Mindanao University (CMU) plantation forest, which has a total area of 576.16ha. devoted to industrial tree plantation (Rojo and Paquit, 2018). Pseudergates (workers) with no wing buds of *C. cynocephalus* were collected from the abandoned laboratory room at CFNR-FPPS, infesting plywood panels from tables. The termites were placed in a sealed container with a piece of wood as a food source. The container was kept inside the unlit oven with a temperature set at 28°C and relative humidity of 85% for a week before testing.

Feeding test

The test was patterned from Indrayani *et al.* (2007) with modification. The study employed two tests: Test A (no-choice feeding) and Test B (free-choice feeding). The sizes of wood specimens used were: 2.5cm (R) × 2.5cm (T) × 3cm (L) for test A. To accommodate termites, a hole was drilled in the middle of the wood sample with a diameter of 1 cm and 2.4 cm depth (Fig. 1A). The outlet was securely covered with fine wire mesh to prevent termites from escaping. For test B, the wood samples were assembled into a pie. The set-up also has a hole in the middle measuring 5 cm to accommodate termites (Fig. 1B) and is covered with fine wire mesh. The oven dry weight of all wood samples was determined first before exposure.

Test A – No choice feeding

Twenty pseudergates were exposed to wood specimens specified above. Three replications were applied for every species. A total of 180 pseudergates were allocated for this test.

Test B- Free- Choice feeding

Part 1

In this test, two set-ups were prepared: set-up 1 contained all wood specimens with sapwood randomly combined and set-up 2 contained the heartwood specimens. One hundred pseudergates were used in each set-up. Each set-up was replicated thrice.

Part 2

In this test, both sapwood and heartwood were combined randomly. Unlike part 1, the wood was exposed to 200 pseudergates in each set-up. The test was also replicated thrice.

All test units were placed inside an unlit oven set at 28°C and relative humidity of 85% for three months. At the end of the test, the survival rate was determined. The wood specimens were oven-dried again and final weights were obtained to determine the wood consumption rate, which refers to the amount of wood consumed per termite per day (Indrayani *et al.*, 2007). Since it is difficult to count the actual no. of termites on a weekly or monthly basis in a non-destructive method, the average number of termites was obtained, representing no. of live termite days. The fecal pellets were also collected, oven-dried and weighed to determine the wood utilization rate. Following Cabrera and Rust (1994) and Indrayani *et al.* (2007), wood utilization rate (Wu) was calculated using the following equation:

$$Wu\left(\frac{mg}{termite}\text{per day}\right) = \frac{\text{Mass loss} - \text{Mass of Pellet}}{\text{Number of live termite days}}$$

The level of resistance of wood species was determined based from the mass loss following the classification shown in Table 1. A completely Randomized design was followed for all data (mass loss, wood consumption rate and wood utilization rate) and analysis of variance (ANOVA) were executed using Statgraphics Centurion 16.1 software. Means were separated by Tukey's Honest Significance Difference (HSD) test (α = 0.05).

Results and discussion

Mass loss and level of resistance

The level of resistance was based on mass loss (%). A Higher mass loss means that certain wood species is non-resistant to termite attack. As shown in Table 2, in no-choice feeding test, all wood species were classified as moderate resistance (MR), although *G. arborea* was significantly lower (p<.05) compared to *S. macrophylla* and *A. Mangium*. In no-choice feeding test, *S. macrophylla* displayed moderately resistance to termites.

Table 1. Classification of wood species resistance based on mass loss (patterned from Indrayani *et al.,* 2007).

Mass loss (%)		Level of resistance
No-choice	Free-choice	
0.00 < 0.10	0.00 < 0.10	Highly resistant (HR)
0.10 – 0.50	0.10 – 3.00	Resistant (R)
0.51 – 1.50	3.01 – 10.00	Moderate resistant (MR)
1.51 – 3.00	10.01 – 20.00	Non-resistant (NR)
>3.00	>20	Susceptible (S)

This shows that among the 3 species, *S. macrophylla* was the preferred species. In free-choice feeding test (Table 3), where all types of wood and species were exposed to drywood termite, *S. macrophylla* sapwood was Non-resistant (NR) and the heartwood was moderately resistant, although both were not significantly different (p <.05). In all test, *G. arborea* exhibited to be the most resistant wood species among the 3 common furniture wood species in this study with actual mean mass loss of .09g compared to *S. macrophylla* and *A. Mangium* with .12 and .13g respectively.

Table 2. Level of resistance of 3 common furniture wood species based on mass loss (%) in no choice and heartwood and sapwood choice feeding test after 119 days and 104 days, respectively.

Method	Species	Mass loss (%)*	Level of resistance
No-Choice feeding	*G. arborea*	0.85±.01a	MR
	S. macrophylla	0.98±.01ab	MR
	A. mangium	1.00±.01b	MR
Heartwood feeding choice			
	G. arborea	1.97±.21a	R
	S. macrophylla	3.11±1.99a	MR
	A. mangium	1.59±1.02a	R
Sapwood feeding choice			
	G. arborea	0.59±.41a	R
	S. macrophylla	4.58±.72a	MR
	A. mangium	3.23±1.66a	MR

*Values are means ± SEM. Means followed by same letter within each method are not significantly different (Tukeys HSD: $p<.05$).

Table 3. Level of resistance of 3 common furniture wood species based on mass loss (%) in free-choice feeding test after 105 days.

Free choice[a]	Mass loss (%)[b]	Level of resistance
G. arborea S	0.91± .19a	R
S. macrophylla S	16.26± 6.60b	NR
A. mangium S	1.23±.40a	R
G. arborea H	0.74±.03a	R
S. macrophylla H	6.91±4.12ab	MR
A. mangium H	2.23±1.12a	R

[a]S-Sapwood; H-Heartwood

[b]values are means ± SEM. Means followed by same letter within a column are not significantly related (Tukeys HSd: $p<.05$).

The resistance of *G. arborea* can be attributed to its extractive content. *G. arborea* has the highest extractive content among the 3 wood species 12.4% (Fuwape, 1992), while *S. macrophylla* has 8.38% (da Silva *et al.,* 2013), and *A. Mangium* has 9.83 (Pinto *et al.,* 2005).

Extractives can be regarded as non-structural wood constituents (Sjostrom, 2013). These were classified into aliphatic and alicyclic compounds, phenolic compounds and other compounds (Yang and Jaakkola, 2011). Wood extractives play a major role in the protection of wood against termites (Syofuna *et al.*, 2012). Some of these extractives render the heartwood unpalatable to wood-destroying organisms. (Nascimento *et al.,* 2013) and may impart higher resistance to termite attacks (Shanbhag *et al.*, 2013). A study conducted by Bultman and Southwell (1976) showed that extractives undoubtedly contributed significantly to the natural resistance of other woods.

Survival

In the no-choice feeding test (Fig. 2), the lowest survival rate of below 7% was observed in *G. arborea*. Survival of termites in both *A. Mangium* and *S. macrophylla* were similar. However, the difference in survival rates was not statistically significant. All sapwood and all heartwood choice feeding tests had a mean survival rate of 36% and the free-choice feeding test had 24% survival. This result was very low compared to that of Minnick *et al.* (1973), in which survival rates ranged from 57-73%. However, the species used was *C. brevis*. Indrayani *et al.* (2007a) also observed a higher mean survival rate reaching 75% using *Incisitermes minor* after three months.

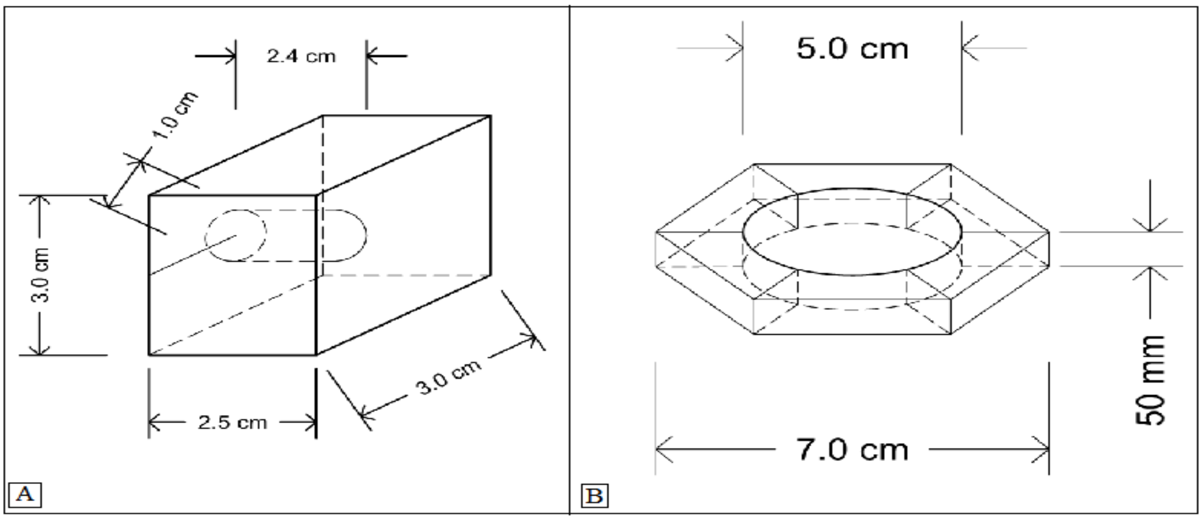

Fig. 1. Experimental set ups for feeding preference test of drywood termites; A- no-choice feeding test, B – Free-choice feeding test.

Wood consumption rate

In the no-choice feeding test, on the average, the *C. cynocephalus* can consume .09 mg/termite/day of wood. As shown in Fig. 3, the wood consumption rate ranges from .08 to .11, but the difference was not statistically significant. A similar consumption rate was also observed by Indrayani *et al.* (2007) in *I. minor*. This consumption rate of drywood termite, when compared with subterranean termite was not substantially different. Tsunoda *et al.* (2012) found out that *Coptotermes formosanus* consumption rate ranged from .05 to .13mg/termite/day.

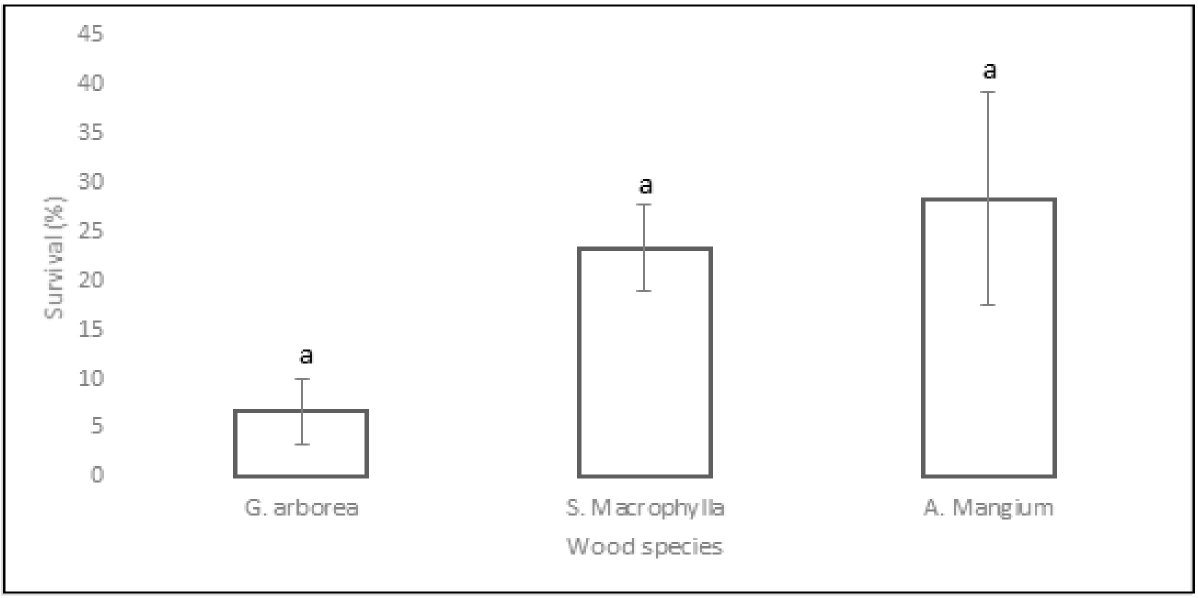

Fig. 2. Survival (%) of termite (mean ± SEM) after 119 days of no-choice feeding test Means followed by the same letter are not significantly different (Tukey's HSD: $p < 0.05$).

Factors affecting wood consumption by termites are numerous and complexly related (Peralta *et al.,* 2004). These include temperature, wood extractives, wood moisture content, specific gravity/Density and wood species (Carter and Smythe, 1974; Fei and Henderson, 2002; Arango *et al.,* 2006; Gautam and Henderson, 2011). In this study, both temperature and moisture content did not have an impact on the consumption rate, as these factors were constant in all wood blocks.

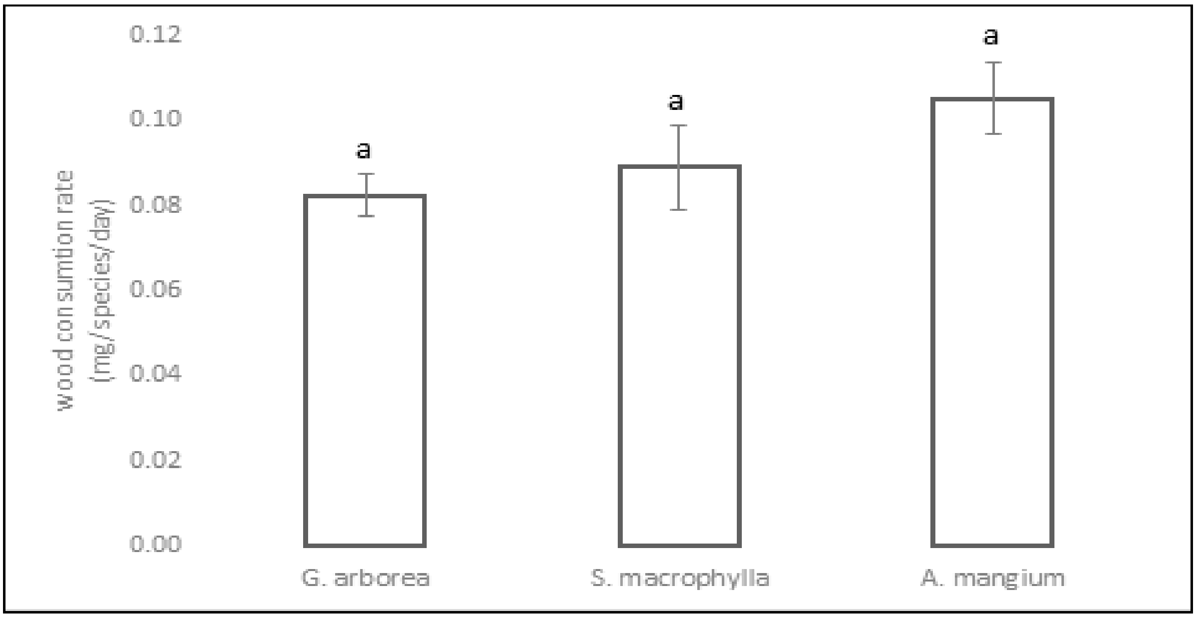

Fig. 3. Wood consumption rate (mean ± SEM) of termite to three common furniture wood species after 119 days of no choice feeding test. Means followed by the same letter within a bar are not significantly different (Tukeys HSD: $p< 0.05$).

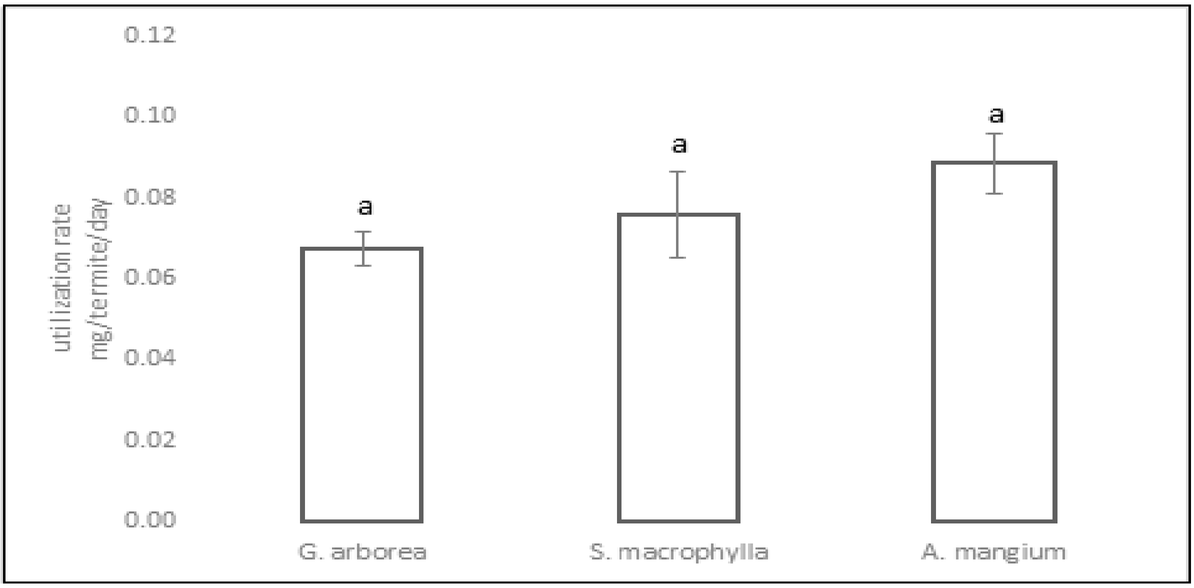

Fig. 4. Utilization rate of *C. cynocephalus* to the 3 common furniture wood species after 119 days of no-choice feeding test. Bars with similar letters are not significantly different (Tukeys HSD: $p<.05$).

The physical and chemical properties of wood are probably interdependent and affect the wood's resistance to termites (Shanbhag *et al.,* 2013). Secondary data on wood density/specific gravity were obtained. *G. arborea* has .41g/cc, *S. macrophylla* has .49g/cc (Reyes *et al.,* 1992), *A.mangium* has .40 g/cc (Sahri *et al.*, 1998). These data suggest that wood density seemed to have no impact on the consumption rate of drywood termites. *G. arborea* and *A.mangium* have similar densities, which are substantially lower than that of *S. macrophylla.* However, *G. arborea* has the lowest mass loss and consumption rate, while *S. macrophylla* and *A.mangium* have a higher mass loss and consumption rates. This may contradict the assumption of Bultman and Southwell (1976) that density probably plays some initial protecting role since harder woods certainly are more difficult for the insects to fragment with their mandibles. In addition, Peralta *et al.* (2004) found that wood consumption rates were not significantly correlated with wood densities.

Wood utilization rate

The utilization rate of *C. cynocephalus* on the three common furniture wood species ranged from 0.07-0.09 mg per termite per day (Fig. 4). This means that about 83% of the consumed wood was converted into termite biomass. A similar utilization rate was also observed by Indrayani *et al.* (2007b) in *I. minor*. The weight of fecal pellets in the no-choice feeding test is shown in Figure 5. *G. arborea* has the lowest fecal pellet weight (4.23 mg) and was significantly lower compared to *A. mangium* at 14.97mg (Tukey's test: $p < .05$), confirming the previous findings regarding mass loss and consumption rate in this study.

The number of fecal pellets per day was not determined in this study.

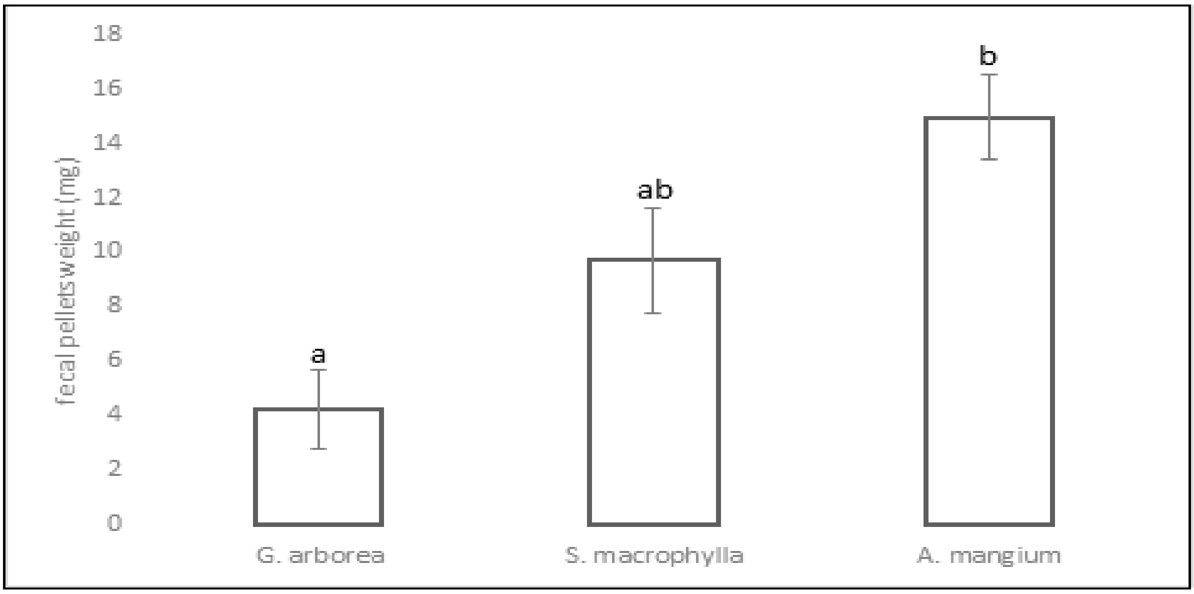

Fig. 5. Weight of fecal pellets (mg) (mean ± SEM) measured after 119 days of no-choice feeding test bar followed by the same letter are not significantly different (Tukey's HSD: $P < 0.05$).

However, Grace and Yamamoto (2009) concluded that, on average, nymphs of both *Cryptotermes brevis* (Walker) and *Incisitermes immigrans* (Light) deposited from 0.7 to 1.0 fecal pellets per day.

Conclusion

The feeding test conducted using three common furniture wood species has provided insights into the wood preference of C. cynocephalus. The observed order of preference was as follows: *S. macrophylla* – *A. mangium* – *G. arborea*, with the latter being the least favored by the termites. The natural resistance of wood against termite attack can be attributed to various physical and chemical properties. Surprisingly, this study found that density had no discernible impact on the resistance of these wood species against *C. cynocephalus*. On the other hand, extractive contents were believed to have a significant contribution to the resistance of wood species against *C. cynocephalus*.

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