

Article

# Termite Diversity in Urban Landscape, South Jakarta, Indonesia

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**Abstract:** The population of South Jakarta, a city within the Province of Jakarta Capital Region, is increasing annually, and the development of land into building causes termite diversity loss. The aim of this research was to determine the diversity of subterranean termite species and their distribution in South Jakarta and to evaluate the soil profile termite habitat. This study was conducted in South Jakarta and was carried out at four residential areas representing four randomly selected sub-districts. Specimens were collected with a baiting system. At each residence, as many as 25–30 stakes of pine wood (*Pinus merkusii*) sized 2 cm × 2 cm × 46 cm were placed for termite sampling. Soil samples were also collected from each residence for testing of their texture, pH, soil water content, and C-organic. Three species of subterranean termites were identified, including *Coptotermes curvoignathus*, *Microtermes insperatus*, and *Macrotermes gilvus*, with area-specific variations in occurrence. The soil and weather conditions in the studied areas provided suitable habitat for termites, and *M. insperatus* was the most commonly found species.

**Keywords:** termite dispersion region; termite diversity and distribution; termite identification; soil characteristics and local weather effect

## 1. Introduction

Termites frequently destroy wood as well as other cellulose materials used in building construction. The insects have successfully adapted to the varied conditions that characterize urban and agricultural environments around the world [1], and their attacks on buildings are an important issue. The intensity of these attacks is high and ongoing, and economic losses associated with them tend to increase from year to year. Subterranean termites are the most commonly occurring type, and they are potentially the most destructive pest in any building. The intensity of a termite attack and the magnitude of the resulting damage can be very high. According to Nandika *et al.* [2], economic losses from termite-related damage in residential buildings in Indonesia was estimated to be Rp 8.7 trillion in 2015. The threat of termite attack on buildings will remain high.

The climate of South Jakarta features moderate rain intensity, and the humid weather can cause building damage, such as cracks and decay. This damage can provide access for termites to enter the buildings. Termites not only attack the cellulose-containing components of a building, such as window or door frames, doors, roofs, and ceilings, but also the interior wooden structures, such as furniture and sculpture. This attack will certainly inflict a high economic cost on maintaining buildings.

The results of the current research study are expected to provide information about the diversity and distribution of subterranean termite species in residential areas and to identify the intensity of attacks in residential buildings.

## 2. Experimental Section

### 2.1. Time and Locations

This research was conducted from December 2014 to April 2015 in four residences chosen from four randomly selected sub-districts out of 10 in South Jakarta: Tebet Barat (latitude:  $6^{\circ}14'03''$ S, longitude:  $106^{\circ}50'60''$ E, altitude 17 m.a.s.l.), Jagakarsa ( $06^{\circ}19'31''$ S,  $106^{\circ}49'06''$ E, 62 m.a.s.l.), Pasar Minggu ( $06^{\circ}17'38''$ S,  $106^{\circ}49'25''$ E, 39 m.a.s.l.), and Cipulir ( $06^{\circ}14'13''$ S,  $106^{\circ}46'25''$ E, 24 m.a.s.l.). Identification of termites was conducted at the Laboratory of Wood Quality Improvement Technology, Department of Forest Products, Faculty of Forestry, Bogor Agricultural University (IPB). Soil analysis was carried out at the Laboratory of Integrated Soil Resource, Soil Research Institute, Agency for Agricultural Research and Development, Ministry of Agriculture, Bogor.

### 2.2. Equipment and Materials

The equipment used in this research included bottles for termite collection, brushes, a digital camera, a stereo microscope, environment meter (thermo-hygro and lux meter) (Krisbow), transparent plastic, surgical instruments for termite dissection, and a soil driller. The materials used were air-dried pine wood (*Pinus merkusii*) stakes measuring  $2\text{ cm} \times 2\text{ cm} \times 46\text{ cm}$ , oil paint (red color), and alcohol 70%.

### 2.3. Collection and Identification of Termite Species

Pine wood was chosen for the stakes because Arinana *et al.* [3] found that subterranean termites prefer pine wood to *Acacia mangium*, *Hevea brasiliensis*, and *Paraserianthes falcataria*. The tops of the stakes were painted with a bright color (red) to help mark their location. The size of the stakes used followed the ASTM standard [4].

Termites were collected with a baiting system, which included 108 stakes in all investigated areas (25–30 stakes per residence). The stakes were installed around the house and outdoor structures on the property in areas that were not covered by concrete or other artificial barriers. Some stakes were also installed in outdoor community areas such as playgrounds, gardens, parks, *etc.* Stakes amounted to as many as 25, 28, 30, and 25 pieces, spread around the housing areas in Tebet Barat, Jagakarsa, Pasar Minggu, and Cipulir, respectively. Stakes were installed vertically into the soil so that half was below the soil surface, as shown in Figure 1. Stakes were left in place for 3 months and checked monthly for termite infestation.

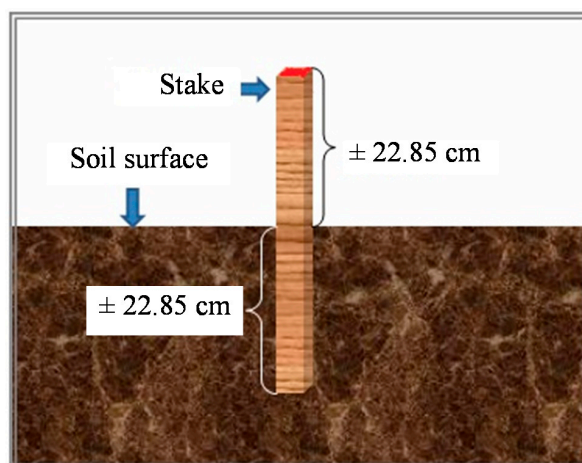


Figure 1. Installation of stakes.

Stakes that were attacked by termites were extracted, and soldiers were collected and preserved in 70% alcohol. The species of the soldier termites were then identified based on literature and key identification according to Ahmad [5] and Tho [6]. The collected termites were photographed and observed by microscope under 10× magnification for the entire insect body and 30× magnification for the head parts including the antennae and mandibles.

#### 2.4. Soil Characteristics Analysis

Soil sampling was conducted at four points (Eastern, Western, Southern, and Northern parts) in every region of the study at depths of 0–20 cm and 20–40 cm; thus, there were 32 soil samples in total. The soil samples were sent to the Laboratory of Integrated Soil Resource (an ISO/IEC1705 certified laboratory) to measure the soil moisture content, pH, C-organic content, and texture.

#### 2.5. Sunlight Intensity, Temperature, and Humidity Measurements

Measurements of sunlight intensity, temperature, and humidity were conducted in the morning (8:00 a.m.), noon (12:00 a.m.), and afternoon (16:00 p.m.).

### 3. Results and Discussion

#### 3.1. Diversity of Subterranean Termites

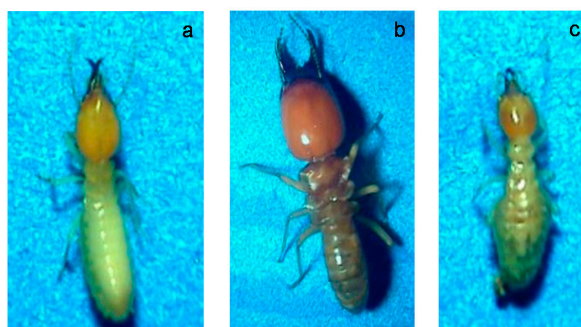
Twenty-one stakes were attacked during the 3 months those stakes were in place, and the identification and method of determination based on Ahmad [5] and Tho [6] revealed that three species of subterranean termites were present. The termites were members of two termite families, namely Rhinotermitidae and Termitidae. The diversity of subterranean termites in South Jakarta is shown in Table 1.

Table 1. Diversity of subterranean termites from four residences in South Jakarta.

Residential	Number of Installed Stakes	Percentage of Infested Stakes	Stakes Code	Family	Termite Species
Tebet Barat	25	8.0%	A1	Rhinotermitidae	<i>Coptotermes curvoignathus</i>
			A2	Rhinotermitidae	<i>C. curvoignathus</i>
Jagakarsa	28	21.4%	B1	Termitidae	<i>Microtermes insperatus</i>
			B2	Termitidae	<i>M. insperatus</i>
			B3	Termitidae	<i>Macrotermes gilvovus</i>
			B4	Termitidae	<i>M. insperatus</i>
			B5	Termitidae	<i>M. insperatus</i>
			B6	Termitidae	<i>M. gilvovus</i>
Pasar Minggu	30	36.7%	C1	Termitidae	<i>M. insperatus</i>
			C2	Termitidae	<i>M. gilvovus</i>
			C3	Termitidae	<i>M. insperatus</i>
			C4	Termitidae	<i>M. insperatus</i>
			C5	Termitidae	<i>M. insperatus</i>
			C6	Termitidae	<i>M. insperatus</i>
			C7	Termitidae	<i>M. insperatus</i>
			C8	Termitidae	<i>M. insperatus</i>
			C9	Termitidae	<i>M. insperatus</i>
			C10	Termitidae	<i>M. insperatus</i>
			C11	Termitidae	<i>M. insperatus</i>
Cipulir	25	8.0%	D1	Termitidae	<i>M. insperatus</i>
			D2	Termitidae	<i>M. insperatus</i>

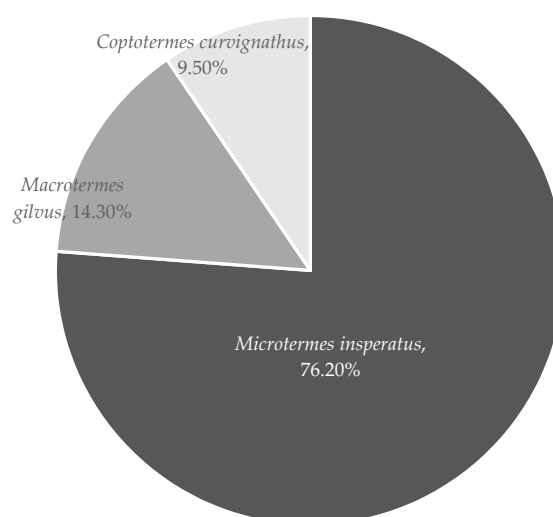
The species found in the research area were *Microtermes insperatus* (attacked sixteen stakes), *Macrotermes gilvovus* (attacked three stakes), and *Coptotermes curvoignathus* (attacked two stakes). Nandika [2] who conducted similar research in West Jakarta and East Jakarta also reported that

*M. insperatus* was frequently found in those two areas. Meanwhile Arinana *et al.* [7] reported that *C. curvignathus* was dominant in residences of Bumi Bekasi-West Java (a nearby district to Jakarta). Figure 2 shows representative photographs of soldier termites found in the research areas. More complete identification information about the termites that attacked the wood stake bait are shown in the appendix.



**Figure 2.** Termites found at the research locations: (a) *C. curvignathus*; (b) *M. gilvus*; (c) *M. insperatus*.

The results of this research showed that the Termitidae (90.48%) family was more dominant than the Rhinotermitidae (9.52%). Eggleton [8] reported that the Termitidae family was dominant in the tropical region. According to Wang *et al.* [9], species of Rhinotermitidae are found more frequently outside natural forests or in areas of natural forest that have been converted into plantations, estates, or farms. The subfamilies of Rhinotermitidae found in the research were Coptotermitinae (*C. curvignathus*), members of the family Rhinotermitidae, genus *Coptotermes*, which are the most likely to attack wood and buildings [10]. Meanwhile, the subfamilies of Termitidae found in the research area was Macrotermitinae, with members *M. gilvus* and *M. insperatus*. Of the three species found, the wood-destroying capabilities of *C. curvignathus* were the highest. *C. curvignathus* has been reported to attack up to the top of a high rise apartment building in South Jakarta [11]. The percentages of termite species are provided in Figure 3.



**Figure 3.** Percentages of subterranean termites represented in South Jakarta.

### 3.2. Soil Characteristics

The soil at each residence contained high amounts of clay and C-organic. Termites can increase the organic matter content in soil that is used to build a nest, and they also modify the composition of clay minerals [12]. Soil characteristics are shown in Table 2.

**Table 2.** Soil characteristics at four residences in South Jakarta.

Residential	Depth (cm)	Water Content (%)	pH	C-Organic (%)	Sand (%)	Silt (%)	Clay (%)	Soil Criteria
Tebet Barat	0–20	27.42	6.85	6.66	46	35	19	Loam
	20–40	22.10	7.30	5.44	19	35	46	Clay
Jagakarsa	0–20	31.07	6.68	9.55	11	33	56	Clay
	20–40	30.20	6.90	8.61	12	26	62	Clay
Pasar Minggu	0–20	28.77	6.72	7.52	5	55	40	Silty Clay
	20–40	23.48	6.48	7.01	15	37	48	Clay
Cipulir	0–20	26.10	6.36	7.17	8	41	51	Silty Clay
	20–40	26.47	6.70	7.09	11	73	16	Loamy Sand

Ground water levels regulate the levels of air and gas exchange that affect the soil properties (water content, pH, texture) and activity of organisms in the soil. There were strong correlations between termite infestation and soil water content and texture (Table 3). Our results showed a neutral pH range between 6.36 and 7.30 and a water content ranging from 22.10% to 31.07%. In those ranges of pH and soil water content, the termites attacked more frequently in the higher moisture content than the lower one. Hillel [13] stated that many other soil properties depend on moisture content, including mechanical properties such as consistency, plasticity, and strength. The characteristics of clay, soil shrinkage, and development are related to the addition or subtraction of water, which causes changes in the density, porosity, and pore size distribution. Termites prefer to nest in silty clay rather than in the loamy sand of soil.

**Table 3.** Correlation between soil characteristics at a depth of 0–20 cm below the soil surface and percentage of termite infestation.

	Soil Water Content (%) *	pH *	C-Organic (%) *	Sand (%) *	Silt (%) *	Clay (%) *	Soil Criteria **
Coefficient of correlation ( <i>r</i> )	0.564	0.270	0.359	−0.568	0.722	0.226	0.500
<i>p</i> -value	0.436	0.730	0.641	0.432	0.278	0.774	0.500

Note: \* = parametric correlation; \*\* = non-parametric (Spearman) correlation.

White [14] argues that the highest C-organic content is located at a depth of 15–20 cm below the soil surface. This is consistent with our research showing that levels of C-organic ranged from 5.44% to 9.55%. C-organic content in 0–20 cm depth of soil has a positive correlation with termite infestation level (Table 3). According to Lee and Wood [15], land with termite activity has very high organic matter content. This agrees with the work of Foth [16], who stated that organic material is influenced by the current amount of the original material and by the rate of decomposition and humification, which are highly dependent on environmental conditions.

### 3.3. Sunlight Intensity, Temperature, and Humidity Measurements

Termite colonies are usually maintained in constant temperature (25–36 °C) and high humidity. Termites build nests and hives to protect the microclimate habitat from outer environment interference. The temperature in the research location showed an optimum temperature range for subterranean termites' life, with a minimum temperature of 26.2 °C and a maximum of 34.7 °C; meanwhile, the atmospheric humidity was considered too low for termite life (Table 4). The lowest humidity (54.5%) in the investigated areas occurred during the day, and the highest humidity (79.4%) was in the morning. According to Nandika *et al.* [17], a suitable humidity for termites ranges between 75% and 90%. The termite nests and hives were built to maintain humidity levels so that the thin-skinned workers can be protected from drying out. Termites are able to create a microclimate inside the hive, however, and humidity levels found in this study are still tolerable.

Since the external temperature of all investigated areas were suitable enough for termite life, the correlation of external temperature and termite infestation was low; meanwhile, the sunlight intensity and humidity were strongly correlated to termite infestation (Table 5). Bahtiar *et al.* [18] reported that sunlight intensity directly and strongly correlated to the temperature and humidity. The temperature and humidity fluctuation is mainly following the sunlight intensity in the area. The sunlight generates radiation and increases the earth's surface energy, which causes the variation in temperature and humidity. The higher sunlight intensity means higher temperature and lower humidity in the investigated area. Since it has a strong correlation with humidity, sunlight intensity was also significantly related to the termite infestation level. Sunlight intensity is also related to swarmer activity which start the termite colony spread in the area. This phenomenon confirmed the higher frequency of termite infestation in the areas with higher sunlight intensity. Similar results have been reported by Axelsson and Anderson [19], who found that average termite mound height had a positive correlation with the average percentage of light. The reduction of canopy cover would increase the sunlight intensity and initiate more intense termite activity.

**Table 4.** Measurement data of temperature, light intensity, and humidity at four residences in South Jakarta.

Residential	Time	Sunlight Intensity (lux)	Temperature (°C)	Humidity (%)
Tebet Barat	08.00	44,900	28.7	79.4
	12.00	64,700	32.7	63.4
	16.00	24,400	27.4	57.7
Jagakarsa	08.00	26,800	31.4	72.6
	12.00	57,900	29.7	60.1
	16.00	43,400	33.2	57.9
Pasar Minggu	08.00	64,800	26.2	71.6
	12.00	62,300	34.7	55.9
	16.00	26,100	32.5	61.2
Cipulir	08.00	29,900	31.5	71.8
	12.00	77,900	33.9	54.5
	16.00	23,000	32.7	67.1

**Table 5.** Correlation between weather characteristics and percentage of termite infestation.

	Sunlight Intensity (lux)	Temperature (°C)	Humidity (%)
Coefficient of correlation ( <i>r</i> )	0.7832	0.0100	−0.7935
<i>p</i> -value	0.217	0.990	0.207

#### 4. Conclusions

Three species of subterranean termites, namely *Microtermes insperatus*, *Macrotermes gilvus*, and *Coptotermes curvignathus*, were found in the urban landscape of South Jakarta. *M. insperatus* occurs with the highest frequency, followed by the other species. The soil and climate characteristics in the entire region provided a habitat conducive to subterranean termites.

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**Author Contributions:** The initial idea of the study was conceived by Dodi Nandika and Arinana. Idham S. Harahap, Aunu Rauf and I. Made Sumertajaya assisted with the design of experimental protocol. Rifat Aldina collected the termites used in the study and performed the experimental protocol. Arinana and Effendi Tri Bahtiar drafted the manuscript. All authors read and approved the final manuscript.

**Conflicts of Interest:** The authors declare no conflict of interest.

Appendix

Table A1. The identification results of termites that attacked wood bait in South Jakarta.

Stake Code	Termite Species and Their Characteristics	Morphology
A1	<p><i>Coptotermes curvignathus</i>                      Characteristics:                      Average length of head with mandible: 1.77 mm                      Average length of head without mandible: 1.2 mm                      Width of head: 1.04 mm                      Overall length: 4.29 mm</p>	
A2	<p><i>Coptotermes curvignathus</i>                      Characteristic:                      Average length of head with mandible: 1.96 mm                      Average length of head without mandible: 1.31 mm                      Width of head: 1.13 mm                      Overall length: 4.99 mm</p>	

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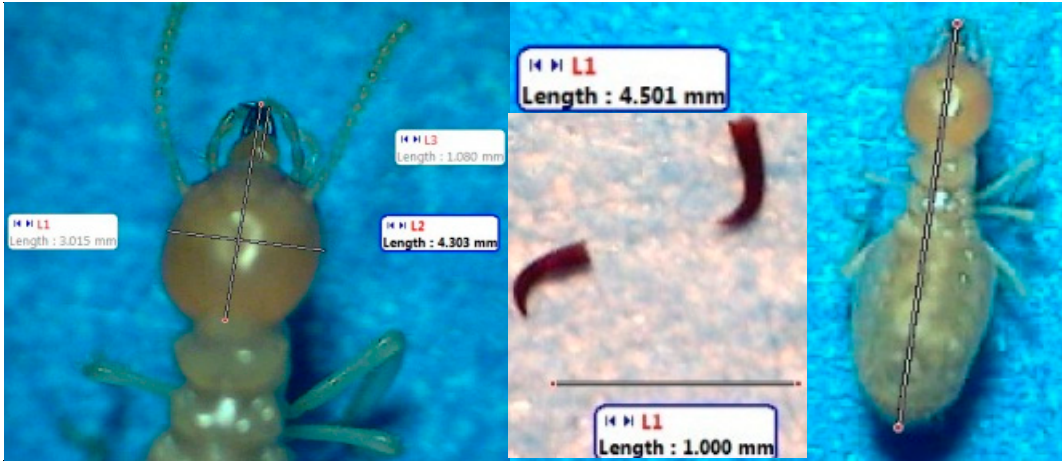
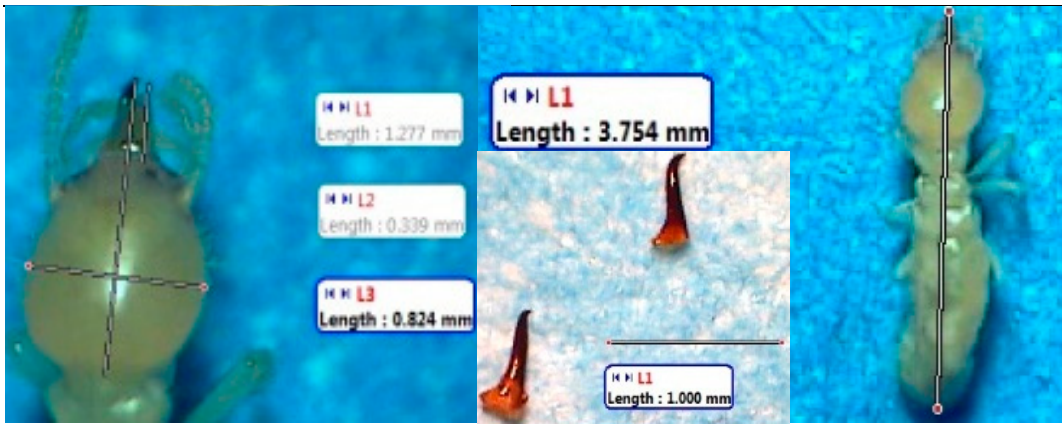
Stake Code	Termite Species and Their Characteristics	Morphology
B1	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.6 mm                      Average length of head without mandible: 1.18 mm                      Width of head: 0.99 mm                      Overall length: 4.5 mm</p>	
B2	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.28 mm                      Average length of head without mandible: 0.94 mm                      Width of head: 0.82 mm                      Overall length: 3.75 mm</p>	



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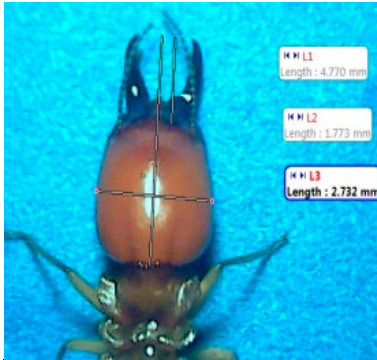

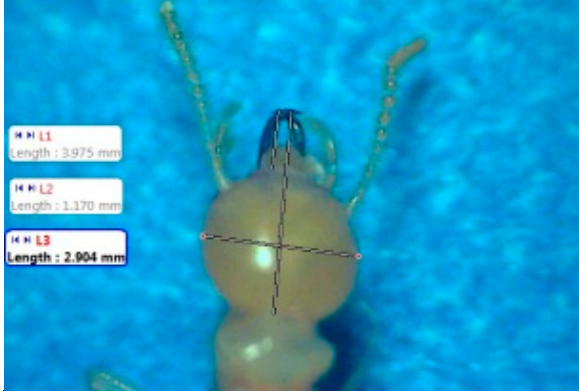

Stake Code	Termite Species and Their Characteristics	Morphology	
B3	<p><i>Macrotermes gilvus</i>                      Characteristics:                      Average length of head with mandible: 4.77 mm                      Average length of head without mandible: 3.0 mm                      Width of head: 2.73 mm                      Overall length: 10.8 mm</p>		
B4	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.35 mm                      Average length of head without mandible: 0.96 mm                      Width of head: 0.96 mm                      Overall length: 4.1 mm</p>		

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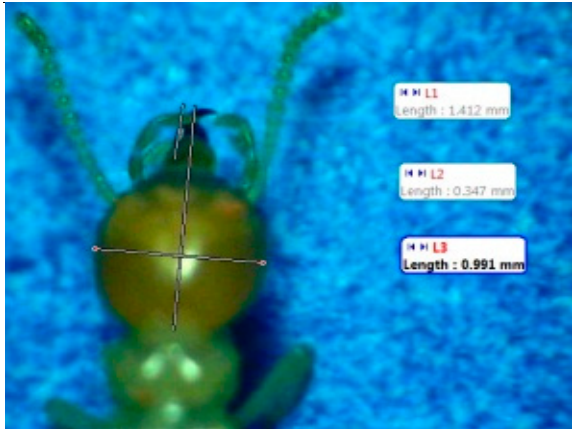
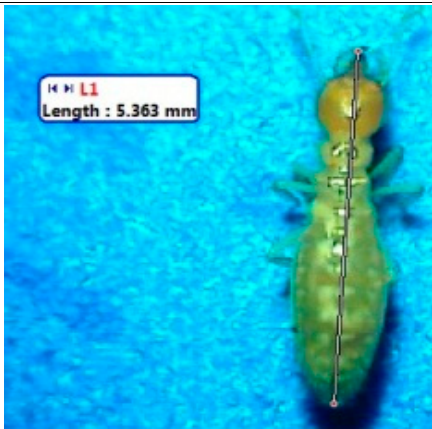
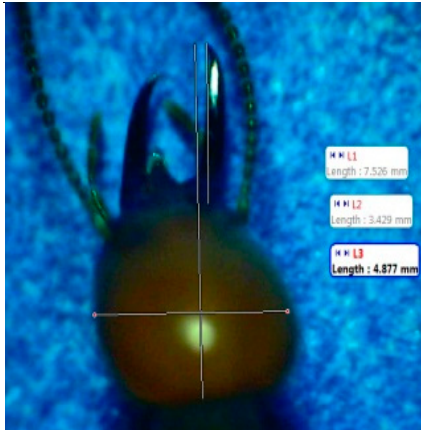
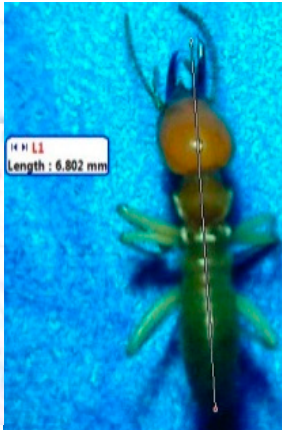
Stake Code	Termite Species and Their Characteristics	Morphology	
B5	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.41 mm                      Average length of head without mandible: 1.07 mm                      Width of head: 0.99 mm                      Overall length: 5.36 mm</p>		
B6	<p><i>Macrotermes gilvus</i>                      Characteristics:                      Average length of head with mandible: 2.46 mm                      Average length of head without mandible: 1.37 mm                      Width of head: 1.58 mm                      Overall length: 6.8 mm</p>		

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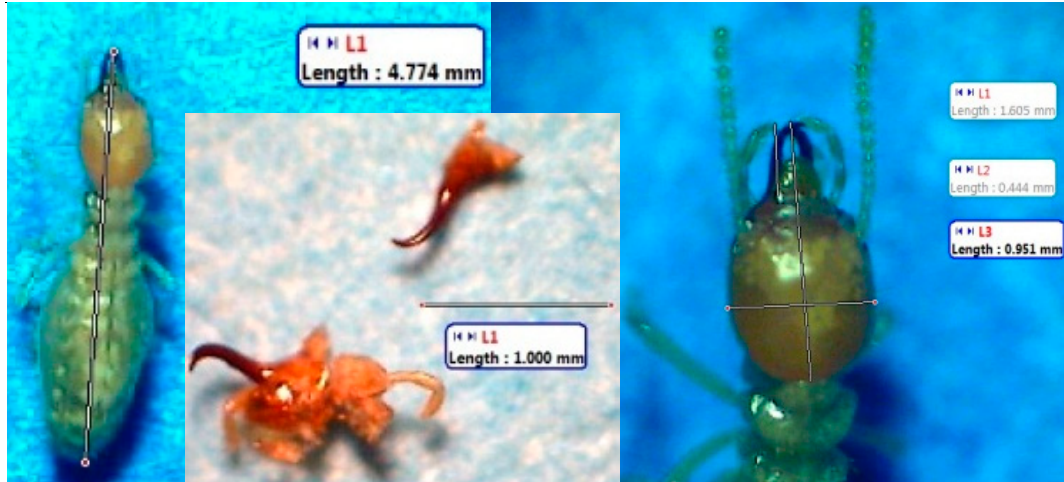

Stake Code	Termite Species and Their Characteristics	Morphology
C1	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.6 mm                      Average length of head without mandible: 1.17 mm                      Width of head: 0.95 mm                      Overall length: 4.77 mm</p>	
C2	<p><i>Macrotermes gilvus</i>                      Characteristics:                      Average length of head with mandible: 3.98 mm                      Average length of head without mandible: 2.55 mm                      Width of head: 2.57 mm                      Overall length: 8.31 mm</p>	

Table A1. Cont.

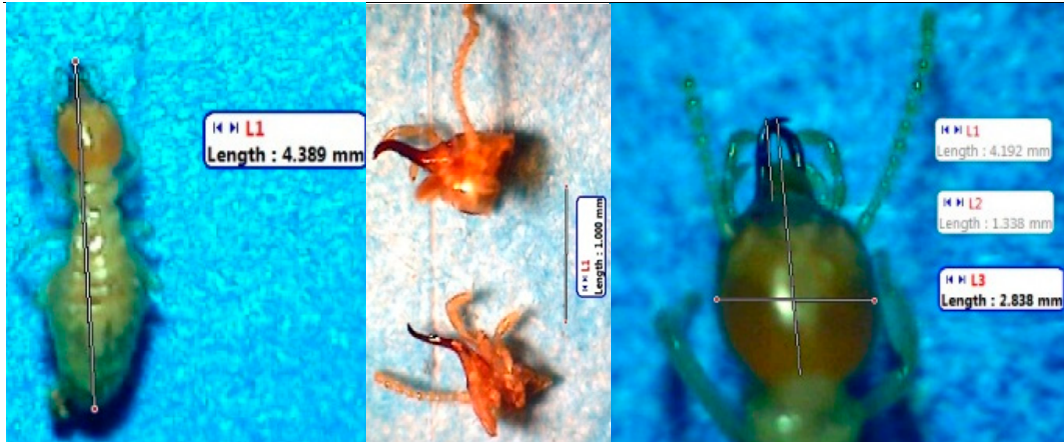
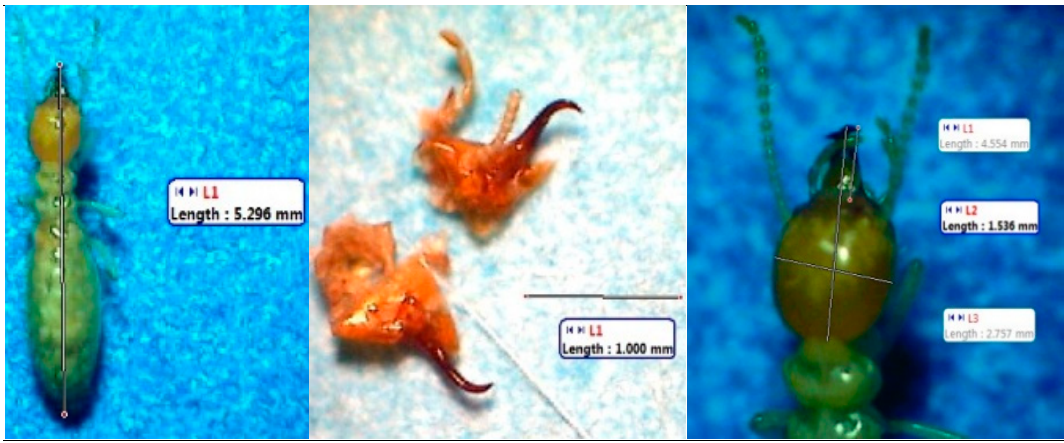
Stake Code	Termite Species and Their Characteristics	Morphology
C3	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.43 mm                      Average length of head without mandible: 0.98 mm                      Width of head: 0.92 mm                      Overall length: 4.39 mm</p>	
C4	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.5 mm                      Average length of head without mandible: 1.07 mm                      Width of head: 0.89 mm                      Overall length: 5.3 mm</p>	

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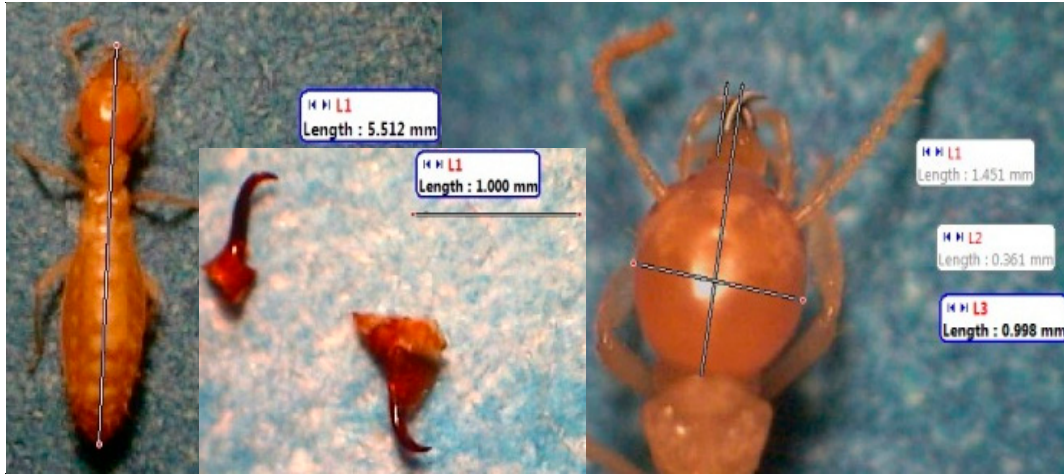
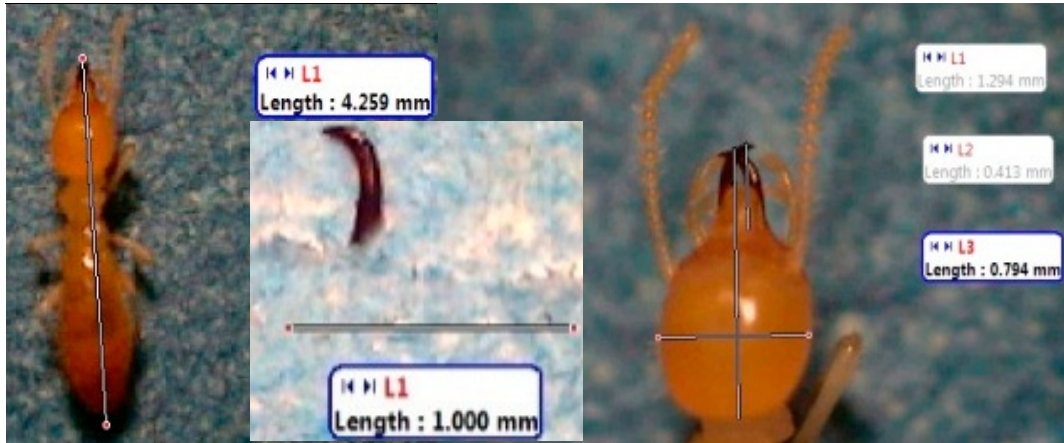
Stake Code	Termite Species and Their Characteristics	Morphology
C5	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.45 mm                      Average length of head without mandible: 1.09 mm                      Width of head: 1.0 mm                      Overall length: 5.51 mm</p>	
C6	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.29 mm                      Average length of head without mandible: 0.88 mm                      Width of head: 0.79 mm                      Overall length: 4.26 mm</p>	

Table A1. Cont.

Stake Code	Termite Species and Their Characteristics	Morphology
C7	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.32 mm                      Average length of head without mandible: 0.9 mm                      Width of head: 0.93 mm                      Overall length: 4.92 mm</p>	
C8	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.53 mm                      Average length of head without mandible: 1.09 mm                      Width of head: 0.95 mm                      Overall length: 5.48 mm</p>	

Table A1. Cont.

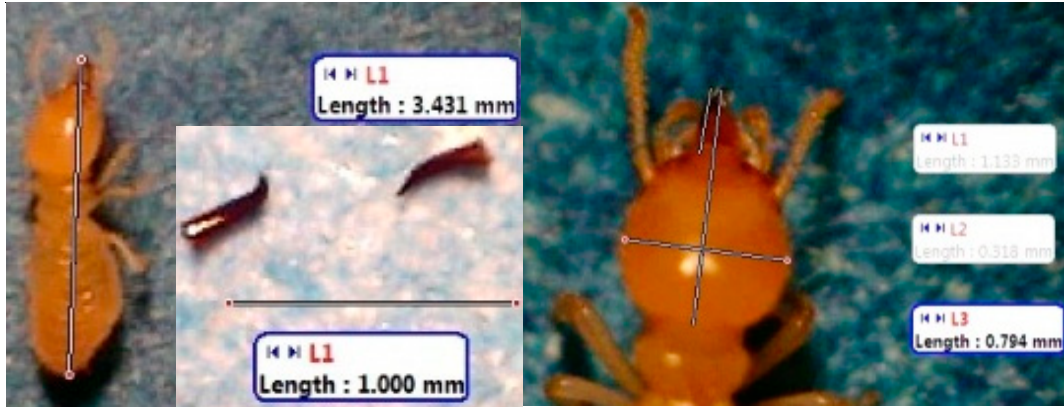
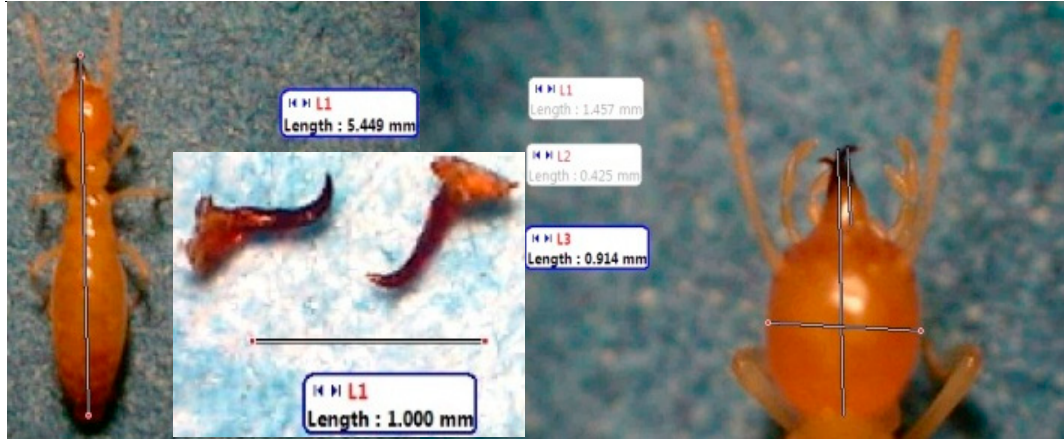
Stake Code	Termite Species and Their Characteristics	Morphology
C9	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.13 mm                      Average length of head without mandible: 0.82 mm                      Width of head: 0.79 mm                      Overall length: 3.43 mm</p>	 <p>Morphology images for C9 showing lateral view, mandibles, and dorsal view with measurements:</p> <ul style="list-style-type: none"> <li>Lateral view: Length: 3.431 mm</li> <li>Mandibles: Length: 1.000 mm</li> <li>Dorsal view:                     <ul style="list-style-type: none"> <li>Length: 1.133 mm</li> <li>Length: 0.318 mm</li> <li>Length: 0.794 mm</li> </ul> </li> </ul>
C10	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.46 mm                      Average length of head without mandible: 1.03 mm                      Width of head: 0.91 mm                      Overall length: 5.45 mm</p>	 <p>Morphology images for C10 showing lateral view, mandibles, and dorsal view with measurements:</p> <ul style="list-style-type: none"> <li>Lateral view: Length: 5.449 mm</li> <li>Mandibles: Length: 1.000 mm</li> <li>Dorsal view:                     <ul style="list-style-type: none"> <li>Length: 1.457 mm</li> <li>Length: 0.425 mm</li> <li>Length: 0.914 mm</li> </ul> </li> </ul>

Table A1. Cont.


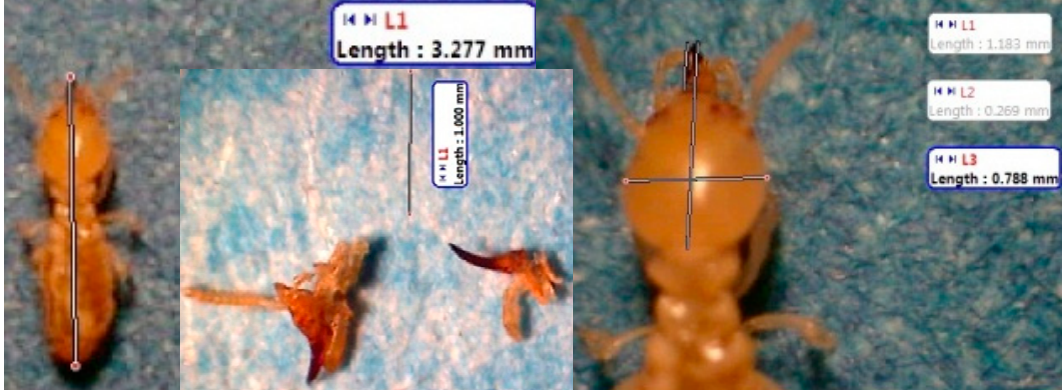

Stake Code	Termite Species and Their Characteristics	Morphology
C11	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.21 mm                      Average length of head without mandible: 0.93 mm                      Width of head: 0.85 mm                      Overall length: 4.48 mm</p>	 <p>Microtermes insperatus morphology images showing measurements: Lateral view (Length: 4.477 mm), Dorsal view (Length: 1.213 mm), Mandible (Length: 0.280 mm), Head width (Length: 0.850 mm), and Head length (Length: 1.000 mm).</p>
D1	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.18 mm                      Average length of head without mandible: 0.91 mm                      Width of head: 0.79 mm                      Overall length: 3.28 mm</p>	 <p>Microtermes insperatus morphology images showing measurements: Lateral view (Length: 3.277 mm), Mandible (Length: 1.000 mm), Dorsal view (Length: 1.183 mm), Head length (Length: 0.269 mm), and Head width (Length: 0.788 mm).</p>



Table A1. Cont.

Stake Code	Termite Species and Their Characteristics	Morphology
D2	<p><i>Microtermes insperatus</i>                      Characteristics:                      Average length of head with mandible: 1.4 mm                      Average length of head without mandible: 1.02 mm                      Width of head: 0.9 mm                      Overall length: 4.21 mm</p>	 <p>The morphology section contains four images with measurement callouts:</p> <ul style="list-style-type: none"> <li>Top-left: Overall length of the termite, labeled "L1" with a length of 4.210 mm.</li> <li>Top-right: Length of the head with mandible, labeled "L1" with a length of 1.403 mm.</li> <li>Bottom-right: Width of the head, labeled "L3" with a length of 0.904 mm.</li> <li>Bottom-center: Average length of the head without the mandible, labeled "L1" with a length of 1.000 mm.</li> </ul>

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