



Biodiversity of Termites and Damage Building in Semarang, Indonesia

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Abstract

Termites cause a lot of damage and big losses for building components, especially those made of wood. High population growth and rapid infrastructure development in Semarang city affect the natural habitats of termites. This phenomenon changes the termites' behavior of foraging in buildings. Semarang city has humidity, temperature, and altitude that allows termites to live and breed well. The purpose of this study was to determine the types of termites living in building in Semarang city as well as the level of attacks on housing. This research was conducted in nine residential buildings in Semarang City. The research was carried out with two methods: building inspection and wood-feeding method by using *Pinus mercurii* wood measures 2 cm x 2 cm x 46 cm. The results found four types of termites that attack wood feeds namely *Macrotermes gilvus*, *Microtermes inspiratus*, *Odontotermes javanicus*, *Coptotermes curvignathus* and *Cryptotermes* sp.. Based on interviews and building inspection, it was known that the condition of the building in the category of "moderate" was occupying the most position (74.44%), good (17.78%) and lightly damaged (7.78%). From the causes of damage to building components, it can be concluded that the level of termite attack against damage to residential buildings in Semarang city 44.58%. Cross-tabulation analysis of Chi-Square shows that there is a correlation between age and treatment with damage to the building. Further, the finding can be used as baseline information for further scientific investigation for effective termites control on residential building components.

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INTRODUCTION

Semarang city is the capital of central Java province and one of the metropolitan cities in Indonesia. It has temperatures ranging from 26.6-29.2 °C, with air humidity ranging in 76% and altitude of 0.75 to 348 masl (BPS, 2016). High population growth and rapid infrastructure development in this city is an influential factor causing a great disturbance to the natural habitat of termites. When termites lose their natural food sources in nature or the soil surface, they will ultimately look for food sources contained in buildings. This causes termites to become a potential threat to buildings (Subekti, 2010).

Termites are insects that cause a lot of damage to wood building (Priadi *et al.*, 2010). Termites can eat cellulose derivatives such as furniture, furnishings, fabrics, paper and all articles containing cellulose (Subekti, 2016). Factors that may affect termite infestations in buildings include building components and furnishings which are made of wood, areas surrounding buildings with a high humidity, wooden building components directly related to soil, piles of wood, and materials containing cellulose (Savitri *et al.*, 2016). The intensity of termite attack and the amount of damage generated can cause high economic losses and tend to increase from year to year (Arinana *et al.*, 2016). According to Nandika *et al.* (2016), economic losses from termites attack in residential buildings in Indonesia was estimated at Rp 8.7 trillion in 2015.

This research was conducted to know the type of termites and the level of attacks on residential buildings in Semarang City, so it can be known how many attacks of termites occurred in all buildings. This study area includes termite diversity, the intensity of damage to residential buildings and the relationship between age and maintenance performed on buildings against the extent of the damage.

The result of research can be used as baseline information for further scientific investigation for effective termites control on residential building components

METHODS

The location of the sampling was done on nine residences in Semarang city namely Sadeng, Semarang Indah, Bringin, Sukorejo, Sron dol, Ngijo, Gombel and Puduk Payung. The study was conducted for four months, covering sampling in the field followed by identification in Bio-

logy Laboratory, Biology Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang.

The instruments used were specimen tube, questionnaire, Lux meter, Thermo hygro, label paper, microscope, Tho determination key book (1992), stationery, small shovel, some Demetra testers, photo camera, waterproof plastic, Global Positioning System (GPS), Petri dish. The materials used are *Pinus mercurii* wood with size 2 cm x 2 cm x 46 cm, 70% alcohol, termite specimen, soil sample.

Sampling method in this research was done by using purposive sampling technique with cross-sectional approach. The research was carried out in two methods: inspection and wood-feeding method. The research procedure was collection and identification of specimen, intensity analysis of damage of building, analysis of soil characteristic, and measurement of temperature, humidity, and light intensity.

Collection and Specimen Identification

The stake was made from *P. mercurii* wood, both the ends of the stake are painted to be distinguished from environmental conditions (ASTM-D 1758-08 2008). The study used 180 stakes (20 stakes in each residence). Stakes were placed in a vertical position with an estimated half under the soil and half above the soil and planted for 2-3 months. Termite sampling was done by inspecting 90 buildings (10 buildings for each residence) with looking to the mark of termite attack that found on building component.

The termite samples from the soldier caste found were inserted into a collection bottle containing 70% alcohol and then were photographed using a stereo microscope. The sample was identified by reference to the book titled Termite of

Peninsular Malaysia from Tho (1992).

Intensity of Building Damage

Analysis of damage intensity in the building was done by interview and inspecting the building by taking samples of 10 buildings from each residence so that there were 90 buildings as samples. This inspection was conducted on the main part of the building such as roof, foundation, wall frame, ceiling, walls, sills, floors, drainage of the yard, and utility. The value of the degree of damage to buildings is presented in Table 1.

Weighting techniques was needed to calculate the value of robustness building. Weighting techniques in each component group can be seen in Table 2.

Table 1. The Intensity of Building Damage

The Building Condition	Score	Information
Good	5	The components of the building are still well functioning and there is a maintenance on a regular basis.
Moderate	4	The building components are still well functioning although there is no maintenance on a regular basis.
Low Damage	3	Components of the building are still functioning, but <10% of the parts are experiencing symptoms of damage (weathered, cracked, attacked by termites, discoloration, etc.).
Medium Damage	2	Components of the building is still functioning, but 10% -40% of them are experienced functional damage (weathered, cracked, attacked by termites, discoloration, etc.)
High Damage	1	As much as 40% of the building components have functional damage (weathered, cracked, attacked by termites, discoloration, etc.).

Sources: Suryadi (2005)

The building robustness value was calculated according to the following formula:

$$VR (\%) = x \times 100\%$$

Information:

$$VR = \text{Value Robustness building}(\%)$$

Determination of categories of building conditions is grouped into five classes of conditions, depending on the final percentage of robustness values obtained. Category of building robustness values and predicates are presented in Table 3.

Table 2. Quisionnaire weighing technique on each component of construction

Object of Research	Rating %	Score (1-5)	Rating x score
Roof Work	27		
Foundation	21		
Wall Frame	19		
Ceiling	10		
Wall	9		
Frame/door leaves	6		
Floor	4		
Drainage System	3		
Utilities	1		
Total	100		

Source: Suryadi (2005)

Table 3. Category of building condition values

Value of Building Robustness (%)	Category
81-100	Good
61-80	Moderate
41-60	Low Damage
21-40	Medium Damage
0-20	High Damage

Source: Depkimpraswis (2003)

Analysis of soil characteristics

Analysis of soil character was to know the texture, moisture content, pH, and C-organic content. Soil samples in each residence were taken in two depths of 0-20 cm and 20-40 cm so that there were nine soil samples at 0-20 cm depth and nine soil samples at 21-40 cm depth (total of 18 samples).

Measurement of air temperature, humidity, and light intensity. Measurements were conducted three times in each residence (07.30 WIB, 12.30 WIB, and 16.30 WIB) (Arinana *et al.*, 2014).

RESULTS AND DISCUSSION

The diversity of Termites

Based from the result 180 stakes were

planted and 90 inspected building at 9 residence spread in Semarang City, as many as 47 stakes were found by termites and damage from termite attack was found in all buildings, so total of termite attack that found in the stake or building as many as 137 termite attack.

The result from termite identification was found five species that was *Coptotermes curvignathus* (43.8%), *Macrotermes gilvus* (18.25%), *Microtermes inspiratus* (10.94%), *Odontotermes javanicus* (2.12%) and *Cryptotermes sp.* (24.82%). The termite species found consisted of three families namely Rhinotermitidae, Termitidae and Kalotermitidae. Presentation of termitidae attacked there are 43.8% for Rhinotermitidae, Termitidae 31.39% and Kalotermitidae 24.81%. According to Nandika *et al.* (2003), family Termitidae and Rhinotermitidae is a family group that mostly attacked the building of several major cities in Indonesia. Presented Termite species found can be seen in Figure 1.

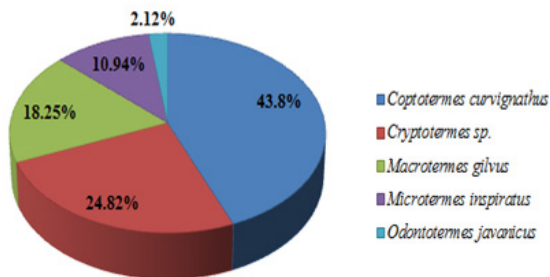


Figure 1. Percentation of five termite spesies found in nine residential buildings of Semarang City

The frequency of damage to buildings

The conducted analysis to know the damage of the building covers the main parts of the building consisting of the roof, foundation, wall frame, ceiling, wall, sills, floor, drainage yard and utility (Puspantoro, 1996). The condition of residential buildings is presented in Figure 2.

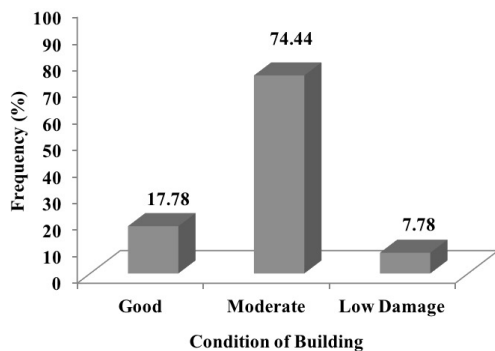


Figure 2. The condition of buildings on residences based on their damage

The results of interviews and inspections (Figure 2) show that the inspected building conditions consist of good, moderate and low damage. Moderate categories was occupying the most position that is 74.44%, because the maintenance is not done regularly, so there is still much damage to the building component. Presentation of Good building condition was 17.78% because maintenance carried out on a regular basis. The condition of the building is low damaged 7.78%, the results due to lack of maintenance periodically, maintenance was done only as necessary so that there was a lot of damage to building components.

The decrease in the quality of buildings can also occur due to the unwillingness of the building users to do maintenance (Dardiri, 2012). Interview results known that the maintenance performed at buildings is usually a periodical painting in one to five years and for treatments on building components that are the most widely done are care on the sills, doors, and windows are attacked by termites.

Types and Form of Building Damage

Factors that cause damage to the building are in the form of biological, mechanical, and physical factors. The most biological factors that cause damage to buildings are termites, beetles, and mosses. The mechanical factor is the damage caused by the static and dynamic force. Forms of damage are like cracks and broken. The physical factor is climate-induced damage such as temperature and humidity. Shape damage is the color change of wood, color fading in the paint, and peeling on paint (Watt, 1999). The frequency of damage can be seen in Figure 3.

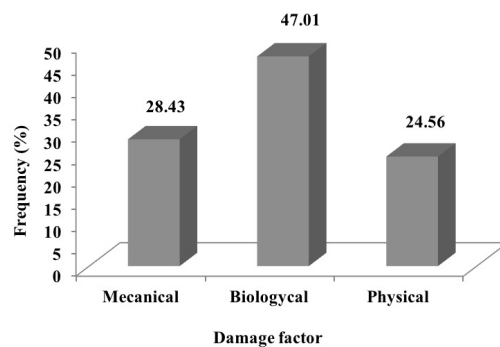


Figure 3. Frequency of damage in residential building caused by three main factors

From the result of the inspection, the condition of the building shows that the cause of damage of building component are the biological factor by 47.01%, mechanical factor by 28.43%,

and physical factor by 24.56%. Building components from the highest to the lowest frequency of damage are roof (23.58%), wall (21.32%), ceiling (19.06%), window and door frames (16.32%), floor (10.18%), and wall frame (4.20%). The most dominated biological factor is termite attack. Tarumengkeng (2000) stated that over the last twenty years, termites are the most disturbing factor of wood and building destruction. The termite attack occurs because the types of wood used as a building material in general are the class III of wood type or low-grade class.

Frequency of termite attack

The results of the inspection showed that the frequency of damage caused by termites and non-termites (beetle, moss, cracks/breaks, flaking paint and discoloration). Termites attacked is 44.58% and non-termites is 55.48%. The frequency of termites attack on damage buildings can be seen in Figure 4.

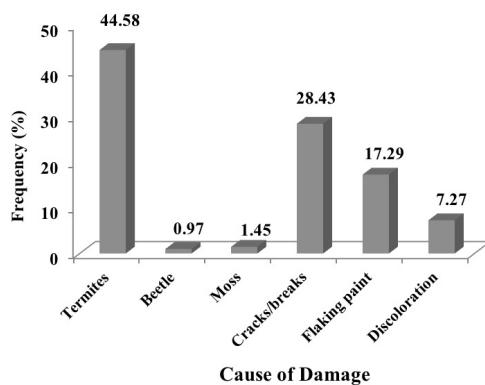


Figure 4. Frequency of termites and non-termites attack on damage buildings

Most termite attacks cause damage to building components. The levels of termite attacks occur in building components are: door frames and windows by 34.90%, roof by 31.16%, ceiling by 11.59%, floor by 9.42%, wall by 11.95%, and wall frame by 3.26%. The attack is caused by termites *Coptotermes* spp. and *Cryptotermes* sp.

Subterranean termites of the genus *Coptotermes* are important urban pest insects in tropical countries (Lee, 2002; Lee *et al.*, 2007). This kind of termite has the impact of damage on building and higher ability to attack buildings than other termites. Prasetyo & Yusuf (2005) stated that *Coptotermes* is a “destroying termite” that causes the most violent attack level. The workers of the genus *Coptotermes* foraging underground and move to rooftops through covered tunnels built along the vertical surfaces of materials (Gentz *et al.*, 2008).

Cryptotermes have distinctive characteristics of other types of termites. They are commonly found in Indonesia and are known as pests for humans. *Cryptotermes* sp. do not require humid conditions, so that, they can attack building components even though the humidity is low as in the frame and window. They have pellets as their excrement which are accumulated under the infested wood (Indrayani *et al.*, 2017)

Soil Analysis

Soil analysis results showed that C-organic content ranged from 0.83-3.18% which was included in low to high category, pH ranged from 6-7.5 which was a neutral pH, Water content ranged from 15.63 to 26.79%, salinity of 0.22-0.69 ms / cm, and soil texture at the research site comprised clay loam (38.9%), loam (22.2%), sandy silt-loam (16.7%), clay loam (11.1%), sandy clay-loam (5.5%), and sandy clay (5.5%).

The organic C-content present in the soil is sufficient to support the process that takes place in the soil. Such a C-organic content does not have a complex problem with chemical processes occurring in the soil (Hardjowigeno, 2003). According to Lee and Wood (1971), land in which there is a termite activity has a high content of organic matter.

In general, termites like the soil type that contains a lot of clay because it has a high content of organic material and fine texture. Termites do not like sandy soil types because they have low organic matter (Nandika *et al.*, 2016). This is in accordance with the results of soil physical analysis that the texture of the soil in the residential buildings of Semarang is clay loam with medium texture and loam so that the termites can live well.

Termites can live and breed in soils with low acid content (Kurniawan *et al.*, 2015). In accordance with the results of the analysis, the pH condition of Semarang City is suitable for termites to live. Soil pH is important because soil and plant organisms are highly responsive to their chemical and environmental properties (Djaenu-din *et al.*, 2003). Dissolved nutrients can conduct electricity, so that, the more dissolved nutrients, the higher the electrical conductivity. This condition is often known as salinity.

Analysis of temperature, humidity and light intensity

Abiotic factors also affect the environment where living creatures live. Abiotic factors measured in this study include the intensity of light, temperature, and humidity. The measurement results can be seen in Table 4.

In Table 4. it is known that the measurement results are in accordance with optimum temperature and humidity conditions of termites. Measurement in the morning (07.30 am) shows the temperature range between 32-34, with range between 65-70% moisture, and light intensity of 5,010 lux. In daytime (12:30 pm), the temperature was 34-40 the humidity was 47-54%, and the light intensity was 13,388 lux. In the afternoon (16:30 pm), the temperature was 31.5-33, the moisture was 67-73% and the light intensity was 5,041.

Table 4. Average light intensity, temperature and humidity

Time	Light Intensity (lux)	Temperature (°C)	Humidity (%)
Morning	5,010	32-34	65-70
Afternoon	13,388	34-40	47-54
Evening	5,041	31.5-33	67-73

The intensity of sunlight that ecosystems receive is an important determinant of primary productivity, which in turn can affect species diversity and nutrient cycles (Mokany *et al.*, 2008). Termites are insects that have thin skin, susceptible to the dehydration process by wind/dry air so that the termites require a stable moisture (Subekti *et al.*, 2008). This study showed that the temperature of Semarang city ranged between 32-38 °C with humidity ranging from 50-70%, so that the termites can live and grow well in the city of Semarang. This is in accordance with the statement of Nandika *et al.* (2016) that termites living at temperatures ranging from 15-38 °C.

Influence of Age, Frequency of Maintenance, and Home Building Care

The result of Cross-tabulation analysis shows that the relationship between age of the building with building condition is shown by the Chi-Square value of 18.114 at DF 4 (p-value 0,001 <0.05) which means that age of the building is significantly related to the building condition. Coefficient correlation of age of the building with the condition of the building is 0.409. The number of buildings that are <15 years old is 12 or 13.3% of all buildings, seven of them (58.3%) have a good conditions, 1 (8.3%) of them is in low damage, and 4 (33.3%) of them are in moderate conditions. The number of buildings aged of 15 to 30 years is 51 or 56.7% of all buildings, eight of them (15.7%) are in a good conditions, while 3 of them (5.9%) are in low damaged, and 38 of them (78.4%) are in moderate conditions. The number of aged of > 30 Years are as many

as 27 or 30% of all buildings, one of them (3.7%) is in a good condition, while 3 of them (11.1%) are in a low damage, and as many as 23 or 85.2% of them are in moderate conditions. It shows that the older the building, the damage will be greater worse.

Relationship of maintenance with building condition of Chi Square value 11.702 at DF 2 (p-value 0.003 < 0.05) which means that building maintenance correlated significantly with the condition of the building. The maintenance of the building that was done affect for the condition of building. Treatment relationship with building condition of Chi Square value is 5.981 at DF 2 (p-value 0.050 > 0.05) which means that building maintenance is not significantly related to the condition of the building.

The finding can be used as baseline information for further scientific investigation for effective termites control on residential building components.

CONCLUSION

Based on the results of research conducted in buildings in Semarang, it can be concluded that there are four types of termites at the research sites i.e. *O. javanicus*, *M. gilvus*, *M. inspiratus* *C. curvignathus* and *Cryptotermes* sp., which are included to Family Rhinotermitidae (43.8%), Termitidae (31.39%) and Kalotermitidae (24.81%). From the causes of damage to building components, it can be concluded that the level of termite attack in buildings in Semarang city is 44.58%. The condition of the buildings in the study location was in moderate condition (74.44%), good condition (17.78%) and low damage condition (7.78%).

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