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Wood decomposers on six community timber species in two different locations

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Abstract. *Nurhadi MW, Arinana A, Rahmawati AI, Herliyana EN, Andika R, Himmi SK. 2023. Wood decomposers on six community timber species in two different locations. Biodiversitas 24: 6629-6640.* Wood has a close relationship with termites and fungi as decomposers. Decomposers are important as dead organic matter is broken down into elements and returned to the soil. This study aims to analyze the amount of wood attacked by termites and fungi on six types of community timber during six months of testing at two different locations, analyze the degree of damage, and identify the species of termites and fungi that attack them. The research was conducted in two locations: the Arboretum of the Faculty of Forestry and Environment of IPB and a residential area in Bogor Asri, Cibinong Sub-district, Bogor District. The wood tested were *Acacia mangium*, *Falcataria moluccana*, *Anthocephalus cadamba*, *Maesopsis eminii*, *Pinus merkusii*, and *Hevea brasiliensis*. Tests were conducted based on ASTM D 1758-06. Infested wood increased with the time tested, and infestation was higher in the arboretum (75%) than in the residential area (39.4%). The highest level of wood damage in the arboretum was *Hevea brasiliensis* (35.4 g); in residential, it was *Pinus merkusii* (18.9 g). The subterranean termite types found during the six months of testing are *Macrotermes* sp., *Microtermes* sp., *Schedorhinotermes* sp., and *Odontotermes* sp. The weathering fungi types found during the six months of testing were *Aspergillus* sp., *Mucor* sp., *Trichoderma* sp., *Gliocladium* sp., *Mycelia sterilia*, and red fungus. Soil type, moisture, and ambient temperature also strongly favored the development of decomposer life found in the two research sites.

Keywords: Arboretum, fungi, residential, subterranean termites

INTRODUCTION

Intensification of land use and different activities can affect soil quality changes (Galindo et al. 2022). Soil quality indicates a sustainable biological ecosystem in the soil that influences the growth of plants, animals, and humans (Panwar et al. 2022). The high soil fauna activities, especially invertebrate fauna, can accelerate the decomposition of plants; the decomposition process usually occurs with the help of decomposing organisms in the soil (Griffiths et al. 2021). Jacobsen et al. (2017) showed that several different species of wood-invading insects carry the fungus to recently dead wood, and at least some of the fungal material is carried as propagules attached to the exoskeleton. According to Issoufou et al. (2019), termite activity significantly increases microbial decomposers' activity and the soil organic matter degradation rate. Termite activity may also contribute to the differences between fungal comb spaces and soil environments. According to Nandika et al. (2015), termites are social insects that eat cellulose materials, and they are active as decomposers. Termites and fungi are insects and microorganisms that play a role in the ecosystem. Subterranean termites are soil macrofauna that act as decomposers of organic matter and topsoil soil structure formation (Arinana et al. 2019). Fungi are important decomposers in forest ecosystems, representing a large and poorly understood component (Fukasawa 2021). They are best identified according to the decomposition types they cause. The most common types are white rot, brown rot, and soft rot (Li et al. 2022). Meanwhile, weathering fungi are also the best decomposers; the initial attack to degrade lignocellulosic biomass may be carried out by fungi, after which other microorganisms, especially bacteria, will join them. Fungi degrade all three major cell wall components, including lignin; research shows that lignin degradation occurs in the final stages of the putrefaction process (Velasco-Rodriguez et al. 2022). Termites and fungi play a role in decomposing various organic materials, soil formation, and weathering wood by attacking three major cell wall components (Martin and López 2023).

Wood is a necessary element in residential settings, and its usage in building construction and as a raw material for interior devices is growing. The availability of wood with durability classes I and II is increasingly limited, making people switch to using wood with durability classes III and IV, which have lower natural durability, such as community timber (Sundararaj et al. 2015). Community timber is wood planted by the community for additional financial income and managed through the Village Forest. (Santika et al. 2019). Most community timber is classified as low durability class IV-V and has potential as an alternative to bait wood because it is a fast-growing species (Ruffinatto and Crivellaro 2019). Wood with a low durability class is susceptible to damage and weathering by wood-destroying organisms, resulting in decreased wood life span (Wu et al. 2021). Several types of community timbers that are widely used by the community include acacia (*Acacia mangium*), sengon (*Falcataria moluccana*), jabon (*Anthocephalus cadamba*), manii (*Maesopsis eminii*), pine (*Pinus merkusii*) and rubber *(Hevea brasiliensis*).

The difference in location for planting the sample wood is due to differences in the ecosystem between the residential site and the arboretum, such as soil texture, temperature and humidity. These ecosystem differences are expected to influence the type of decomposer, especially termites and fungi, and the damage they cause. The residential site is an area that has been built with many buildings that are used as residences, very different from the arboretum which has high biodiversity which influences the activity of organisms in the area, including decomposers. Therefore, this research is to determine the amount of infested wood, the level of wood damage, and the types of wood decomposer organisms in different locations using several types of community timber.

The objectives of this study were to identify the termites and fungi species that attacked the bait wood during the six-month feeding time, calculate the amount of wood attacked by termites and fungi as decomposers per type of community timber per month of testing per location, measure the damage level of termite and fungal attacks as decomposers at two different locations, namely the Arboretum of the Faculty of Forestry and Environment of IPB and Bogor Asri, Cibinong Sub-district, Bogor District, and analyze soil and weather characteristics at those two different locations. This study is expected to determine the types of termites and fungi that attack several types of community timber in settlements in the arboretum and the amount of degradation caused by these decomposers.

MATERIALS AND METHODS

Materials

The materials used in this study were acacia (*A. mangium*), sengon (*F. moluccana*), jabon (*A. cadamba*), manii (*Ms. eminii*), pine (*P. merkusii*), and rubber (*H. brasiliensis*) obtained from the Curug Nangka area, Sukajadi Tamansari Sub-district, Bogor District.

Procedures

Wood preparation

The diameter of the logs used was 40 cm. The logs were cut into boards 200 cm long and 4 cm thick, then dried in the sun until the moisture content of the boards dropped. The boards were made into 2 cm (tangential) x 2 cm (radial) x 46 cm (longitudinal) sizes, referring to the ASTM D 1758-06 (2006) standard. The wood sample is then oven-dried for 1x24 hours until the moisture content is below 12%. The surface of the wood sample is cleaned using sandpaper, and one end is painted. The wood sample was then weighed (W1).

Field planting of wood sample

Moreover, 360 wood samples were randomly planted in two sites: the Arboretum of the Faculty of Forestry and Environment, Bogor Agricultural University, Darmaga, and the Bogor Asri Residential, Cibinong, Bogor District, West Java Province, Indonesia. The wood samples were planted vertically until 25 cm of the total length was immersed into the soil, and the painted end was above the surface (Figure 1). Each wood sample was planted with a column spacing of 30 cm and a row spacing of 60 cm. The residential and arboretum testing site is shown in Figure 2. Each wood sample was planted with a distance between columns of 30 cm and between rows of 60 cm. The test was conducted for six months, and the wood sample was uprooted according to the time treatment used, which was 1, 2, 3, 4, 5, and 6 months. After uprooting, the wood sample was cleaned and oven-dried for 2x24 hours until the moisture content was <12%.

Measurement of wood density

Wood density measurement followed the BS 373 (1957) standard. Five test replicates were conducted for each type of wood, beginning with measuring the dimensions and initial weight of the test sample. The test samples were then dried in an oven at 103±2°C until constant weight. After that, the samples were put into a desiccator and weighed to determine the Kiln Dry Weight. Measurement of wood density based on BS 373 (1957) standard can be obtained using the following equation:

$$\text{Wood density} = \left(\frac{\text{Kiln Dry Weight}}{\text{Wood Volume}}\right)$$

Subterranean termite identification

The termite specimens (soldier caste) found in each wood sample were placed separately in collection bottles filled with 70% alcohol. Furthermore, following to Krishna (2013) and Constantino (2021), termite specimens were identified. Morphological termite specimen observations were conducted with a Digital Microscope Keyence, VHX - 7000 series.

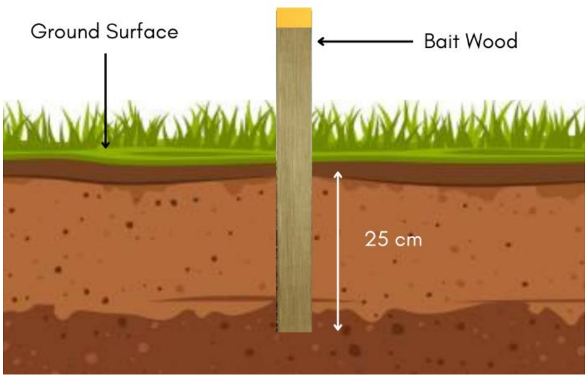


Figure 1. Sketch of wood sample in the test site

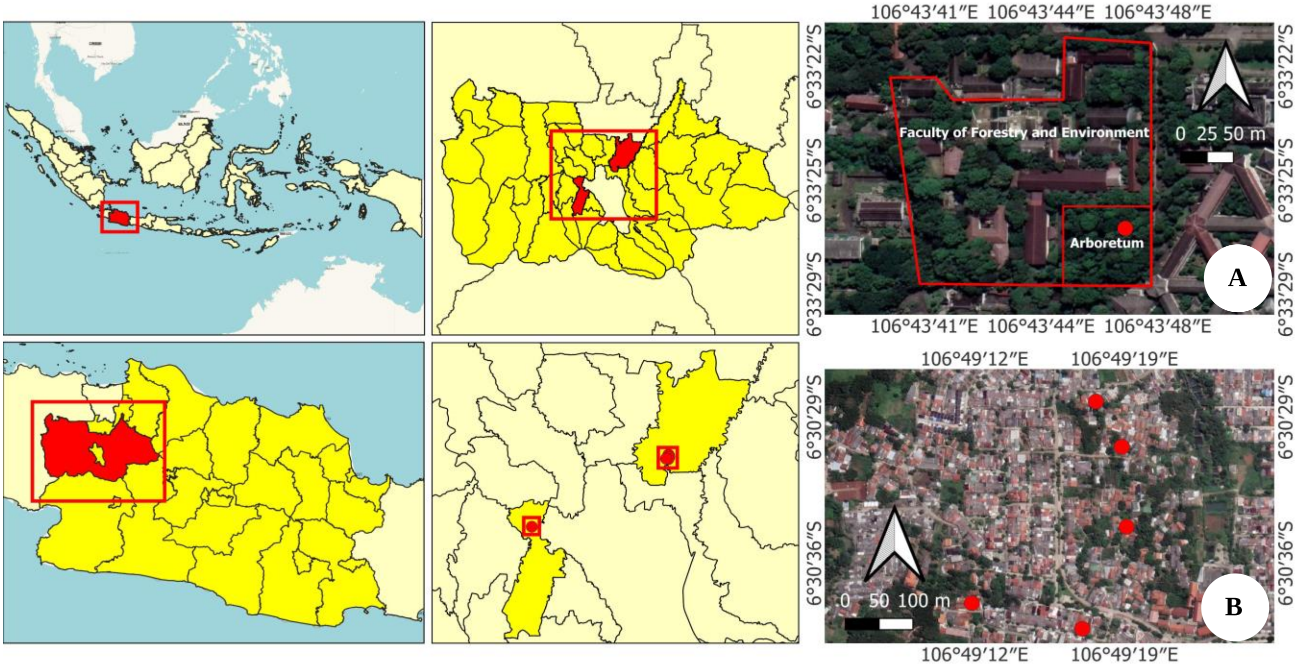


Figure 2. Map of the research site. A. Arboretum, B. Residential

Morphological identification of fungi

The fungi were identified by observing their macroscopic and microscopic characteristics. Macroscopic identification was done by observing the fungi characteristics of colonies on the wood sample in color and shape forms. Meanwhile, fungi microscopic identification begins by preparing the isolation results. The preparations were observed under a binocular microscope with 400x total magnification to observe the fungi morphology in hyphae, conidiophores, and conidia forms. The fungi morphological identification was done using the help of the identification key book by Samanta (2015) and Siddiquee (2017).

Number of wood infested with termites and fungus and the degree of damage

After one, two, three, four, five, and six months of planting, five wood samples of each species per test site were collected, cleaned, dried to a moisture content of <12%, and weighed (W2). The decoy wood was observed and measured for damage. Furthermore, the degree of the wood damage samples and the amount of infestation by subterranean termites and weathering fungi were measured.

Infested wood is the ratio between the amount of wood sample infested by termites and soil fungi by the total amount planted in the test area and expressed in percentages. According to research by Cookson and Trajstman (2002), the amount of infested wood is classified into six classes. The average amount of infested wood obtained in the study was classified with the data in Table 1.

The wood sample damage levels include weight loss, wood consumption, percentage damage, and damage value of wood sample due to attack by destructive organisms (subterranean termites and weathering fungi) from the cross-section direction referring to ASTM D 1758-06 (2006) with the following formula:

$$WL\ (\%) = \frac{W_1 - W_2}{W_1}\ x\ 100\%$$

Where:
WL : Weight loss of test sample (%)
W1 : Air dry weight of test sample before feeding (g)
W2 : Air dry weight of test sample after feeding (g)

Wood sample consumption:

WC (g) = W1 - W2

Where:
WC : Wood sample consumption (g)
W1 : Air dry weight of wood before feeding (g)
W2 : Air-dry weight of wood after feeding (g)

Analysis of soil characteristics

Soil analysis determines the characteristics and content present in the soil. Soil samples were taken at five points on the test sites. At each point, 1 kg of soil samples were taken from a depth of 0-20 cm compositely using a crowbar (Ge et al. 2019). The soil samples were then analyzed at the Indonesian Center for Biodiversity and Biotechnology (ICBB) Bogor to determine their characteristics: texture (percentage of sand, dust, and clay), pH, and soil C-organic content.

Measurement of temperature and humidity

Temperature and humidity measurements were taken using a Digital Temperature Humidity Data Recording Logger Meter type DWL-20 installed at one point around the test site. Air temperature and humidity data were automatically recorded on the device every hour for six months of observation.

Table 1. Classification of attacks

Class	Frequency (%)	Description
1	0	No infestation
2	1-10	Very low
3	11-20	Low
4	21-30	Medium
5	31-40	High
6	>40	Very high

Data analysis

Data analysis was carried out using quantitative and qualitative data. Quantitative data was calculated using the Microsoft Excel application and presented in graphical forms. The qualitative data is presented in images and described narratively after observing the research object.

RESULTS AND DISCUSSION

Wood density

Wood density is one of the essential physical properties of wood about its use. The results showed a variation in wood density between 0.32 and 0.60 (Table 2). Pine and acacia have the highest wood density (0.60), while sengon has the lowest (0.32). The density of wood is influenced by the level of density and the content of natural chemicals (Scharnweber et al. 2023). Wood with a high wood density generally has a denser structure and lower moisture content. According to Martin and López (2023), Wood density determines termite feeding activity because termites prefer wood with lower density and little extractive content. However, the presence of extractives that cause high wood density may also attract termites to infested the wood. Decomposers more easily attacked pine wood with a wood density of 0.60. This is because pine wood contains higher extractive substances that are attractive to termites (Brischke and Alfredsen 2022).

Termite species that attack wood sample

The study revealed there were at least four specimens of termites that attacked after one, two, three, four, five, and six months of feeding on the two test sites, namely *Macrotermes* sp., *Microtermes* sp., *Schedorhinotermes* sp., and *Odontotermes* sp. (Figure 3). *Schedorhinotermes* sp. is a member of the Rhinotermitidae family, while the other three termite species are members of the Termitidae family. The data shows that the Termitidae family is more dominant than the Rhinotermitidae family because it has more feeding termites. Termite specimens found in residential testing sites are similar to the research of Arinana et al. (2020a), who found four species of subterranean termites attacking wood samples in Sinarsari Nature housing, namely, *Macrotermes* sp., *Microtermes* sp., *Schedorhinotermes* sp., and *Odontotermes* sp. Meanwhile, the specimens in the arboretum testing site are slightly different from the research of Arinana et al. (2020b) and Arinana et al. (2022), who found *Capritermes* sp. specimen on the Bogor Agricultural University arboretum testing site. According to Nandika et al. (2015), the Termitidae family belongs to a group of high-level termites that account for three-fourths of the total termite population and are found mainly in tropical areas. Within one to six months of the feeding period on both sites, termites were more numerous and easier to find on the arboretum test site.

The attack of decomposers on the wood samples is shown in Table 3. In the first month of baiting at both test sites, subterranean termite species *Macrotermes* sp. and *Microtermes* sp. were found attacking all wood sample species except manii. The first *Schedorhinotermes* sp. subterranean termite was found attacking wood samples in the second month and feeding on the pine wood species on the arboretum. *Odontotermes* sp. was only found attacking one pine wood sample in the fourth month on the residential and one acacia wood sample in the third month on the arboretum. From the two test sites, subterranean termites actively attacked the wood sample from the first month to the sixth month in the pine wood sample. The number of *Microtermes* sp. subterranean termites in the residential sites attacked 17 wood samples during the six months. *Microtermes* sp. subterranean termites also dominated the arboretum by attacking 24 wood samples during the six months of feeding. Meanwhile, *Macrotermes* sp. attacked five wood samples in the residential, eleven in the arboretum, and *Schedorhinotermes* sp. attacked three in the residential, and five in the arboretum sites.

Termites are essential as decomposers in the ecosystem, helping decompose difficult organic materials, such as dead wood, litter, and dead plants. However, termites are considered harmful insect pests due to changes in habitat conditions by human activities, such as residential development. According to Anyango et al. (2020), Higher termite abundance, incidence, activity, and diversity were found in soil with high organic content, which indicates that the presence of termites, although considered pests, also has a positive impact on the surrounding environment, especially in the decomposition of organic material. *Microtermes* sp. is common in urban landscapes, residentials, plantation land, and grazing areas (Arinana et al. 2019; Netshifhefhe et al. 2020; Pratiknyo et al. 2020). Arboretum Faculty of Forestry IPB is a suitable habitat for *Microtermes* sp. nests because there are many organic materials such as logs, litter, and humus. According to Alamu et al. (2021), *Microtermes* sp. is found in eucalyptus plantations abundantly, even in rainy or dry seasons.

Table 2. Specification of wood density

Wood species	Wood density
Manii	0.41
Rubber	0.46
Jabon	0.42
Acacia	0.60
Sengon	0.32
Pine	0.60

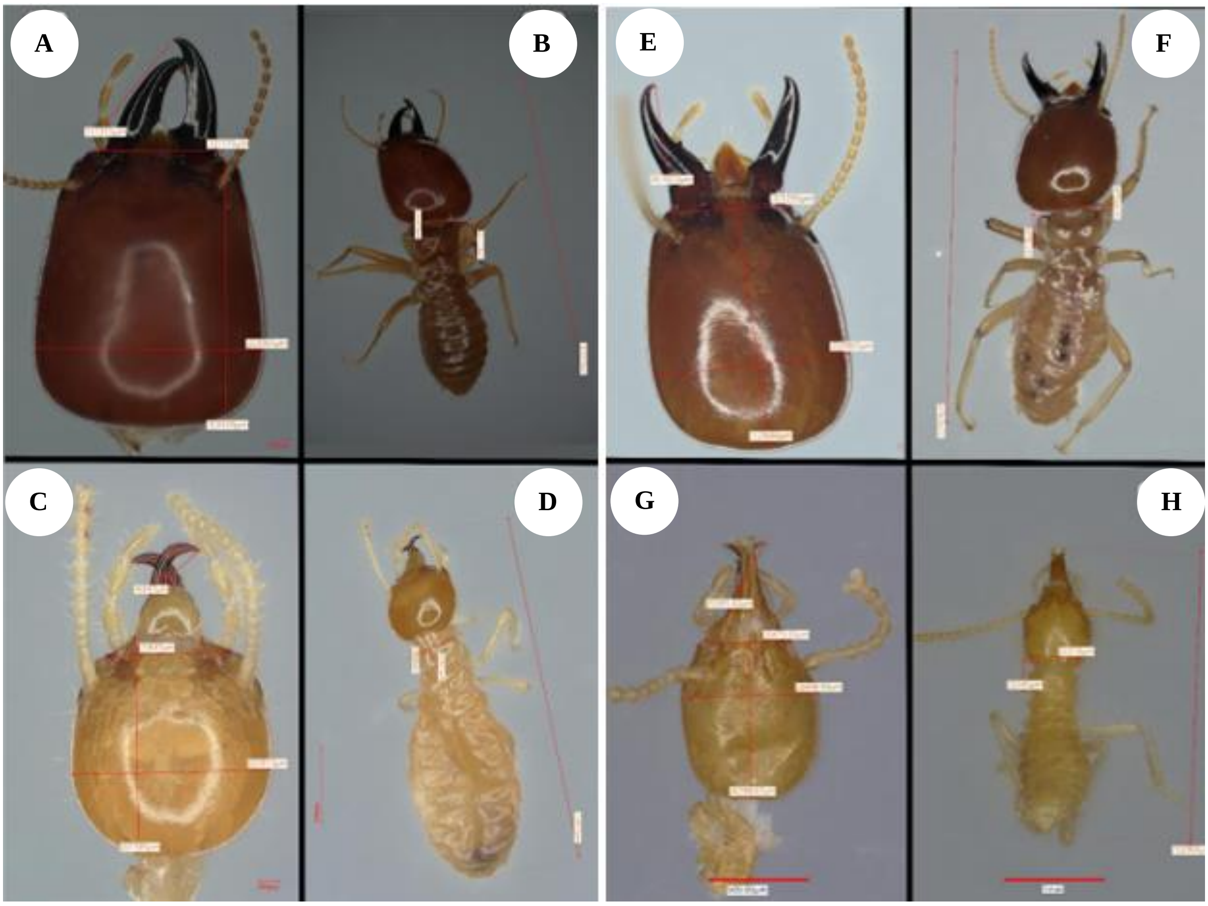


Figure 3. Termite species found in the testing site of Residential and Arboretum of Faculty of Forestry and Environment IPB: A. Head of *Macrotermes* sp., B. *Macrotermes* sp., C. Head of *Microtermes* sp., D. *Microtermes* sp., E. Head of *Odontotermes* sp., F. *Odontotermes* sp., G. Head of *Schedorhinotermes* sp., H. *Schedorhinotermes* sp.

Schedorhinotermess sp. is a termite species that belongs to the lower termites number; the results showed that the Rhinotermitidae family only found the termite species *Schedorhinotermes* sp. The data aligns with Neoh et al. (2023), which investigated *Schedorhinotermes* sp. in abandoned degraded peatlands and peatlands planted with oil palm in Riau, Indonesia. Furthermore, *Schedorhinotermess* sp. was common because the species has a wide range of area distribution. In addition, *Macrotermes* sp. were also found in both test sites due to environmental conditions supporting their growth. Heriza et al. (2021) also revealed that *Macrotermes* sp. are found in residential areas and oil palm plantations. Subekti and Milanio (2023) state that *M. gilvus* colonies are optimally active for reproduction and foraging at 75%-90% humidity; this humidity is very suitable. *Macrotermes gilvus* is one of the termite species found in various regions in Indonesia due to its cosmopolite nature (Nandika et al. 2015). Besides *Macrotermes* sp., the termite species of the Termitidae family found in both test sites is *Odontotermes* sp., and according to Arif et al. (2021), *Odontotermes javanicus* was scattered in many habitat types; for example, pinus plantation, forests with mixed vegetation, and logged-over areas. Indrayani et al. (2021) also reported that *Odontotermes* sp. is one of the termite species with a high altitude adaptation found at 100-300 meters above sea level.

Fungi species that attack wood sample

The study shows that four fungal genera were found during all research periods (one, two, three, four, five, and six months) of feeding at the two sites. The four fungal genera were identified based on Samanta (2015) and Siddiquee (2017), which were divided into three categories: mold fungi *(Aspergillus* sp. and *Mucor* sp.), stain fungi (*Trichoderma* sp., and *Gliocladium* sp.), and decay fungi (*Mycelia sterilia*). *Trichoderma* sp., *Aspergillus* sp., and *Gliocladium* sp. belong to the phylum Deuteromycota (Samanta 2015), while the molds found in this study were *Aspergillus* sp. and *Mucor* sp. Mold fungi can decompose organic materials as part of the decomposition and recycling of nutrients in nature. *Aspergillus* sp. was mainly found on manii and pine wood samples since the first month of feeding. Hidayah et al. (2021) stated that *Aspergillus* is a fungus commonly found in soil and overgrows and is antagonistic to other fungi. Its mechanisms occur through competition, mycoparasitic, and antibiosis.

Macroscopically, the conidia head of *Aspergillus* sp. appears round, and most of the mycelium of *Aspergillus* sp. is erect. Colonies of *Aspergillus* sp. are usually fast-growing and colored white, yellow, brownish-yellow, and brown to black. At the same time, *Mucor* sp. has a hyphal colony surface that is initially white and then becomes grey-black. Microscopically, the colonies have non-concentrated hyphae and conidia that are round, oval, and branched mycelium. *Mucor* sp. is a genus of fungus that is abundant in organic and mineral soil layers and dominant in chestnut and linden plantations (Maršalkienė et al. 2022). Based on Nandika et al. (2021), stain fungi are light green on the surface, in the middle of the colony, mostly covered by white mycelia, and the shape of the colony is circular with intact edges. In the research of Dellanerra et al. (2019) stated that macroscopic research of mold has a texture that is dominated by smooth texture, with a brown on the surface and visible growth zones Wood decay fungi are mostly identified as Basidiomycota and several Ascomycota, They are identified by the type of decay they cause., wood decay fungi often increase the permeability of the wood (Li et al. 2022). Figure 4 is the identification of mold found during the study.

Stain fungi grow on wood samples but cannot decompose their components, so they do not affect wood deterioration. In this study, *Trichoderma* sp. and *Gliocladium* sp. were the stain fungi. Based on the identification key book of Samanta (2015) and Siddiquee (2017), five species of *Trichoderma* sp. were found attacking manii and rubber wood samples; they dominated the attack on both sites more than other fungi. At the same time, *Gliocladium* sp. was only found in the residential site by attacking six wood samples. The *Trichoderma* sp. colonies' shape is smooth, and the color is initially white. Then, it turns green to dark green due to fast and evenly distributed hyphae spreading, forming circular lines in the colonies. Microscopically, *Trichoderma* sp. has a branching mycelium resembling a pyramid. In addition, *Gliocladium* sp. macroscopically has greenish colonies with thin mycelium and a fast-growing power, while microscopically, it has hyphae insulated with erect mycelium and round-shaped conidia. Moreover, Pratiwi et al. (2021) state that *Trichoderma* decomposes organic material in 36-45 days. In degrading the cell wall material that *Trichoderma* decomposes, the fungus uses cellulase, xylanase, and glucanase enzymes (Zin and Badaluddin 2020). Although derived from the same species, *Gliocladium* sp. is not as much and common as *Trichoderma* sp. *Gliocladium* sp. is essential in decomposing vegetation in forest ecosystems by nutrient cycling and humus formation in the soil, as they colonize the lignocellulose matrix of litter that other organisms cannot break (Abubacker and Prince 2021). Figure 5 is the identification of stain fungi found during the research.

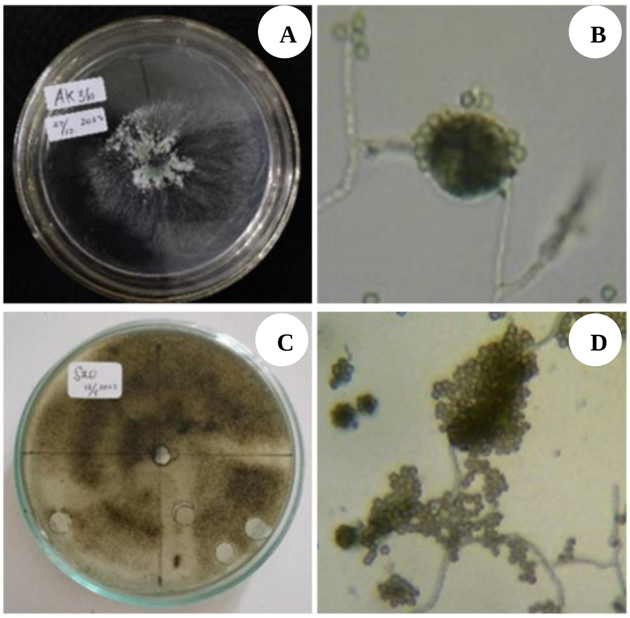


Figure 4. Mold found in the Residential and Arboretum testing site of the Faculty of Forestry and Environment IPB. A. Fungal isolates, B. *Aspergillus* sp. mycelium, C. Fungal isolates, D. *Mucor* sp. mycelium

Table 3. Decomposers that attack wood samples in the arboretum and residential

Types of wood	Feeding time in month-											
	1		2		3		4		5		6	
	R	A	R	A	R	A	R	A	R	A	R	A
Manii	A. (1)		Mic (1)	T.4 (2)	A (1) G (1)		Mic (1) G (1)	Mac (1) Mic (1)	M.1 (1)		M.1 (1)	Mic (1)
Rubber	Mic (1) T.1 (1)	Mic (1) A (1) T.3 (2)	Mic (2)	Mac (1) Mic (2) T.5 (1)	T.2(1)	Mac (2) A (1)		Sch (1) Mic (1) T.2 (1)	Mac (1) Sch (1)	Mic (1)	Mac (1) Mic (2)	Mic (1)
Jabon	Mic (1)	Mac (1) Mic (1)		Mac (2) Mic (1)	Mic (2)		Sch (1)	M.2 (1)	G (1) T.1 (1)		Mac (1)	
Acacia	G (1)	Mic (1) A (1)	A (1)	Mac (2) Mic (2)		Mic (2) Odo (1)	A (1) M.2 (1)	Mac (1)	G (1)	M.3 (1)		Mic (1)
Sengon		Mic (1) T.2 (1)		M.1			Muc (1)		Mic (1)		R.F Mic (1)	Mic (1)
Pine	Mac (1) A (1)	Mac (1)	G (1) T.1 (1)	Sch (2)	Sch (1)	Sch (1)	Mic (1) Odo (1)	Mic (2)	Mic (2)	Mic (1)	Mac (1) Mic (2)	Mic (2) Sch (1)

Note: Numbers in brackets indicate the amount of wood attacked by decomposers. R: Residential, A: Arboretum, Mac: *Macrotermes* sp., Mic: *Microtermes* sp., Sch: *Schedorhenotermes* sp., Odo: *Odontotermes* sp., A: *Aspergillus* sp., G: *Gliocladium* sp., T.1: *Trichoderma* sp. 1, T.2: *Trichoderma* sp. 2, T.3: *Trichoderma* sp. 3, T.4: *Trichoderma* sp. 4, T.5: *Trichoderma* sp. 5, Muc: *Mucor* sp., M.1: *Mycelia sterilia* 1, M.2: *Mycelia sterilia* 2, M.3: *Mycelia sterilia* 3, R.F.: Red Fungus

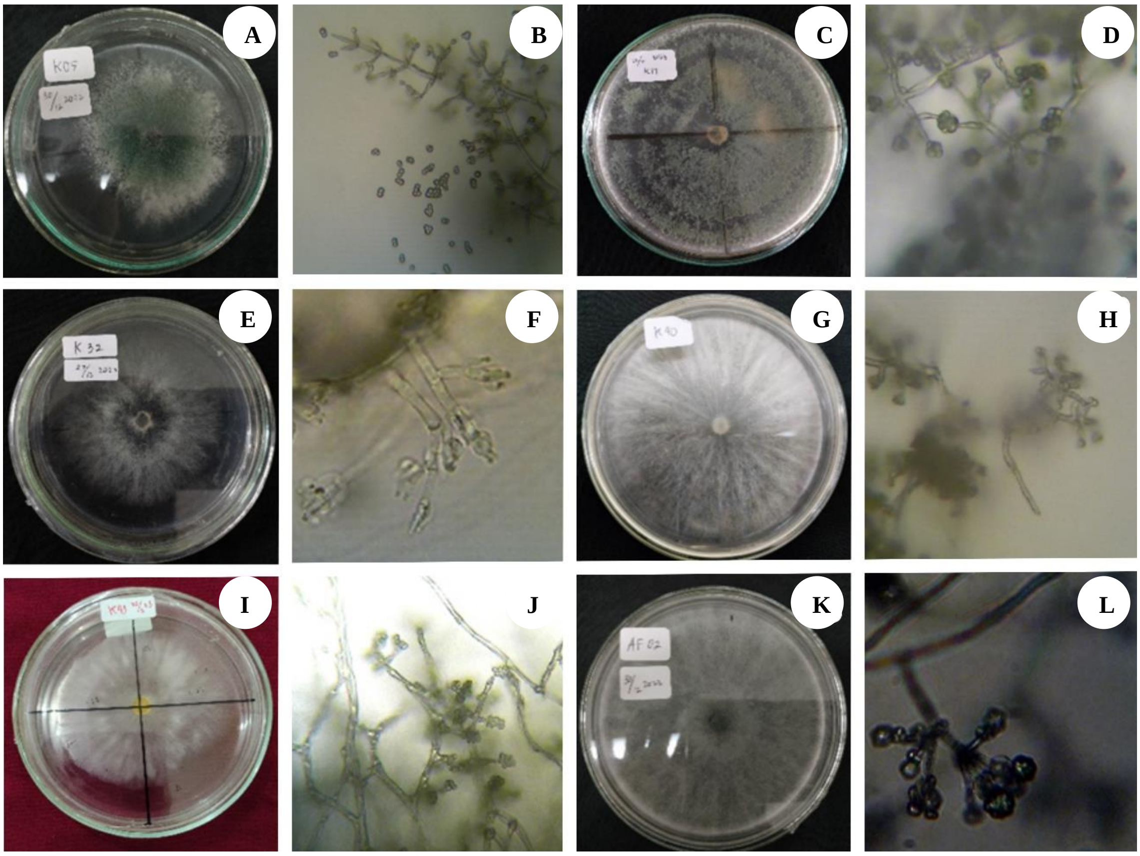


Figure 5. Stain fungi found in the testing site of Residential and Arboretum Faculty of Forestry and Environment IPB. A. Fungal isolate, B. Mycelium of *Trichoderma* sp.1, C. Fungal isolate, D. Mycelium of *Trichoderma* sp.2, E. Fungal isolate, F. Mycelium *Trichoderma* sp.3, G. Fungal isolate, H. Mycelium *Trichoderma* sp.4, I. Fungal isolate, J. Mycelium *Trichoderma* sp.5, K. Fungal isolate, L. Mycelium *Gliocladium* sp.

Figure 6 is the identification of decayed fungi found during the study. *Mycelia sterilia* is a group of fungi consisting of only sterile hyphae, no conidiophore structure, and no conidia. *Mycelia sterilia* is often found in collections of bifurcated mycelium, erect conidia, round vesicles with uniseriate sterigmata with basal succession of conidia chains (Srinivas et al. 2015). At least three types of *Mycelia sterilia* were found on both sites. *Mycelia sterilia* began to be found in the third month of feeding, with some white colonies attacking the wood sample. On microscopic observation, *Mycelia sterilia* only showed hyphal structures and no reproductive organs. *Mycelia sterilia* has limitations in identification because it does not have typical reproductive structure and has a similar or identical morphology, making it difficult to distinguish one species from another. Carbungco et al. (2017) stated that *Mycelia sterilia* has no spore texture and a greenish-white periphery with a circular fibrous zone. *Mycelia sterilia* has hyphae 40 μ in length and 8 μ in diameter and does not have spores. *Mycelia sterilia* are also found in vegetables. In addition to *Mycelia sterilia*, the red fungus was found on sengon samples in residential sites. In addition, red fungi, a group of decayed fungi with red characteristics or red spots on their fruiting bodies, are also found. The red fungus helps decompose dead organic matter, especially in wood-based materials.

Number of termite and fungi infested wood samples in the Residential site

The total amount of wood samples planted in the two residential test sites was 180. The results showed that within a six-month feeding period, subterranean termites attacked 71 samples, while fungi attacked 135 wood samples. That results in 39.44% subterranean termite infestation of wood samples in the residential sites and 75% fungal infestation. Since the first month of feeding, not all wood samples were attacked by subterranean termites, but fungi have; the wood samples' durability influenced this. Manii, rubber, and pine are types of wood with low durability classes, so they are vulnerable to attacks by termites, fungi, and other decomposing organisms. According to Ruffinatto and Crivellaro (2019), *Maesopsis eminii* or manii is classified into durable class IV, and rubber wood has a low level at class V, so rubber wood is more vulnerable to attacks by wood-destroying organisms. The amount of wood attacked by subterranean termites in residential sites reached 100% in the fifth month in manii and rubber. In comparison, the amount of wood attacked by fungi in residential sites reached 100% in the third month in manii and rubber. Based on the type of wood sample in the residential site, manii, rubber, and pine have the highest value of the number of infested wood samples.

Number of termite and fungi infested wood sample in the Arboretum testing site

The study showed that within a six-month feeding period in the arboretum site with a total of 180 wood samples, there were 42 wood samples that subterranean termites did not attack, so the number of attacked wood samples reached 76.67%. This value is greater than the frequency value obtained in the research of Arinana et al. (2020a). The value of the number of wood samples attacked by subterranean termites was 68.5%, and active termites were found in 71 wood samples. The fungi found 127 uninfested wood samples, so the number of infested woods was 29.44%. The amount of termite-infested wood samples in the arboretum testing site is much more significant than that in the residential testing site. Khan and Ahmad (2018) state that climatic characteristics and vegetation structure determine termites' abundance, diversity, and species richness. Greater species richness has been observed in moist forests than in dry or semiarid environments. Meanwhile, the arboretum is a site covered by natural vegetation, allowing an increase in weathering organisms. The percentage of wood infested by subterranean termites and fungi from the first month to the sixth month at the residential site is shown in Table 4, and the arboretum is shown in Table 5. Subterranean termites have attacked all wood samples since the first month of feeding. Rubber and jabon wood reached 100% wood sample infestation at two months of feeding. While none of the wood samples reached 100% infestation by fungi in the six months of application, the most extensive infestation was 80% in manii wood samples in the fifth and sixth months.

Wood deterioration

Weight loss

This study's weight loss of wood samples occurred from the first month of feeding in both sites. The loss of weight indicates damage or decay to the wood samples. Damage to wood samples by decomposers is shown in Table 6. The average weight loss of wood samples from one to six months in the residential site was highest for jabon wood (22.92%), while acacia had the lowest average value of 9.23% (Figure 7). In comparison, the results at the arboretum site, the average value of wood sample weight loss at one to six months of feeding was highest for rubber wood (34.79%), and sengon wood had the lowest average value of 21.94% (Figure 8). It can be seen that termite consumption in the arboretum area is higher than in the residential area. This aligns with Heriza et al. (2022), which suggests that termite consumption in natural and secondary forest areas is higher than in residential areas. This is due to differences in environmental factors between arboretums and residential sites, such as temperature and humidity, where termites have seasonal foraging behavior; that is, they refrain from foraging at unideal temperatures (Pervez 2018).

Figures 7 and 8 show that the graphs presented in the residential site are more fluctuative than those in the arboretum testing site. Different types and components influence different weight loss values in wood. This is consistent with Oh et al. (2023) that the content of extractive substances and wood density affect the durability of a wood type. In general, the weight loss of the wood samples increases with the time it is tested; termites prefer moist and moldy wood conditions because they are easier to consume. Nandika et al. (2015) stated that some termite species prefer to attack wood than fungi. Furthermore, fungi produce compounds that can degrade wood and attract termites to come and eat it.

Table 4. Percentage of wood infested by subterranean termites and fungi in residential sites

Wood species	Percentage of wood infested by termites and fungi in month-											
	1		2		3		4		5		6	
	T	F	T	F	T	F	T	F	T	F	T	F
Manii	0	80	0	80	0	100	0	80	100	100	20	100
Rubber	40	80	80	100	40	100	40	80	100	100	100	100
Jabon	60	20	80	40	20	80	20	60	60	60	40	80
Acacia	20	40	20	60	20	60	20	60	20	80	40	80
Sengon	40	60	40	60	20	80	20	60	20	60	20	80
Pine	20	80	80	80	40	60	40	80	60	80	60	100

Note: T: Termite, F: Fungi

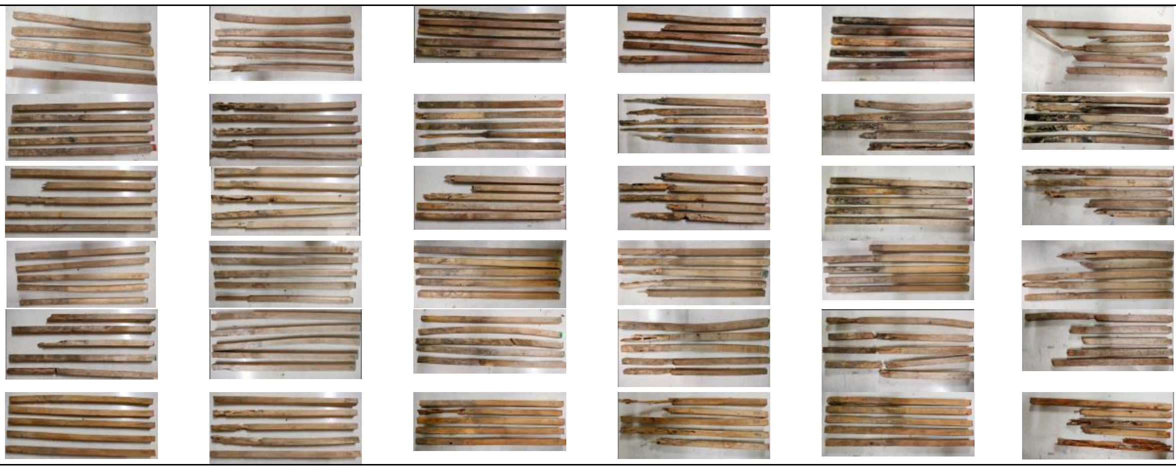
Table 5. Percentage of wood sample infested by subterranean termites and decay fungi in the arboretum site

Wood species	Percentage of wood infested by termites and fungi in month-											
	1		2		3		4		5		6	
	T	F	T	F	T	F	T	F	T	F	T	F
Manii	40	0	60	20	60	60	80	60	100	80	80	80
Rubber	80	0	100	0	100	60	80	40	80	40	100	60
Jabon	60	0	100	0	80	0	80	40	100	40	100	40
Acacia	40	0	60	20	100	20	80	20	60	40	80	40
Sengon	20	0	40	0	60	20	60	20	80	40	80	40
Pine	80	0	80	20	80	20	80	40	100	40	100	60

Note: T: Termites, F: Fungi

Table 6. Damage to wood samples by decomposers

Types of wood	Feeding time in month-					
	1		2		3	
	R	A	R	A	R	A
Manii						
Rubber						
Jabon						
Acacia						
Sengon						
Pine						



Types of wood	Feeding time in month-					
	4		5		6	
	R	A	R	A	R	A
Manii						
Rubber						
Jabon						
Acacia						
Sengon						
Pine						

Note: A: Arboretum, R: Residential

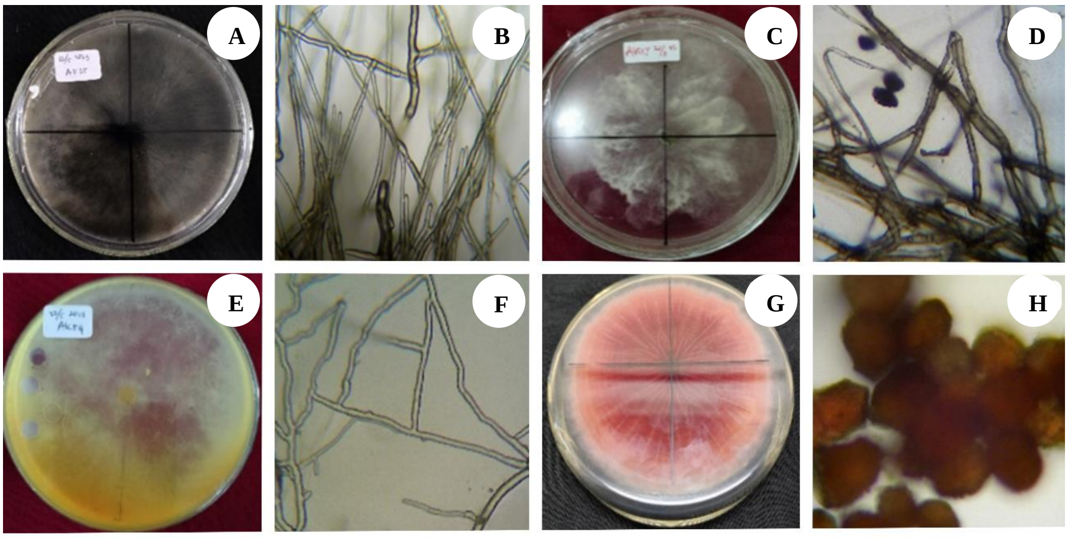


Figure 6. Decayed fungi found in the testing site of Residential and Arboretum of Faculty of Forestry and Environment IPB. A. Fungal isolate, B. *Mycelia sterilia* 1 mycelium, C. Fungal isolate, D. *Mycelia sterilia* 2 mycelium, E. Fungal isolate, F. *Mycelia sterilia* 3 mycelium, G. Fungal isolate, H. Red fungus mycelium

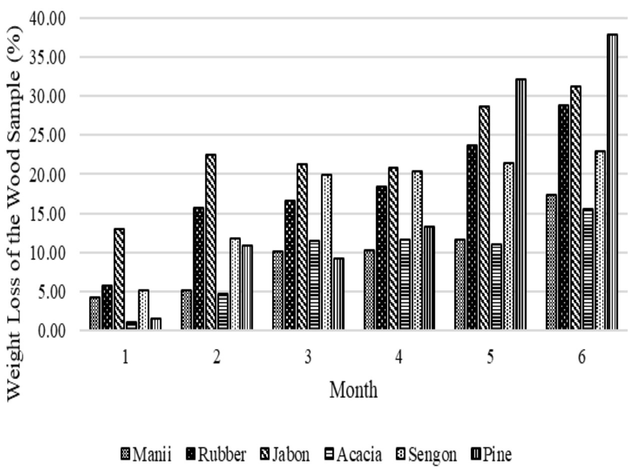


Figure 7. Weight loss of wood sample due to subterranean termite and fungi infestation at the residential site with a feeding time over one to six months

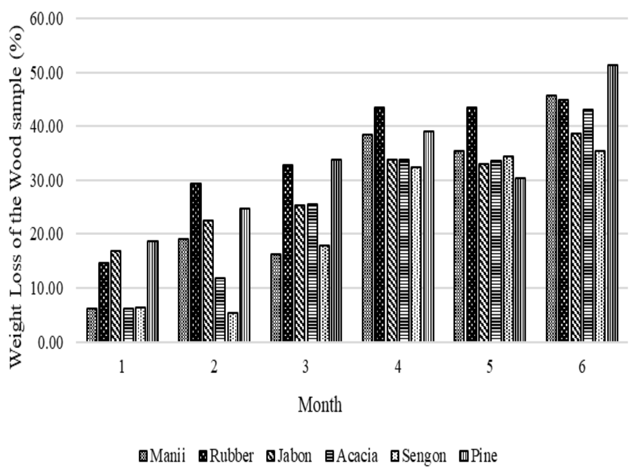


Figure 8. Weight loss of wood sample due to subterranean termite and fungi infestation in the arboretum site over one to six months

Wood sample consumption

The results show that subterranean termites and fungi consumed the wood samples in the test site has occurred since the first month of feeding. In Figures 9 and 10, the consumption of wood samples increases with the length of feeding time. Pinewood was the highest consumption value of the wood samples due to subterranean termites and decay fungi in the residential test site, with an average of 18.9%. In comparison, the highest wood sample consumption value in the arboretum site was rubber, averaging 35.41%. Decomposer species that attack wood samples also affect the wood consumption rate (Subekti 2012). The data shows that pine has a relatively large average wood consumption rate at the feeding time.

Soil and weather characteristics of the testing site

Topography, climate, and soil type determine the development of destructive organisms and the wood damage level (Khan and Ahmad 2018). According to Nandika et al. (2015), the soil has an important function for subterranean termites; to live and protect termites from extreme temperatures and humidity. The study showed that these two sites had different soil pH values; in the residential test site, the pH was 5.5, while in the arboretum site, at 3.9. Soil pH values in both sites that tend to be acidic are thought to be caused by the influence of high air humidity due to high rainfall. Enagbonma and Babalola (2020) reported that the pH in termite mounds and the soil around termite nests tends to be acidic. Mustafa et al. (2023) also said that most fungi had been identified as thriving in the pH range of 3.0-8.5. Water content in the soil can affect soil pH value and soil C-organic content (Kusuma and Yanti 2021). The soil C-organic content obtained in the residential site was 3.18%, while in the arboretum test site, at 3.63%; following Balittanah (2009), the soil found in both test sites is classified as high, with a 3-5% C-organic classification. High levels of soil C-organic can reduce erosion and increase soil organic matter by increasing the population of microorganisms (Arifin et al. 2016). The soil sample analysis shows (Table 7) that the residential testing site contains sand (27%), silt (18%), and clay (55%), while the arboretum testing site contains sand (17%), silt (17%), and clay (66%); therefore, the soil texture on both test sites are dominated by clay. According to Mujinya et al. (2013), termite mounds have texture classes ranging from clay to heavy clay in epigeous units, subsurface units, and silt clay in the surrounding soil. Likewise, the relative abundance of fungi to degrade organic compounds increases with silt and/or clay content. Fungal diversity consistently increased in coarse-textured soils because fungi obtain and redistribute nutrients over long distances through the elongation and branching of hyphae, especially through large pores (Xia et al. 2020). Jalaludin et al. (2018) found that clay-textured soil led to termites that decompose wood in clay-textured soil. Details of soil characteristics (pH, C-organic, sand, dust, clay) in both test sites are presented in Table 7.

In addition to a suitable soil type, Woon et al. (2019) reported that humidity and temperature within the optimum limits are the drive of high termite consumption activity. Humidity and temperature, in general, are also the most critical factors affecting the presence of fungal particles. Coleine et al. (2022) state that humidity, wet, and acid soils are essential for fungal sprouting. Daily air temperature and humidity fluctuations for the six months of testing are shown in Figure 11 for the residential site and Figure 12 for the arboretum. The study showed that the average air temperature in the residential and arboretum test site was 27.8℃ and 26.1℃ with a maximum temperature of 37.6℃ in the residential and 31.8℃ in the arboretum, while a minimum temperature of 23.0℃ in the residential, and 22.4℃ in the arboretum. Meanwhile, the average air humidity in the residential and arboretum test sites was 72.7% and 86.3%, with a maximum humidity of 94.1% in the residential and 98.5% in the arboretum, while a minimum humidity of 35.3% in the residential and 49.3% in the arboretum. Pratiknyo et al. (2020) stated termites live optimum at an air temperature of 15-38℃ with a relative humidity of 75-90%. In addition, Chen et al. (2014) reported that the soil moisture at 80-90% shows the best growth of fungi.

Table 7. Soil characteristics at two test sites

Sample code	pH	C-organic (%)	3 fraction texture			Soil texture
			Sand (%)	Silt (%)	Clay (%)	
Residential	5,5	3,18	27	18	55	Clay
Arboretum	3,9	3,63	17	17	66	Clay

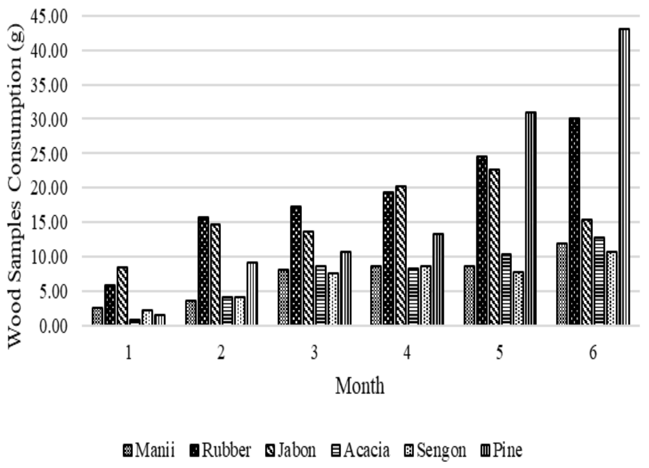


Figure 9. Consumption of wood samples due to subterranean termite and fungi infestation at the residential site with a feeding time over one to six months

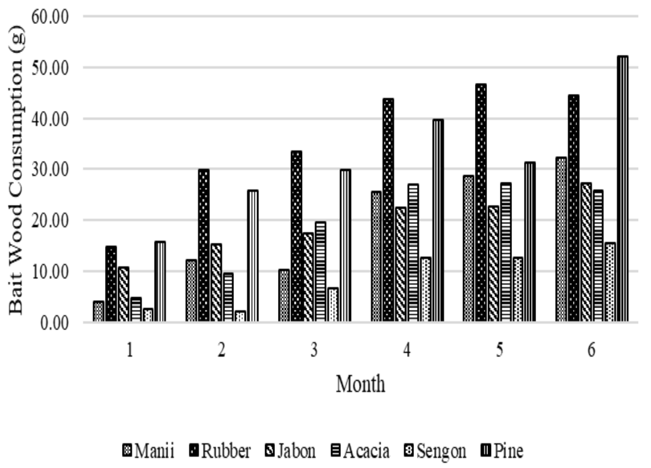


Figure 10. Consumption of wood samples due to subterranean termite and fungi infestation at the arboretum site over one to six months

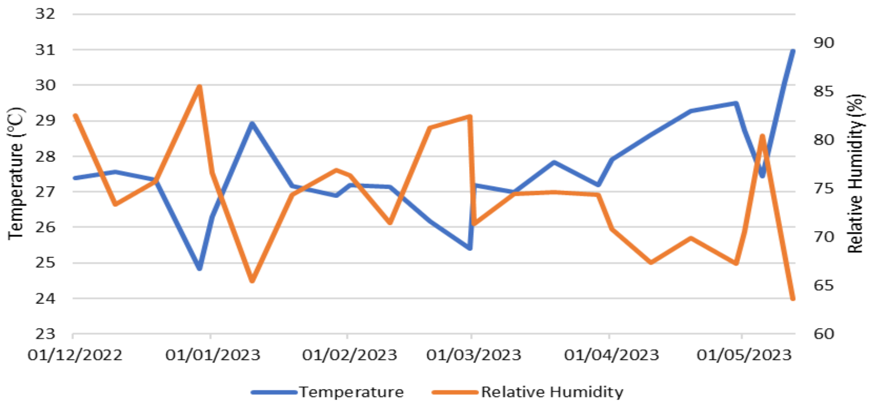


Figure 11. Daily air temperature and humidity fluctuations at the residential testing site during the six months of testing

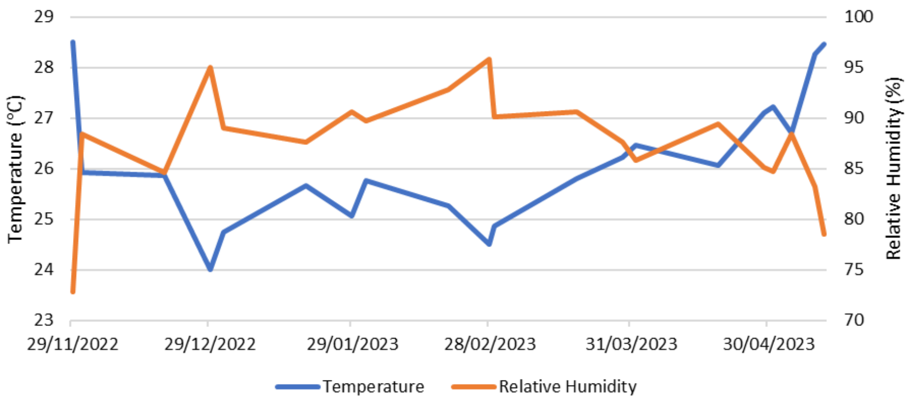


Figure 12. Daily air temperature and humidity fluctuations in the arboretum test site during the six months of testing

The number of wood infested with termites and fungi increased with the length of the feeding time. At least four similar termites species were found in the two test sites (residential and arboretum) over one to six months period, such as *Macrotermes* sp., *Microtermes* sp., *Schedorhinotermes* sp., and *Odontotermes* sp. The fungi species found in residential areas were *Trichoderma* sp., *Aspergillus* sp., *Mucor* sp., *Gliocladium* sp., *Mycelia sterilia*, and red fungus. While in the arboretum, three species of fungi were found, namely *Aspergillus* sp., *Trichoderma* sp., and *Mycelia sterilia*. The amount of wood infested by subterranean termites on wood samples in residential (39.44%) was lower than that in the arboretum (76.67%). The weight loss value of the wood samples in the residential area fluctuates more than in the arboretum. Pinewood had the highest consumption value of samples by the subterranean termites and decaying fungi in residential areas (18.9 g); the highest in the arboretum was rubber (35.41 g). Soil type, humidity, and ambient temperature were very favorable for the development of decomposer life found in the two study sites. The results of this study can be used to determine the degradation of termites and fungi of six types of community timber when in direct contact with the soil in locations dominated by buildings and overgrown by various types of vegetation.

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