

Assessment of the physical properties and conditions of stacked harvested industrial tree plantation logs in selected sites in the Caraga Region, Philippines

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ABSTRACT. Caraga region boasts the nation's highest log production, primarily from *Falcataria falcata* (L.) or falcata, a key industrial tree plantation species (ITPS), and *Gmelina arborea* Roxb. (gmelina) and *Acacia mangium* Willd. (mangium). This study aimed to address the research gap regarding the condition of harvested logs in Caraga by determining the physical properties of the stacked harvested logs and documenting the landing site conditions. Sound and infested logs were taken as samples at each landing site. Information like species, stacking duration, extent of deterioration, biodeterioration agents, and log dimensions were determined. Gross features, as observed in the end-grain of the samples, were characterized, and the physical properties of the sample logs were determined. Identification of biodeterioration agents (termites and fungi) in the samples was also conducted. A notable disparity in physical properties was observed between the two sets of logs. Infested logs showed higher moisture content, lower density, and specific gravity than sound logs. The species of fungi and termites present in the logs are *Auricularia cornea*, *Pycnoporus sanguineus*, *Phanerochaete chrysosporium*, and *Macrotermes gilvus*, respectively. The findings underscore the significance of proper log storage at landing sites. This study supports the development of effective infestation mitigation strategies and improved practices in handling and stacking harvested logs.

Keywords: decay fungi, log landing site, log stacking duration, termite species, wood physical properties

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INTRODUCTION

Wood is a vital forest resource used for various increasing applications, *i.e.*, no longer limited to construction, furniture, handicrafts, toys, and musical instruments. Unfortunately, wood, being an organic material, is naturally susceptible to decay, and this condition is further aggravated when used in unfavorable service environments like in humid or wet conditions. All wood species

can deteriorate if exposed to conditions that support the growth and infestation of different wood degrading and destroying organisms. With the diminishing supply of local wood caused by deforestation and the implementation of Executive Order (EO) 23, which shifts our dependence on wood sources to plantation species, it is now more important than ever to ensure proper utilization

and protection to maximize the benefits we derive from tree plantations.

In the Philippines, EO 23 has imposed a moratorium on the cutting and harvesting timber in the natural and residual forests. This has led to increased utilization of wood from plantation species such as *falcata* (*Falcataria falcata* (L.) Greuter & R. Rankin), *gmelina* (*Gmelina arborea* Roxb. ex Sm.), and *mangium* (*Acacia mangium* Willd). These species have been reported to possess good physical and mechanical properties (Alipon *et al.*, 2017; Alipon *et al.*, 2019; Marasigan *et al.*, 2022) and are extensively cultivated in the Caraga region. However, if improperly stored after harvesting, these species are more susceptible to the attack of wood-destroying organisms like termites and fungi than non-fast-growing hardwood species (Hidayat *et al.*, 2018).

Caraga region is recognized as the "Timber Corridor of the Philippines" owing to its abundant forest resources and significant role in the timber industry (Espiritu-Cabral *et al.*, 2020; Peras *et al.*, 2020). Caraga boasts extensive forested areas, encompassing natural and planted forests, making it one of the most densely forested regions in the Philippines. Notably, the region's log production is the highest in the country at 362,989.80 m³, with *falcata* accounting for 345,429.03 m³ (FMB, 2023). The region contributed around 55% of the country's total log production for 2023. As of 2021, there were 388,815 ha of forest land covered by 136 existing forest tenure agreements, along with 6,702 ha of private tree plantations in the region (NEDA, 2022). This log production supports local economies and provides raw materials for various industries. Logging operations involve felling, bucking, and transporting logs from the stump site to the roadside log landings (Espiritu-Cabral *et al.*, 2020). Logs are transported from the stump site to the roadside using carabao, manual hauling, motorcycles, or small trucks. Logs are delivered directly to sawmills or piled at the roadside landings, where buyers converge and pick up the logs to be delivered to sawmills within the Caraga region or in Cagayan de Oro.

Log landings serve as designated areas for collecting and temporarily storing harvested logs. However, prolonged storage at these sites presents challenges that can significantly impact wood quality and overall processing operations. Biotic and abiotic factors can significantly affect the quality of stored logs. Biotic factors encompass fungi (decay/rot fungi, stain fungi, and mold), insects (like beetles and termites), and bacteria (Yalcin, 2020). Extended exposure to moisture, which can come from periodic rains, high relative humidity, and damp ground, can lead to fungal growth, which causes decay and reduces the marketability of logs. In addition, the prolonged storage of logs in landing sites increases the risk of insect infestation, further compromising the logs. As the quality of the logs deteriorates, their economic value decreases, potentially leading to financial losses for tree farmers.

The present study documents and evaluates the conditions of selected landing sites in the Caraga region and the physical properties of the harvested logs stacked in them. This will provide vital information that can contribute to ensuring timber quality, optimizing economic returns, and supporting sustainable forest management practices. This information can raise awareness among stakeholders and local communities about the importance of proper log storage at landing sites. It can also help identify risk factors leading to infestations, develop mitigation strategies, and improve log-handling practices.

METHODOLOGY

The team coordinated with Industrial Tree Plantation Species (ITPS) farmers and Forest and Wetland Research, Development, and Extension Center—Ecosystems Research and Development Bureau (FWRDEC–ERDB) personnel to assist in locating and documenting the logs' properties and conditions within the Caraga region. The five (5) landing sites, located in Agusan del Norte, Agusan del Sur, and Surigao del Sur (**Figure 1**), were selected due to the availability of stacked logs when the study was conducted.

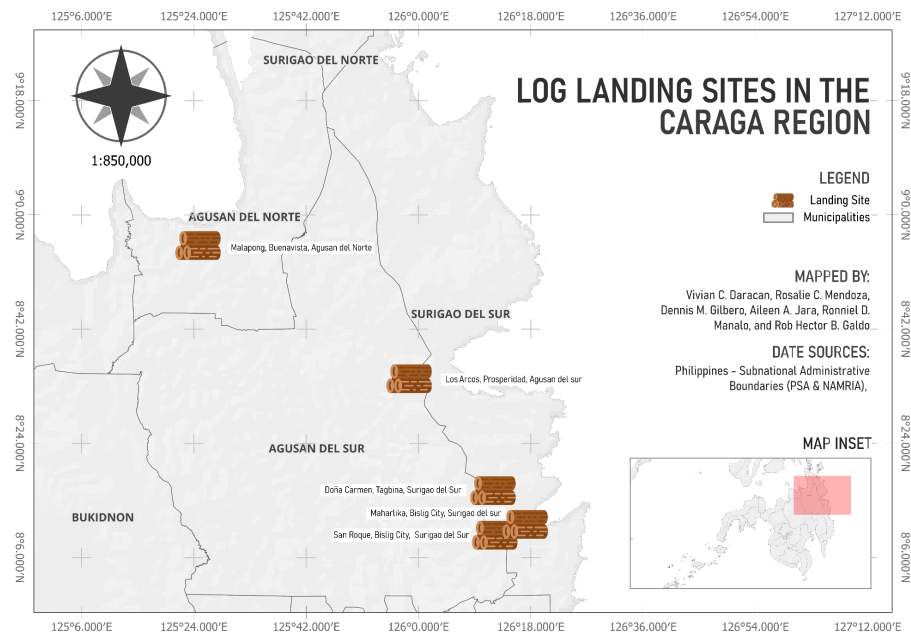


Figure 1. Map showing the location of the five log landing sites.

Documentation of existing log and site conditions

Information like the species' identity, stacking duration, the extent of deterioration, and log dimensions were determined. Expert consultations were used to identify biodeterioration agents. Several site visits (at least three) were also conducted to document site conditions.

The structural and physical properties of the sample logs on site were also examined. The logs' structural features were characterized using a Xylorix lens (**Figure 2**) attached to a smartphone, which captured images of the sample using the smartphone's camera application. The Xylorix lens is manufactured by Agritix, based in Malaysia.

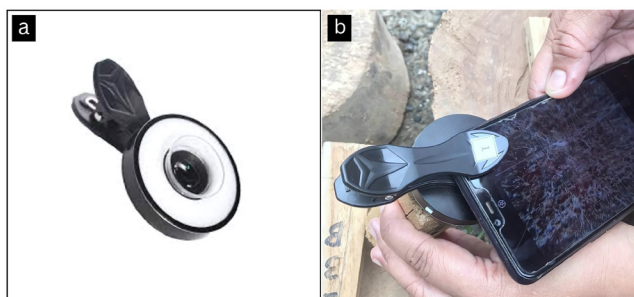


Figure 2. The Xylorix lens (a) and setup as clipped to a smartphone (b) when used in the field.

Determination of physical properties

The samples for physical property characterization were prepared from a 9-inch log segment, which was chainsawed and cut to appropriate sizes to obtain the needed measurements. Circular and band saws were used to cut samples for moisture content, density, and specific gravity. Wood blocks measuring 2.54 cm x 2.54 cm x 2.54 cm were prepared from each log. Each block's initial weight and volume were determined before placing them in an oven at 103 ± 2 °C until the weight became constant. Wood samples were removed and cooled in a desiccator before obtaining their final weight and volume (Glass & Zelinka, 2010).

Moisture content was measured and calculated using the oven drying method. Density and specific gravity at the green condition were calculated using the following formulas. Six (6) samples were prepared from each of three sound logs and three infested logs per species.

$$MC (\%) = \frac{W_g - W_o}{W_o} \times 100$$

$$\rho_g = \frac{W_g}{W_o}$$

$$G_g = \frac{W_o}{\rho_{(water)} - V_g}$$

Where: MC (%) = Moisture content

$\rho_{(water)}$ = Density of water

Gg = Green specific gravity

Wg = Initial weight (*all samples have initial MC higher than FSP*)

Wo = Oven-dry weight or mass

Vg = Green volume

Statistical analysis

The means of each physical property measured were computed, and the Welch t-test was used to compare the moisture content, green density, and specific gravity of sound and infested logs.

RESULTS AND DISCUSSION

Description of the stacked logs and site conditions

The team identified five landing sites, one landing site each in Agusan Del Norte and Agusan del Sur, and three landing sites in Surigao del Sur. **Figure 3** shows the different landing sites where the logs were stacked and studied. All five landing sites lack covered storage areas, and all logs were stacked in the vacant areas near the harvested logs. Logs stored in the landing sites have maximum exposure to the weather conditions prevailing in the said areas. The logs are also directly in contact with the ground, with no protective sheet to prevent attacks of biodeterioration agents like termites or fungi.

The species documented in the landing sites are falcata, gmelina, and mangium. It is important to note that not all three species may be available in a landing site. This depends on the log species' availability and harvesting timing. In Caraga, falcata logs are harvested more frequently than the other species in this study. The sample logs were classified as sound and infested in all landing sites. The succeeding paragraphs present the findings and analysis of the data collected on falcata, mangium, and gmelina logs, including their physical properties, dimensions, storage duration, and decay levels.



Figure 3. Stacked logs studied from various sites: a) Malapong, Buenavista, Agusan del Norte, b) Los Arcos, Prosperidad, Agusan del Sur, c) San Roque, Bislig City, Surigao del Sur, d) Doña Carmen, Tagbina, Surigao del Sur, and e) Maharlika, Bislig City, Surigao del Sur landing sites.

Falcata log dimensions, stacking duration, and decay descriptions

For falcata samples, the conditions of sound and infested logs from all the landing sites are summarized in **Table 1**. In Agusan Del Norte, the average diameter of sound logs is 36.00 cm, while the average diameter of infested logs is 33.83 cm. The sound logs' stacking duration was four (4) weeks, while infested logs were stacked up to 28 weeks. The infested samples were attacked by *Auricularia cornea* and *Macrotermes gilvus*. *A. cornea*, commonly known as wood ear fungus or jelly fungus, demonstrates exceptional ability in decomposing a wide range of decaying wood materials (Ye *et al.*, 2024). Meanwhile, according to Acda (2003), *M. gilvus* is a fungus-growing termite regarded as one of the most destructive termite species in the Philippines.

In Agusan del Sur, sound logs had an average diameter of 35.63 cm, whereas infested samples measured 31.92 cm. The stacking duration of the sound logs was two weeks, while the infested logs were stacked for 16 weeks. *Phanerochaete chrysosporium* and *M. gilvus* attacked the infested logs. *P. chrysosporium* is a crust white-rot fungus

Table 1. Summary of log condition, dimensions, stacking duration, and decay descriptions of observed falcata logs in all landing sites.

Landing site	Log condition	Average DBH (cm)	Stacking duration (in weeks)	Extent of deterioration	Biodeterioration agent
Sitio Sampinit, Malapong, Buenavista, Agusan del Norte	Sound	36.00	4		
	Infested	33.83	28	fungi and termites attacked all parts of the logs; termites severely attacked the bottom parts of the logs	<i>Auricularia cornea</i> and <i>Macrotermes gilvus</i>
Los Arcos, Prosperidad, Agusan del Sur	Sound	35.63	2		
	Infested	31.92	16	fungi and termites attacked all parts of the logs; termites severely attacked the bottom parts of the logs	<i>Phanerochaete chrysosporium</i> and <i>Macrotermes gilvus</i>
Road 14., Maharlika, Bislig City, Surigao del Sur	Sound	32.00	3		
	Infested	27.83	16	all parts of the logs were attacked by fungi and termites	<i>Macrotermes gilvus</i> and <i>Phanerochaete chrysosporium</i>
Purok 10 Doña Carmen, Tagbina, Surigao del Sur	Sound	15.73	2		
	Infested	17.83	12	all parts of the logs were attacked by fungi and termites	<i>Macrotermes gilvus</i> , <i>Phanerochaete chrysosporium</i> , and <i>Pycnoporus sanguineus</i>

that breaks down wood. It plays a major role in the natural decay process of fallen logs (Lundell *et al.*, 2014).

In Surigao del Sur, two landing points were identified. The first location is at Rd 14., Maharlika, Bislig City, Surigao del Sur. In this location, the average diameter of the sound logs is 32.00 cm, while the average diameter of the infested logs is 27.83 cm. The infested logs were stacked for 16 weeks, while the sound logs were stacked for three weeks. *M. gilvus* and *P. chrysosporium* attacked the infested logs. At P-10 Doña Carmen, Tagbina, Surigao del Sur, the second landing point, the average diameter of the sound log is 15.73 cm. The logs stacking duration is between one (1) to two (2) weeks, while the infested logs are stacked for 12 weeks, and the average diameter is 17.83 cm. Aside from the usual decaying agents (*M. gilvus* and *P. chrysosporium*), *Pycnoporus sanguineus* (Fr.) Murr. was also observed in the infested logs (**Figure**

4). *P. sanguineus*, a member of the Polyporaceae family, is a saprobic fungus prevalent in tropical and subtropical regions, typically colonizing dead hardwoods (Dulay & Damaso, 2020). It is reported to be abundant in the molave forest of La Union, producing basidiocarps that are up to 34 cm wide (Tadosa & Arsenio, 2014).

**Figure 4.** Falcata logs stacked in Purok 10 Doña Carmen, Tagbina, Surigao del Sur landing sites: a) sound and b) infested.

Decay in the logs is not limited to a specific area but extends throughout their entire length. In most cases, the bottom sections are the most severely

affected, likely because termites attacked them first, allowing decay to spread upward. As the wood deteriorates, it becomes softer, develops cracks, and may begin to delaminate—clear signs of fungal degradation breaking down its lignin and cellulose.

Color changes often signal fungal activity. Affected logs may darken, develop black spots, or take on reddish orange, especially in the presence of *P. sanguineus*. The surface may also become uneven, showing pits, furrows, and weakened wood fibers due to the action of fungal enzymes.

The presence of fungal fruiting bodies further confirms active decay. *Auricularia cornea* produces jelly-like growths along the log, while *P. chrysosporium* forms white, cottony mycelial mats that indicate deep rot, even if visible fruiting bodies are absent. Meanwhile, *P. sanguineus* is easily recognizable by its bright orange to reddish bracket fungi, which often appear on exposed surfaces.

Termites, particularly *M. gilvus*, accelerate the decay by tunneling extensively within the logs, creating hollow spaces and mud tunnels that allow fungal degradation to progress more rapidly. As the infestation spreads, the structural integrity of the wood weakens. In advanced stages, the logs become brittle and break easily, showing signs of fungal rot and termite damage.

Falcata gross features

In all sites, the following gross features were observed in both sound and infested logs: the color is from cream white to light pink; hardness varies if it is infested or sound; the sound log is moderately soft while the infested ones are softer;

luster of the logs is generally dull; the topography is diffuse-porous with moderately large pores arranged in solitary and radial multiples of 2-3; visible parenchyma is vasicentric, and lastly, wood rays are narrow. The characteristics observed match the descriptions reported by Escobin *et al.* (2015) and Nugroho *et al.* (2024). A cross-sectional comparison of sound and infested falcata logs is depicted in **Figure 5**.

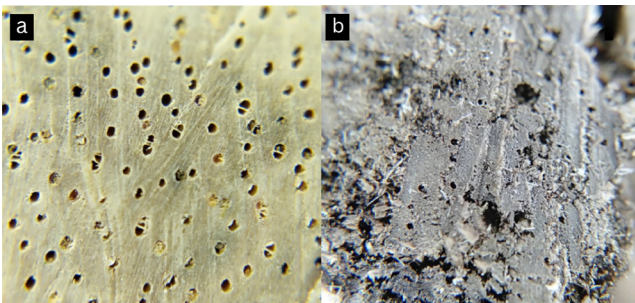


Figure 5. Cross-sections of falcata logs at 24X magnification: a) sound and b) infested.

Gmelina log dimensions, stacking duration, and decay descriptions

Sound and infested samples of gmelina were sourced from P-10, Doña Carmen, Tagbina, and Maharlika, Bislig City, Surigao del Sur. The conditions of both sound and infested logs from all the landing sites were summarized in **Table 2**. The average diameter of the sound samples is 18.92 cm, while for the infested, the average diameter is 24.37 cm. The infested logs were stacked for 15 weeks, while the sound logs were stacked for two (2) weeks. *M. gilvus* and *P. sanguineus* attacked the infested logs. Like the falcata samples, all the infested gmelina samples were observed to show considerable decay along the whole length (**Figure 6**). This degradation

Table 2. Summary of log condition, dimensions, stacking duration, and decay descriptions of observed gmelina logs in Surigao del Sur landing sites.

Landing site	Log condition	Average DBH (cm)	Stacking duration (in weeks)	Extent of deterioration	Biodeterioration agent
P-10 Doña Carmen, Tagbina, Surigao del Sur	Sound	18.92	2		
Maharlika, Bislig City, Surigao del Sur	Infested	24.37	15	all parts of the log by fungi and termites	<i>Phanerochaete chrysosporium</i> and <i>Macrotermes gilvus</i>

was accompanied by noticeable discoloration, indicative of fungal growth and termite activity. Exit holes and tunnels bore further witness to active termite infestation and their characteristic feeding patterns within the wood structure.



Figure 6. Stacked gmelina logs at Purok 10, Doña Carmen, Tagbina, Surigao del Sur (a) sound, and at Maharlika, Bislig City, Surigao del Sur (b) infested.

Gmelina gross features

The following gross features were observed in sound and infested gmelina logs: the logs' color is creamy white with a pink tinge; hardness varies if it is infested or sound; the sound log is moderately soft while the infested ones are usually softer; luster of the logs is generally dull; the topography is semi-ring porous with moderately small and moderately large pores arranged in solitary and radial multiples of 2-3; visible parenchyma are vasicentric and boundary, and lastly, wood rays are narrow. The observed features align with the findings of Vignesh and Sumitha (2020). **Figure 7** presents the cross sections of gmelina logs, highlighting the difference between sound and infested wood.

Mangium log dimensions, stacking duration, and decay descriptions

Mangium samples were collected from Sitio Mamparasan, San Roque, Bislig City and Los Arcos, Prosperidad, Agusan del Sur. The

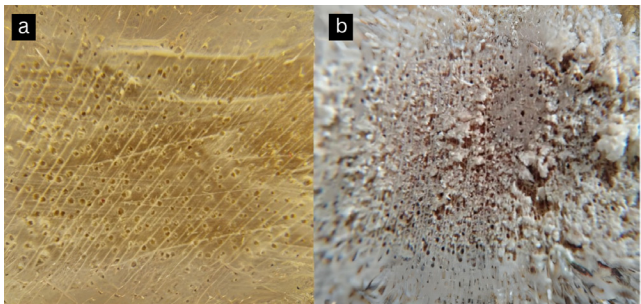


Figure 7. Cross-sections of gmelina at 24X magnification: a) sound and b) infested.

conditions of both sound and infested logs from all the landing sites are summarized in **Table 3**. The average diameter of the sound samples is 20.22 cm, while for the infested, the average diameter is 17.75 cm. The infested logs were stacked for 10 weeks, while the sound logs were stacked for two (2) weeks. *M. gilvus* and *P. chrysosporium* attacked the logs (**Figure 8**).

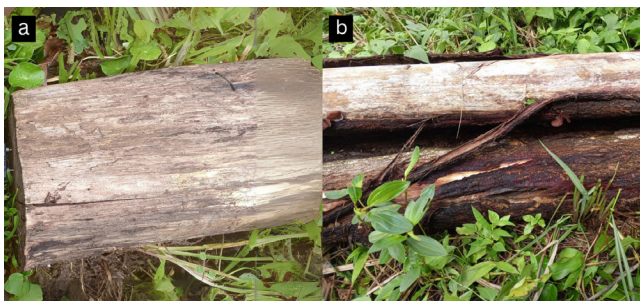


Figure 8. Stacked mangium logs at Sitio Mamparasan, San Roque, Bislig City (a) sound, and Los Arcos, Prosperidad, Agusan del Sur (b) infested.

Mangium gross features

The following gross features were observed in both sound and infested mangium logs: the logs' color is from whitish to light brown; the sound log is moderately hard, while the infested ones'

Table 3. Summary of log condition, dimensions, stacking duration, and decay descriptions of observed mangium logs in Agusan del Sur landing sites.

Landing site	Log condition	Average DBH (cm)	Stacking duration (in weeks)	Extent of deterioration	Biodeterioration agent
Sitio Mamparasan, San Roque, Bislig City	Sound	20.22	2		
Los Arcos, Prosperidad, Agusan del Sur	Infested	17.75	10	all parts of the log by fungi and termites	<i>Phanerochaete chrysosporium</i> and <i>Macrotermes gilvus</i>

hardness did not differ mainly with the sound logs; the luster of the logs is quite lustrous; the topography is diffuse-porous with small and moderately numerous pores arranged in solitary, radial multiples of 2-4 and tangential multiples of 2; visible parenchyma are vasicentric and aliform, and lastly, wood rays are narrow. These findings are consistent with the results of the study conducted by Savero *et al.* (2022). **Figure 9** below shows the cross-section of sound and infested mangium logs.

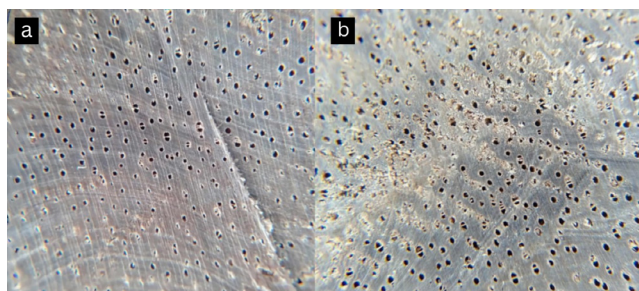


Figure 9. Cross-sections of mangium logs at 24X magnification: a) sound and b) infested.

Determination of physical properties of wood

The moisture content, density, and specific gravity of sound and infested falcata, gmelina, and mangium logs were determined and compared. For all three (3) species, infested logs had higher moisture content and lower density and specific gravity values.

Moisture content

The results show that infested logs of all three species (falcata, gmelina, and mangium) had significantly higher average moisture content than their respective sound counterparts (**Table 4**), indicating a potential link between insect infestation and elevated moisture levels in the wood.

Table 4. Average moisture content (%) of sound and infested falcata, gmelina, and mangium logs.

Species	Moisture content (%)		P(T<=t) two-tail
	Sound	Infested	
Falcata	46.33 ± 4.70	78.65 ± 5.98	0.0018*
Gmelina	118.78 ± 4.40	158.97 ± 15.10	0.0474*
Mangium	97.10 ± 16.89	124.07 ± 21.94	0.1669**

Note: * significant at the $p < 0.05$ level; ** not significant

The Welch t-test results at a 95% confidence level ($\alpha = 0.05$) demonstrated a significant statistical difference in the moisture content of falcata and gmelina logs between sound and infested samples. This suggests that higher moisture content in these species may be associated with increased susceptibility to decay and insect infestation. However, for mangium logs, the difference in moisture content between sound and infested samples was not statistically significant, indicating that moisture content alone may not be a strong predictor of decay in this species.

Moisture content plays a crucial role in wood decay. Decay fungi require a certain level of moisture to thrive and degrade wood. When wood's moisture content exceeds a critical threshold, typically around 20–30%, it becomes more susceptible to fungal attack (Goodell *et al.*, 2020; Morel-Rouhier, 2021). In the case of falcata and gmelina, the higher moisture content in infested logs may have created an environment conducive to fungal growth, leading to decay and subsequent infestation.

The combined effects of fungal decay and termite infestation on wood degradation may also explain the higher moisture content of the infested logs. According to Zabel and Morrell (2020a), many wood-inhabiting fungi move through wood primarily by penetrating pits rather than directly penetrating the wood cell walls. Removing the pit membrane enhances fluid absorption in decayed wood, making it more permeable than healthy wood. Consequently, decayed wood can absorb and desorb liquids more easily than healthy wood. This increased permeability allows decayed wood to absorb water more readily, creating an environment favorable for microbial colonization. Through tunneling and comminution, insects enhance the aeration and accessibility of wood to microorganisms (Zabel & Morrell, 2020b).

While moisture content is important, it is not the only determinant of wood decay. Other factors, such as wood species (Zabel & Morrell, 2020c), the presence of decay fungi (Wilcox, 2001), and environmental conditions (Alshammari *et al.*,

2020)), can also influence the extent of decay. For mangium, other factors, such as natural resistance mechanisms or specific environmental conditions, may be more significant in determining susceptibility to decay.

Density and specific gravity

The study compared the green density and specific gravity of sound and infested falcata, gmelina, and mangium logs (Tables 5 and 6). The results showed that sound logs consistently exhibited higher values for green density and specific gravity than their infested counterparts.

Table 5. Average density (g cm^{-3}) at the green condition of sound and infested falcata, gmelina, and mangium logs.

Species	Density (g cm^{-3})		P(T<=t) two-tail
	Sound	Infested	
Falcata	0.50 $\pm$ 0.05	0.32 $\pm$ 0.06	0.0143*
Gmelina	1.02 $\pm$ 0.03	0.80 $\pm$ 0.09	0.0597**
Mangium	0.90 $\pm$ 0.06	0.81 $\pm$ 0.09	0.2153**

Note: * significant at the $p < 0.05$ level; ** not significant

A Welch t-test statistical analysis at a 95% confidence level ($\alpha = 0.05$) indicated a significant difference in density between sound and infested falcata and gmelina logs at green conditions. This suggests that higher density in these species may correlate with increased resistance to decay and insect infestation. For falcata, sound logs had an average green density of 0.50 g cm^{-3} , while infested logs had a value of 0.32 g cm^{-3} . Gmelina also displayed a similar pattern. Sound gmelina logs had an average green density of 1.02 g cm^{-3} , significantly higher than the infested logs' value of 0.80 g cm^{-3} . Finally, mangium logs did not clearly distinguish between sound and infested samples. Sound mangium logs had an average green density of 0.90 g cm^{-3} , while infested logs had a lower value of 0.81 g cm^{-3} . This is due to the observed limited deterioration in the sampled logs.

Similar to the density, a Welch t-test ($\alpha = 0.05$) revealed significant differences in average green specific gravity between sound and infested falcata and gmelina logs, suggesting a potential correlation between higher specific gravity and

Table 6. Average specific gravity at the green condition of sound and infested falcata, gmelina, and mangium logs.

Species	Specific gravity		P(T<=t) two-tail
	Sound	Infested	
Falcata	0.35 $\pm$ 0.03	0.20 $\pm$ 0.04	0.0063*
Gmelina	0.43 $\pm$ 0.03	0.35 $\pm$ 0.05	0.0755**
Mangium	0.48 $\pm$ 0.07	0.40 $\pm$ 0.07	0.2189**

Note: * significant at the $p < 0.05$ level; ** not significant

wood soundness. No significant difference in moisture content was found between sound and infested mangium logs, indicating that the difference in specific gravity can be attributed to the difference in the cell wall material of both wood groups.

Sound falcata logs had a higher green specific gravity value of 0.35 than infested logs at 0.20. The same trend was observed for sound gmelina logs, which had a value of 0.43, compared to infested logs' specific gravity value of 0.35. The green specific gravity value of sound mangium logs was also higher at 0.53 than infested logs at 0.44.

Specific gravity and density are crucial indicators of wood quality and durability (Gartner, 2005; Williamson & Wiemann, 2010). Higher specific gravity and density typically indicate a higher amount of wood substance. Specifically, this may mean thicker cell walls and or the presence of more prosenchymatous elements on wood. According to Broda (2020), this can also be attributed to the species' relatively high extractive content. Moreover, species with high density and specific gravity are expected to have better resistance to decay. Conversely, lower values suggest a more porous wood structure, which is more susceptible to decay and attack by wood-boring insects. ITPS species covered in this study at sound conditions fall under light to medium density classification based on FPRDI classification, which means that naturally, these species are more prone to deterioration than non-fast-growing species with higher density and specific gravity.

The lower specific gravity and density values of the infested samples compared to the sound

wood are clear manifestations of the effect of deterioration caused by the attack of fungi and termites. This means that the wood substance present per unit volume of wood is significantly reduced in the infested wood group. Boakye *et al.* (2023) noted that the deterioration of wood caused by pests has a detrimental effect on wood density. The deterioration caused by boring insects, such as beetles, which create tunnels within the wood, leads to structural weakening and decreased density. Similarly, termites contribute to this density reduction by consuming cellulose and lignin.

There are available environmental conditions data for Caraga through the Climate and Agrometeorological Data Section (CADS), Philippine Atmospheric, Geophysical and Astronomical Services Administration. The average annual temperature in Caraga ranges from 25°C to 32°C. The region experiences slight variations in temperature throughout the year. Humidity levels are generally high, especially during the rainy season. The reported relative humidity ranges from 75% to 85%. The high humidity and the reported range of temperatures in the region generally favor the attack of different biodeterioration agents (Alwakeel, 2008).

CONCLUSION AND RECOMMENDATION

Five landing sites were identified in the study area, each lacking adequate storage facilities. Logs were directly exposed to the elements and ground contact, increasing susceptibility to decay. The primary species documented were *falcata*, *gmelina*, and *mangium*, with *falcata* being the most prevalent. These conditions, coupled with specific fungi and termite species, pose significant threats to the quality of the harvested timber. This study documented the current fungal and termite species in the landing sites. The identified fungi included *A. cornea*, an ear-shaped fungus that grows on decaying wood, and *P. chrysosporium*. Surveys conducted in Agusan del Norte and Surigao del Sur revealed *M. gilvus* as the sole termite species attacking the wood. This common, mound-building termite is known to consume wood and crops, although other termite species

may also inhabit the region. Analysis of physical properties revealed that infested logs exhibited significantly elevated average moisture content compared to sound logs of the same species. This increase in moisture content likely contributes to the observed reductions in density and specific gravity, which were consistently lower in infested logs across all three species. These diminished physical properties can be attributed to the activity of biodeterioration agents.

The study suggests establishing and applying detailed log handling and stacking protocols to control infestations and enhance current practices. These protocols should include inspection procedures immediately after harvest, optimized stacking methods that minimize ground contact and maximize airflow, and recommended storage time frames to limit pest reproduction. Furthermore, the study recommends using wood protection treatment, particularly plant-based options, as an environmentally sound alternative to chemical treatments. These plant-derived solutions can be applied post-harvest to prevent termite activity and fungal growth, thus maintaining wood quality and minimizing losses.

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