Temperature Fluctuation in *Coptotermes curvignathus* Holmgren (Isoptera: Rhinotermitidae) Nests

by
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Abstract

One of the external factor which influence the survival of termites is temperature. Termites try to maintain the temperature of the nest within a certain range in order to survive. The objective of this research analyzed the temperature inside nests of the subterranean termite *Coptotermes curvignathus*. This research was conducted at the Laboratory of Termite-Department Forest Products-Bogor Agricultural University and simultaneously analyzed temperature data inside the nest of *C. curvignathus* and in the laboratory using a thermocouple. Data analysis was based on a model sinusoidal equation. The results showed that average temperature in the nest was 31.4 ^{O}C. which was 1.3 ^{O}C warmer than the temperature in the laboratory. The data showed that temperature alterations in termite nest were more stable than temperature alterations in the laboratory. It was determine based on value of the amplitude. Termites can maintain stable temperatures inside the nest.

Key Words: amplitude, degrees celsius, laboratory, sinusoidal equation, thermocouple

Introduction

Indonesia as tropical country located at 95^{o} – 141^{o} East Longitude and 6^{o} -11^{o} South Latitude (Sukojo 2003) characteristized by high temperatures and humidity throughout the year, with the lowest temperature being 18^{o} C (Suharsono 2008). Bogor is a city located in West Java with an average minimum altitude of 190 m and maximum 330 m above sea level. This city has warm climatic conditions with annual average temperatures between 25.1-26.4^{o} C and humidity of about 92 percent (BPS 2014) making it a nice place for termite to live.

The subterranean termite *Coptotermes curvignathus* have a high intensity of attacks in Indonesia (Nandika and Tambunan 1990), This termite can make secondary nests high in buildings. Ritalupa (2006) said that this termite is able to attack apartments and hotels in Jakarta-Indonesia up to floor 33. In addition, this termite can attack living trees and these attacks can lead to the death of the tree (Badaruddin 2007).

Weather elements such as temperature, humidity, and solar radiation affect the behavior of termites. According to Harris (1971), termites are able to maintain physical conditions in their nest so the temperatures inside and outside of the nest will be different. Differences of temperature can be used to determine the temperature range needed in order for the nest to survive. By knowing the characteristics of the termite nest, the damage caused by termites in the woods or houses can be reduced and avoided. Therefore, it is necessary to investigate the optimum temperature for *C. curvignathus* nests located in Bogor to hopefully develop an action plant to prevent termite attack to houses or buildings and the environment.

Materials and Methods

This research was conducted at the Termite Laboratory, Faculty of Forestry, Bogor Agricultural University, in a facility used for rearing *C. curvignahus*, during August, 2014. The temperature was measured in one of the termite nest rearing stations with a size of 150 x 100 x 100 cm as well as inside of the laboratory room where nest was located. The tools used were small-sized thermocouples that can be placed into termite nests (Figure 1) and a multimeter as the temperature reader. Microsoft Excel 2007 was used as a data processing software. Clock or timers were also used for the calculation of observation times.

Figure 1. Thermocouple instrument for measuring the temperature used during the study

Temperature measurements were carried out for 3, 24-hours periods and the temperature recorded every hour. The first temperature observations were conducted at 18.00 pm. The thermocouple was laid in the rearing chambers filled with termites which can be seen in Figure 2.

Figure 2. Thermocouples were laid in *Coptotermes curvignathus* rearing chambers in the Termite Laboratory

Data analysis was based on a model sinusoidal equation developed by Bahtiar *et all.* (2014 a, 2014 b) to fit the daily temperature cycle inside and outside the termite nest . The following model was chosen:

$$y = a + b\sin\left(\frac{\pi}{12}(t - t_0 - k_1)\right) + cz\sin\left(\frac{\pi}{12}(t - t_0 - k_2)\right)$$

Which:

y	= Temperature (T) (°C)
a, b, c	= Regression coefficient
z	= Dummy variable (binary variable which the value is 0 at night and 1 at daytime)
t	= Time of measurement (hour) (GMT+7)
t_0	= Sunrise (hour) (GMT+7)
k_1	= Additional phase for earth's surface energy effects (hour)(GMT+7)
k_2	= Additional phase for sunrays radiation effects (hour) (GMT+7)
L	= Length of the day (hour)

Results and Discussion

The result of this research showed that the temperature inside of a nest on the first day ranged from 29.6-33.8 ^{O}C, on second day 29.9-33.1 ^{O}C, and third day 29.4-33.2 ^{O}C. While the temperature outside of the nest (temperature in laboratory room) provided the following respectively ranges 27.5-33.2 ^{O}C, 28.2-32.1 ^{O}C, and 28.2-32.1 ^{O}C (Table 1).

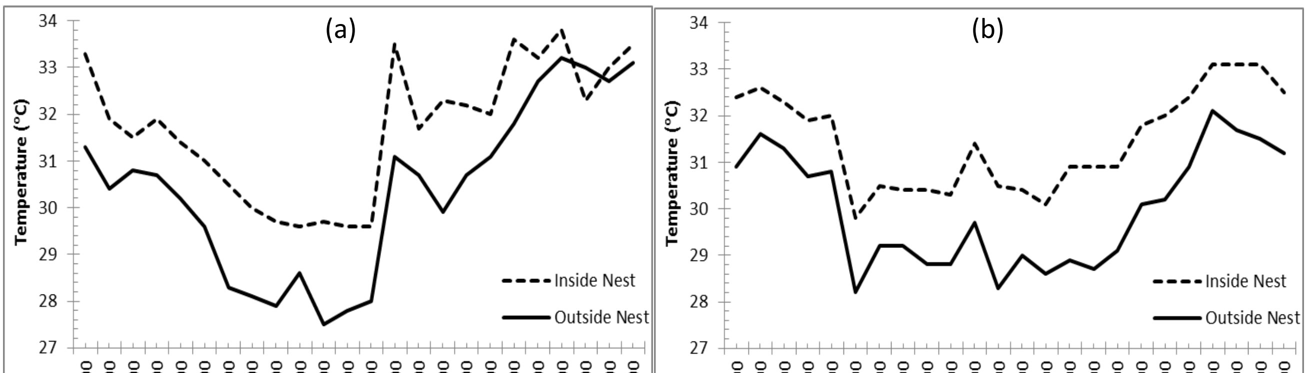
Table 1 The temperature inside and outside of nest *C. curvignathus*

Observation time (day)	Temperature ranges (^{O}C)	
	inside nest	outside nest
1	29.6 – 33.8	27.5 – 33.2
2	29.9 – 33.1	28.2 – 32.1
3	29.4 – 33.2	28.2 – 32.1

Based on the temperature values in Table 1, changes in the nest were lower than outside. In this case, temperatures in nest ranged from 29.4-33.8 ^{O}C (changes 4.4 ^{O}C). While the temperature outside of the nest ranged from 27.5-32.2 ^{O}C (changes 5.7 ^{O}C). It means, termites can maintain more stable nest temperature. Generally, temperature inside of nest was warmer than outside (laboratory temperature). Lee and Wood (1971) said that diurnal temperature on the nest of termites varied daily but the temperature in the nest was higher than the soil or environment temperatures. Noirot (1970) also stated that the temperature was higher outside the nest (environment) than the area where termites resided.

Fluctuations in the temperature inside termite nests tend to follow fluctuations of the outside temperature. Termite nest temperature observations on the first day showed that temperatures reached their lowest at 06.00 and reach their maximum at 14.00. On the second day temperatures reached their lowest at 07:00 and reached the maximum at 14.00. Meanwhile, on the third day temperatures reached their lowest at 05.00 and reached the maximum temperature at 14.00. Temperature fluctuations inside and outside the termite nests are shown in Figure 3.

Temperature differences in termite nests by day and hour can be caused by activity, the number of individuals in the colony, the heat generated by the food collected by the termites (Nandika *et al.* 2015), termite metabolism (Noirot 1970), and the friction that occurs when the termites feed on the wood. In addition, Nandika *et al*. (2015), stated that one way to maintain the termite nest temperature is thermoregulation so the temperatures in some parts of the nest may be different but still can be controlled by termites.



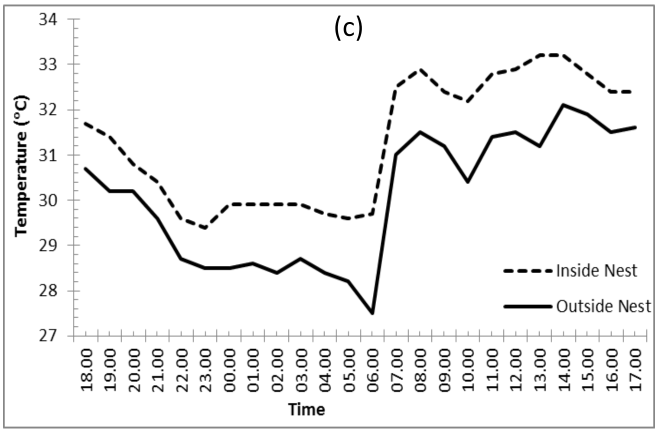


Figure 3. Fluctuations in temperature inside and outside of termites nest at firs day (a), second day (b), and third day (c).

Based on the data processing sinusoidal equation models we obtained two equations that describe the average temperatures and temperature fluctuations inside and outside the nest.
The equations are:

Inside Nest:

$$y = 31.3697 + 1.49492\sin\left(\frac{\pi}{12}(t-6-3)\right) - 0.50917\sin\left(\frac{\pi}{12}(t-6-9.3)\right)$$

Outside Nest:

$$y = 30.1487 + 1.82938\sin\left(\frac{\pi}{12}(t-6-2.9)\right) - 0.02397\sin\left(\frac{\pi}{12}(t-6-1.2)\right)$$

Based on these two models it can be seen that the average temperature of the termite nest is approximately 1.3 ^{O}C higher than the temperature outside the nest, which can be seen from the value of the regression coefficient a in the equation, where the average temperature of the termite nest is 31.4 ^{O}C, while the temperature outside the nest is 30.1 ^{O}C. It is stated that the temperature inside the termite nest is warmer than outside the termite nest. Woodrow and Grace (1999) showed that the temperature inside the galleries of dry wood termites *Cryptotermes brevis* is 24.33-37.04 ^{O}C. Optimum temperature for Macrotermes termite nests is 29-32 ^{O}C (Krishna and Weesner 1969).
While the fluctuations in temperature can be seen in the summed amplitude value of b and c. The amplitude value inside the nest is smaller than outside the nest. The mean amplitude value inside the nest was 0.98575 (from 1.98575 + (-0.50917)) and the mean amplitude values outside nest was 1.80533 (from 1.82938 + (-0.02397)). Temperature fluctuations measured and estimated iinside and outside of the termite nests during 3 x 24 hour observation periods are shown in Figure 4. Termites are able to maintain more stable nest temperatures when outside temperatures fluctuated. It showed

the insulating power of subterranean termites nest to ambient temperature. There are fluctuations of air temperature and relative humidity thatmake a cyclic loop every day. These fluctuations are caused by solar radiation and earth-surface energy. Bahtiar et al (2014a, 2014b) developed a sinusoidal equation to take into effect both sunrays radiation and earth surface energy on the daily cycles of air temperature and relative humidity.

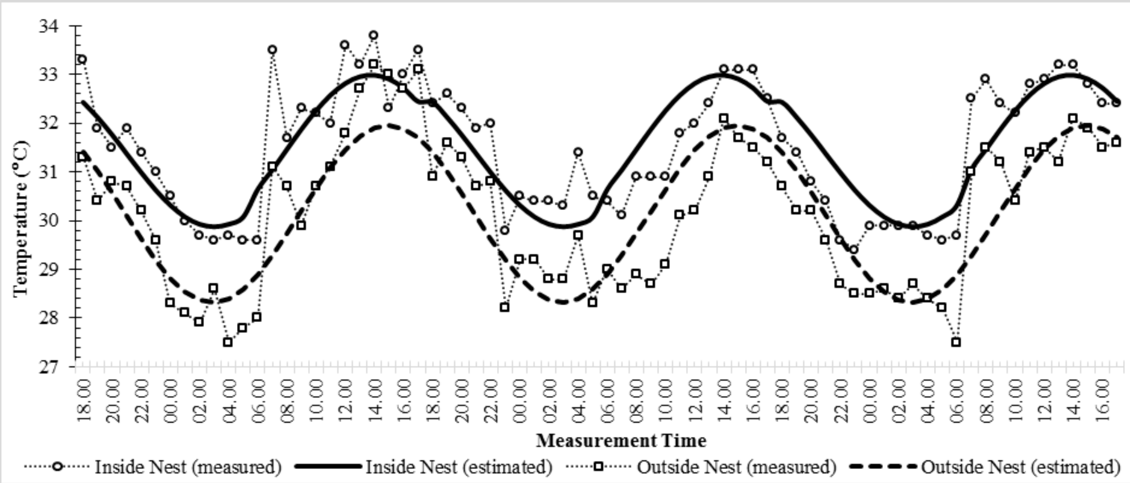


Figure 4. Temperature fluctuations measured and estimated inside and outside termite nests during 3, 24 hours observation periods.

Conclusions

Average temperature in the nest of *Coptotermes curvignathus* was 31.4 ^{O}C (ranged between 29.4 - 33.8 ^{O}C) This nest temperature was 1.3 ^{O}C warmer than the temperature on the outside surface of the nest or in the laboratory. Nest termite temperatures fluctuate following outside temperature, but termites can maintain a more stable nest temperature.

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