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FIRST RECORD OF AMBROSIA BEETLE (*Euplatypus paralellus* Fabricius) INFESTATION ON SONOKEMBANG (*Pterocarpus indicus* Willd.) FROM MALANG INDONESIA

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ABSTRACT

Sonokembang (*Pterocarpus indicus* Willd.) is native of Asia trees, and commonly planted in large numbers as shade trees along roads in Malang. Research was conducted on 76 roads to identify damage intensity of dying trees on sonokembang and clarify the causal agent of dying trees in Malang from May to December 2012. Seven variables was also investigated such as characteristic of tree`s damage, distribution of holes based on sunlight exposure, vertical position of stem, and stem diameter, morphological characteristic of beetle, the intensity of dying trees, and distribution of dying trees. Results showed that there were unique damaging characteristic such as dying and then fallen leaves, holes on the stem and branches, and frass production. *Euplatypus parallelus* Fabricius was identified as a causal agent of dying sonokembang. There were some indications shown such as beetles preferred to attack stem side with much sunlight exposure, upper stem and medium or bigger size of stem diameter. From 3,206 trees on 76 roads, 69.7% were found dying trees. In dry and rainy season, the intensity of dying trees increased from 8.14 to 9.76% and from 10.26 to 10.79%, respectively.

Keywords: *Euplatypus paralellus*, frass, dying trees, number of holes, sonokembang

INTRODUCTION

Pterocarpus indicus Willd. is described as native of Asia (Anonymous, 2005), it has the western limit to be Southern Burma and the eastern limit in the Solomon Islands (Carandang, 2007). *Pterocarpus indicus* is a deciduous tree and a member of the Leguminosae (Pyatt *et al.,* 2005). In Indonesia, *P. indicus* was named as sonokembang (Indonesia). Sonokembang is commonly planted in large numbers as ornamental or shade trees along roads, in parks and residential areas in the tropics (Furtado, 1935). This tree is beauty and fast growing, evergreen, has an attractive canopy shape, and has a typically synchronized short flowering period (Furtado, 1935; Joker, 2002). This tree is of social and ecological value especially in urbanized areas (Bumrungsri *et al.,* 2008).

Wilt disease on sonokembang was first reported in Malacca in 1870 (Sanderson *et al*., 1996). The disease was recorded in Singapore in 1914 and many trees had either been killed by the disease, or had been removed to prevent its spread in 1919 (Sanderson *et al.,* 1996). In addition, over 800 trees were removed as a consequence of the disease between 1980 and 1992 (Sanderson *et al.,* 1996).

On our preliminary studies in the early 2012, there were some dying sonokembang trees along road in Surabaya, Batu and Malang. Based on symptom and sign on dying trees, there were dying leaves, holes on stem and branch followed by frass around holes. In addition, there were found beetles inside the holes.

The samples of ambrosia beetle were classified as Platypodids. The most popular species of Platypodid in Japan is *Platypus quercivorus* Murayama which attacked some oak in the Japanese forest and caused dying and killed oak trees (Ueda and Kobayashi, 2004). Ambrosia beetle in Japan collaborated with ambrosia fungi (*Raffalea quercivora* Kubono et Shin) caused dying and fallen leaves

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on Japanese Oaks (Esaki *et al.*, 2004). Similar case was occurred in South Korea, Moon *et al.* (2008) reported ambrosia beetle, *P. koryoensis* (Murayama) (Coleoptera: Platypodidae) as an ambrosia fungi vector caused dying oak trees in South Korea. In the tropical area, there were some examples such as in an urban area of Campinas City, Brazil, *Platypus parallelus* and *P. sulcatus* were found attacking 16.2% of the trees, mainly in the Caesalpinaceae family (96% of the records (Queiroz and Garcia, 2007). In Singapore, *P. parallelus* was ambrosia beetle which collaborated with *Fusarium oxysporum*, caused dying trees of sonokembang in urban area (Sanderson *et al.,* 1996; Sanderson *et al.*, 1997b).

Based on the important value of sonokembang and there was no report related to dying sonokembang trees in Indonesia, research was aimed to identify damage intensity of dying trees on sonokembang and to clarify the causal agent of dying trees. Characteristic of tree`s damage, distribution of holes based on sunlight exposure, distribution of holes based on vertical position of stem, distribution of holes based on stem diameter, morphological characteristic of beetle, the intensity of dying trees, and distribution of dying trees was also investigated on sonokembang in Malang, Indonesia.

MATERIALS AND METHODS

Research was conducted in five sub districts of Malang City (Klojen, Sukun, Lowokwaru, Kedung Kandang and Blimbing), Laboratory of Entomology, and Laboratory of Geographic Information System, Faculty of Agriculture, University of Brawijaya from May to December 2012. There were three groups of activities in this research. **First one**, we counted and calculated dying trees from all of sonokembang trees distributed among seventy six roads located in five sub districts of Malang. This activity was aimed to identify *the intensity and the distribution of dying trees*. **Second one**, we observed eighteen trees which located in Veteran Street (Lowokwaru sub district). Eighteen trees were chosen randomly, then classified into three categories of stem`s diameter, vertical position of stem and sunlight exposures. Second activity was aimed to describe *characteristic of sonokembang tree`s damage, distribution of holes based on sunlight exposure, vertical position of stems and stem`s diameters*. **Last one**, we collected samples of ambrosia beetle from five dying trees at once to check *the morphological characters* for species identification of ambrosia beetle.

Characteristic of Sonokembang Tree`s Damage

All of sonokembang trees on 76 roads were observed in a week regularly for seven weeks. Characteristic of attacked and damaged trees were described by using symptom and sign on stems and leaves. All characters were clearly described and documented. Picture was also used to described symptom and sign of tree`s damages.

The Intensity of Dying Trees

Numbers of healthy, attacked and dying trees were recorded to estimate intensity of dying trees. Each healthy, attacked and dying tree were marked and recorded. All of sonokembang trees on 76 roads were observed in a week regularly for seven weeks and then data was classified into two groups i.e.: dry and rainy season. By MS-excel 2010, chart was used to describe the intensity of dying trees for each season.

Distribution of Dying Trees

Digital Map was created to clarify the distribution of dying and attacked trees in dry and rainy season. Map of Malang city was collected from Laboratory of Geographic Information System, Faculty of Agriculture, University of Brawijaya, Malang (Figure 1). Global Positioning System (GPS) data was collected from each dying trees on 76 roads based on seven weeks observation. Distribution pattern of dying trees was made from GPS data by using ArcGIS software.

Distribution of Holes Based on Sunlight Exposure

Eighteen trees were selected as sample to describe the distribution of holes on stem. We divided samples into two groups (in qualitative measurement), i.e.: exposed stem`s side (much sunlight exposure) and unexposed stem`s side (less sunlight exposure) by sunlight between morning and noon periods. We compared two aspects of stems to the sunlight exposure such as size of stem`s diameters and vertical position of stems. Eighteen trees were divided into three categories based on size of stem`s diameter and vertical position of stems. First categories of stem`s diameters was small size (19.0-35.5 cm), medium size (36.0-45.5 cm) and large size (46.0-59.0 cm).

Second categories based on vertical position of stems included lower part (5-26 cm), middle part (57-78 cm), and upper part (109-130 cm) from ground. Finally, we compared between two groups based on sunlight exposure for eighteen tree`s samples. Transparent plastics and permanent inks were used as tool to calculate the number of hole. Total number of holes were calculated for each stem`s side and compared each other. By using MS-excel 2010, T-test was used to compare data of number of holes between two aspects.

Distribution of Holes Based on Vertical Position of Stems

Eighteen trees were used as samples and divided into three parts for each tree. Distribution of holes on stem vertically was described based on three parts such as 5-26 cm (lower part), 57-78 cm (middle part) and 109-130 cm (upper part) from basement. Transparent plastics and permanent inks were used as tool to calculate the number of hole for each part. Transparent plastic was attached on bark in three heights (parts) and counted by making mark on it. Total number of holes was calculated for each (height) part and compared each other by using analysis of variance (anova) and continued by post hoc (Tukey). SPSS 17 was used as statistical software.

Distribution of Holes Based on Stem`s Diameter

Eighteen trees were divided into three groups based on the size of stem`s diameter, and six trees for each group. Stem diameter were divided on three categories i.e. small size (19.0-35.5 cm), medium size (36.0-45.5 cm) and large size (46.0-59.0 cm). Transparent plastics and permanent inks were used to count the number of hole. Total number of holes was calculated for each stem`s diameter and compared each other by using analysis of variance (anova) and continued by post hoc (Tukey). SPSS 17 was used as statistical software.

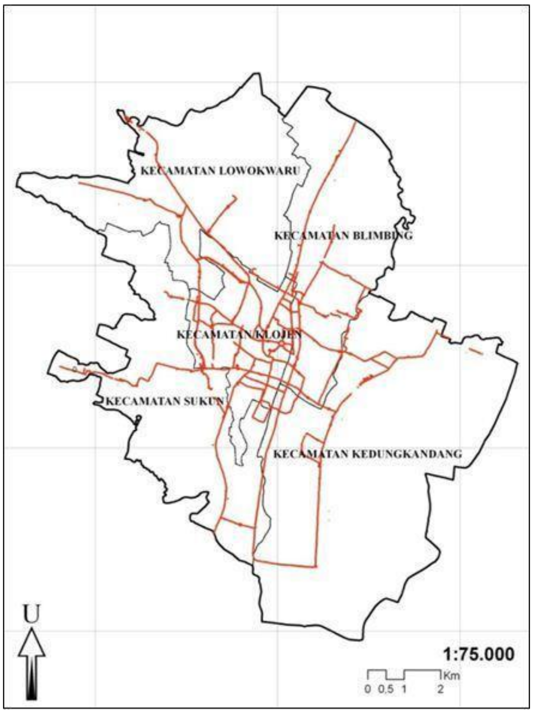

Figure 1. Seventy six roads in Malang city (shown by red line)

Morphological Characteristic of Beetle on Sonokembang

Beetle`s samples were collected from five attacked trees at once to clarify species of beetle. Beetle`s samples were handpicked and then fixed by 70% alcohol. Clarification of beetle`s samples was conducted by using Wood (1993) and Atkinson (2011) for species level. Identification of samples and analysis of data were conducted in the laboratory of entomology, Faculty of Agriculture, University of Brawijaya, Malang.

In addition, we also collected data of temperature from Station of Climatology, Meteorology and Geo-physic (BMKG) Karang Ploso, in Malang. Temperature was used only from May to June and from October to November 2012.

RESULTS AND DISCUSSION

Characteristic of Sonokembang Tree`s Damage

Based on our observation, symptom on attacked trees by ambrosia beetle was described as fallen leaves. Sign was shown by some holes on tree's stems and branches, frass around holes and on ground. In addition, occasionally there was a red color around new holes (Figure 2e). Dying trees showed signs such as a lot of holes (Figure 2b) and much frass. Stems or branches of attacked trees shown dying symptoms (Figure 2a) and all leaves were fallen down (Figure 2c). On attacked and dying trees, there were two types of frass produced, fibrous and powdery frass. During observation, powdery frass dominated (Figure 2f). Diameter average of holes was 1.9 ± 0.2 mm. Gallery pattern inside of stems was clearly shown with a black color (Figure 2d).

There was evident that dying trees were caused by tiny beetle, and commonly called as ambrosia beetle. On all of dying trees were found some indicators related to ambrosia beetle activities such as frass and the beetle itself. Sanderson *et al.* (1996) mentioned that in Singapore, during 10 months periods there were 87% of 147 wilting *P. indicus* trees had been attacked by ambrosia beetle (*Platypus* spp.) and struck by lightning. In urban area of Campinas City, Brazil, there was also infestation of Platypodids on trees (Queiroz and Garcia, 2007).

Frequently, on attacked and dying trees, frass was adhered on holes, branches, stems and on ground. Tarno *et al.* (2011) mentioned that there were two types of frass produced by Japanese ambrosia beetle, *Platypus quercivorus* (Murayama), and same types were found in this research i.e.: *fibrous* and *powdery frass*. Fibrous frass was produced by adult beetles both male and female beetle and powdery frass was produced by larva after adult beetles stopped their activity in gallery's making (Tarno *et al.*, 2011).

There were some reports related to damage on trees because of ambrosia beetle, such as *Platypus quercivorus* in Japan and *P. koryoensis* in South Korea. In Japan, *P. quercivorus* caused serious damage on Japanese Oak forest, and they make gallery inside wood laterally and vertically (Kinuura and Kobayashi, 2006). *Platypus koryoensis* was identified as ambrosia beetle in South Korea and they produce the same symptoms and signs such as Japanese ambrosia beetle (Moon *et al.*, 2008). In United State, there were seven species of Platypus and four species found in Florida (Atkinson, 2011). All species in Florida caused dying trees and give economic impact in United State (Atkinson, 2011). In Brazil, *Platypus parallelus* and *P. sulcatus* were found attacking 16.2% of the trees, mainly in the Caesalpinaceae family (96% of the records). *Platypus parallelus* was more frequent than *P. sulcatus* in *Cassia* spp. and *Caesalpinia ferrea* (Queiroz and Garcia, 2007).

Ambrosia fungi were reported as carried plant pathogen of ambrosia beetle. In Japan, *Raffaelea quercivora* (Kubono et Shin) was ambrosia fungi that carried by *P. quercivorus* (Kubono and Ito, 2002). Indication of fungal infection and mass attack by ambrosia beetle in Japan was described clearly in wood (Kuroda and Yamada, 1996; Ito and Yamada, 1998; Ito *et al.,* 1998). In South Korea, *P. koryoensis* has been reported as a major pest of oak trees, because it causes sooty mold of oak by introducing the pathogenic fungus *Raffaelea* sp. (Moon *et al.*, 2008). Between 1980 and 1992, over 800 trees were removed as a consequence of the disease caused by *Fusarium oxysporum* carried by *Platypus* spp. (Sanderson *et al.*, 1996; Sanderson *et al.*, 1997a; Sanderson *et al.*, 1997b).

Distribution of holes based on sunlight exposure. Based on T-test, there was no different between number of holes on surface of stems under much sunlight exposure and less sunlight exposure based on vertical position of stems. Few number of samples have to be responsible factor to make no different result. It was clearly described when we compared all of samples of trees as cumulative samples (Table 1), there was difference between much sunlight exposure and less sunlight exposure. It means that commonly ambrosia beetles preferred to attack stem sides with much sunlight exposure. In Japan, adults of *P. quercivorus* have positive phototaxis and prefer to healthy trees (Igeta *et al.*, 2003). Positive phototaxis behavior of ambrosia beetle can guide beetle to choose stem sides of trees with much exposure of sunlight.

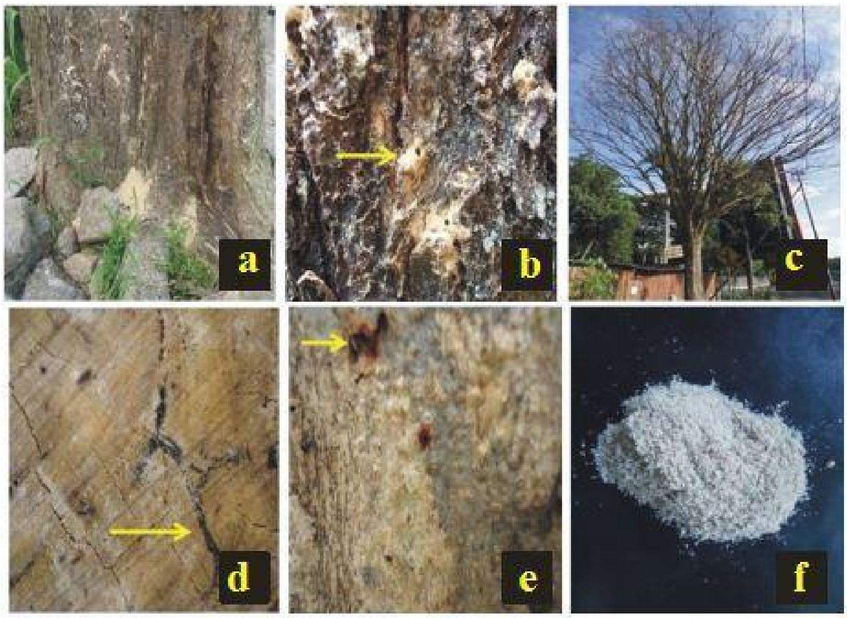

Figure 2. Sign and symptoms of attacked and dying trees, i.e.: Frass on basement of tree (a), holes on stem (b), fallen leaves (c), gallery pattern inside tree's stem and branches (d), red color around newly hole (e), and powdery frass (f)

Table 1. Number of holes based on sunlight exposure based on categories

Categories	Number of Holes (Average±SE)	
	Much Sunlight Exposure	**Less Sunlight Exposure**
Position of Stem:		
Upper (109-130 cm)	24,556 ± 3,785 *ns*	20,611 ± 3,468 *ns*
Middle (57-78 cm)	22,111 ± 3,499 *ns*	18,500 ± 2,942 *ns*
Lower (5-26 cm)	14,444 ± 2,269 *ns*	13,778 ± 1,837 *ns*
Stem Diameter:		
Small (19.0-35.5 cm)	16,278 ± 3,289*	10,722 ± 2,448*
Medium (36.0-45.5 cm)	22.944 ± 4,080*ns*	24.000 ± 3,478*ns*
Large (46.0-59.0 cm)	21,889 ± 2,453*ns*	18,167 ± 1,481*ns*
Cumulative (All tree`s samples)	20.339 ± 1.935*	17.736 ± 1.651*

Remarks: T-test was used to compare between much and less sunlight exposure; * shown there was differences between much and less sunlight exposure; *ns* shown there wasn`t significant differences.

Distribution of Holes Based on Vertical Position of Stems

In Table 2, number of holes on three different position of stem vertically showed that there were differences between upper stem and others. It means that beetle preferred to attack upper stem (up to 109 cm from above ground). This result, supported by Igeta *et al.* (2004) that adults of *P. quercivorus* preferred on trees less than 250 cm from ground.

Table 2. Number of holes based on vertical position of stems

Stem position vertically	Number of Holes (average ± S.E.)*
Upper (109-130 cm)	22.583 ± 2.551*b*
Middle (57-78 cm)	20.306 ± 2.274*ab*
Lower (5-26 cm)	14.111 ± 1.440*a*

Remarks: *Based on Tukey's post hoc on 95% significant level

Table 3. Number of holes based on diameter of stem

Diameter of stem	Number of holes (average ± S.E.)*
Small (19.0 – 35.5)	13.500 ± 1.488 *a*
Medium (36.0 – 45.5)	23.472 ± 2.644 *b*
Large (46.0 – 59.0)	20.28 ± 2.045 *ab*

Remarks: *Based on Tukey's post hoc on 95% significant level

Distribution of Holes Based on Stem`s Diameter.

Number of holes on three different stem`s diameter showed that there were differences between three sizes of stem diameter (Table 3). Medium diameter of stem (36.0-45.5 cm) was significantly different with others. Average of number of holes on medium diameter of stem was 23.472 ± 2.644. It means that beetle preferred to attack medium and bigger size of stem diameter. Stem with bigger diameter tend to provide the bigger volume of sapwood. Bigger volume of sapwood will provide enough area for ambrosia beetle. It's related to the case of rearing of Japanese ambrosia beetle, where ambrosia beetle preferred to bigger size of oak logs (Kitajima and Goto, 2004; Tarno *et al.,* 2011). In the forest, tree size can be an important factor for tree selection by *P. quercivorus* (Yamasaki and Sakimoto, 2009) and the larger diameter trees having the highest incidence of *P. subgranosus* attack (Elliot *et al.,* 1987).

Morphological Characteristic of Beetle on Sonokembang

Based on morphological characteristic of beetles, beetle`s samples were collected from all sides in Malang city can be classified into Platypodinae with clubbed antenna, round and convex eyes, and brown body (Figure 5a). Boror and Dwight (1992) mentioned that beetles commonly with brown color and 2-8 mm in length. Their pregule sclerite was narrow and similar to their pregule (Figure 5a). This beetle can be classified into Platypodini with distance on posterior of prothorax extremely tend to pleural area and mesoepisternum clumb. Protibia on male was protected by four or more hairs (Figure 5c) and there was suture in tip with or without tubercles and spines (Figure 5b). They had body's length ca. 4 mm (Figure 3a-b and 4a-d). Pronotum without conspicuous pores in either sex and based on elytra of beetle`s samples, declifity of male elytra was same to the declifity of *Euplatypus parallelus*. Atkinson (2011) explained that on male elytra of *P. parallelus* (synonim of *E. parallelus*), male elytral striae deeply impressed, subequal in width to interstriae at base of declivity.

In Indonesia, there is no research related to this beetle. Beaver (1999) reported that *E. parallelus* (F.) is of American origin, and is abundant in the forests of Central and South America. Wood and Bright (1992) described that it was introduced to and has an extensive distribution inthe Afrotropical region. *Euplatypus parallelus* are extremely polyphagous and commonly attracted to light (Atkinson, 2011). In Asia, especially Malaysia, Singapore, Thailand and India, there were several reports related to *Euplatypus* (Sanderson *et al.,* 1997a; Sanderson *et al.,* 1997b; Bumrungsri *et al.,* 2008 and Maruthadurai *et al.,* 2013). *Euplatypus parallelus* was also found in USA such as Florida (Atkinson, 2011), Texas and Oklahoma (Atkinson and Riley, 2013), In South America, Brazil there were some reports about *Euplatypus* (Queiroz and Garcia, 2007; Zanuncio *et al.,* 2002).

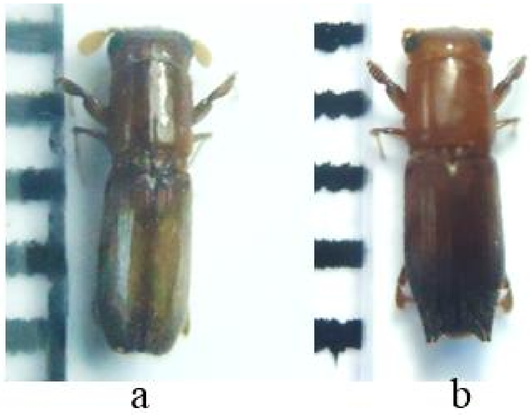

Figure 3. Morphological characteristics of beetle in whole body, Female (a) and Male (b)

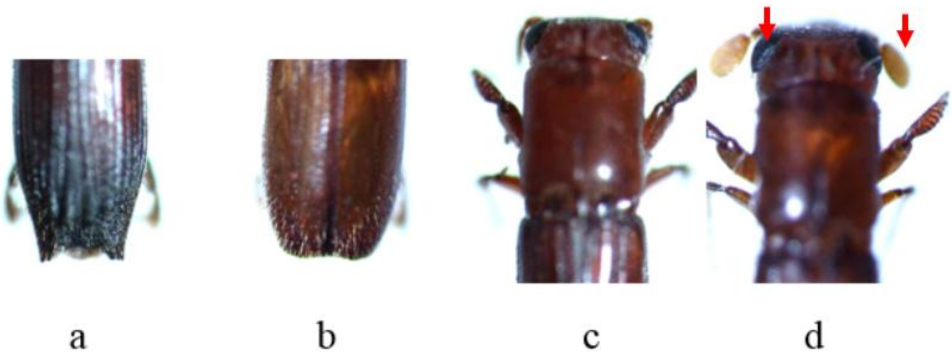

Figure 4. Morphological characteristics of beetle in each part of body, Abdomen of male (a), Abdomen of female (b), Caput and thorax of male (c), Caput and thorax of female with the clubbed antenna and round-convex eye (d)

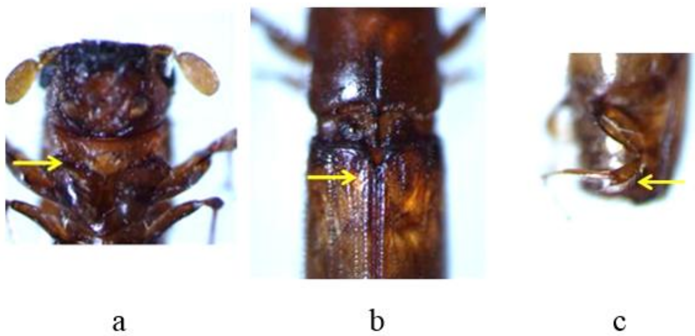

Figure 5. Morphological characteristic of beetles, sclerite pregule (a) and tubercle on female (b), hair on pretibial of male (c)

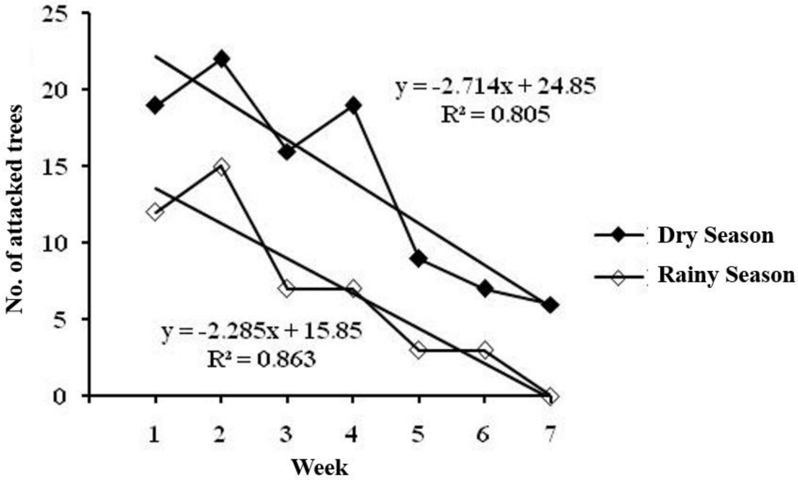

Figure 6. Relationship between additional number of attacked trees and week observation on dry season (from May to June 2012) and rainy season (from October to November 2012)

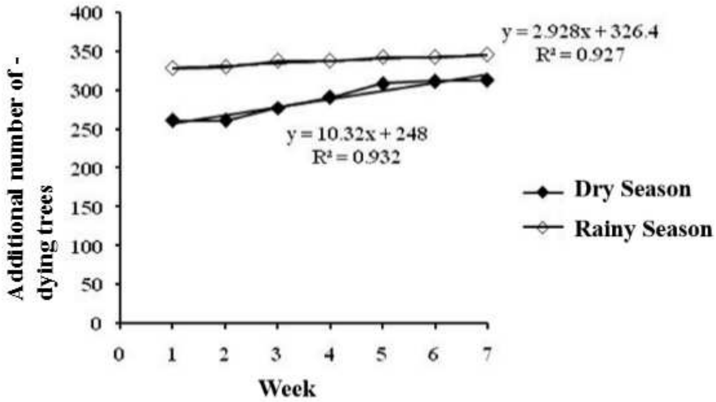

Figure 7. Relationship between additional number of dying trees on dry season (May-June 2012) and on rainy season (October-November 2012)

The Intensity of Dying Trees

From 3,206 sonokembang trees on 76 roads in five sub districts of Malang city, mostly on every road was found dying trees (Figure 8 and 9). In total 53 (69.7%) roads was found dying trees.

It's meant that dying trees was distributed on mostly road in Malang. Five sub districts of Malang city was occupied by dying trees. Increasing of attacked and dying trees on dry and rainy seasons was shown in Figure 6 and 7. In the end of observation, the intensity of dying trees was 10.79%.

In dry season, the intensity of dying trees increased from 8.14 to 9.76%. Number of attacked trees tends to decrease in the end of dry season. In the rainy season, the intensity of dying trees increased from 10.26 to 10.79%. Similar case with dry season was occurred that number of attacked trees tends to decrease in December 2012. Between dry and rainy season, there were similar tendency, number of attacked trees tended to decrease however the intensity of dying trees increased slowly for each season. Indonesia as tropical country provides stable temperature in a year, and temperature between dry and rainy season was no different (Table 4). Beetle can survive on the average of temperature during dry and rainy season (22.7-24.7°C) and range of temperature from 19.9 to 30.3°C). It's related to preferences of Japanese ambrosia beetle (*P. quercivorus*), where they have the best survival temperature 25° C (Kitajima and Goto, 2004).

Table 4. Temperature for each month, during observation periods in Malang city

Temperature	Months (in 2012)			
	May	June	Oct.	Nov.
Average (°C)	23.7	22.7	24.6	24.7
Range (°C)	19.9-28.0	21.0-24.6	19.7-30.3	21.1-29.5

Remarks: Data was collected from BMKG (2012) Oct: October Nov: Novmeber

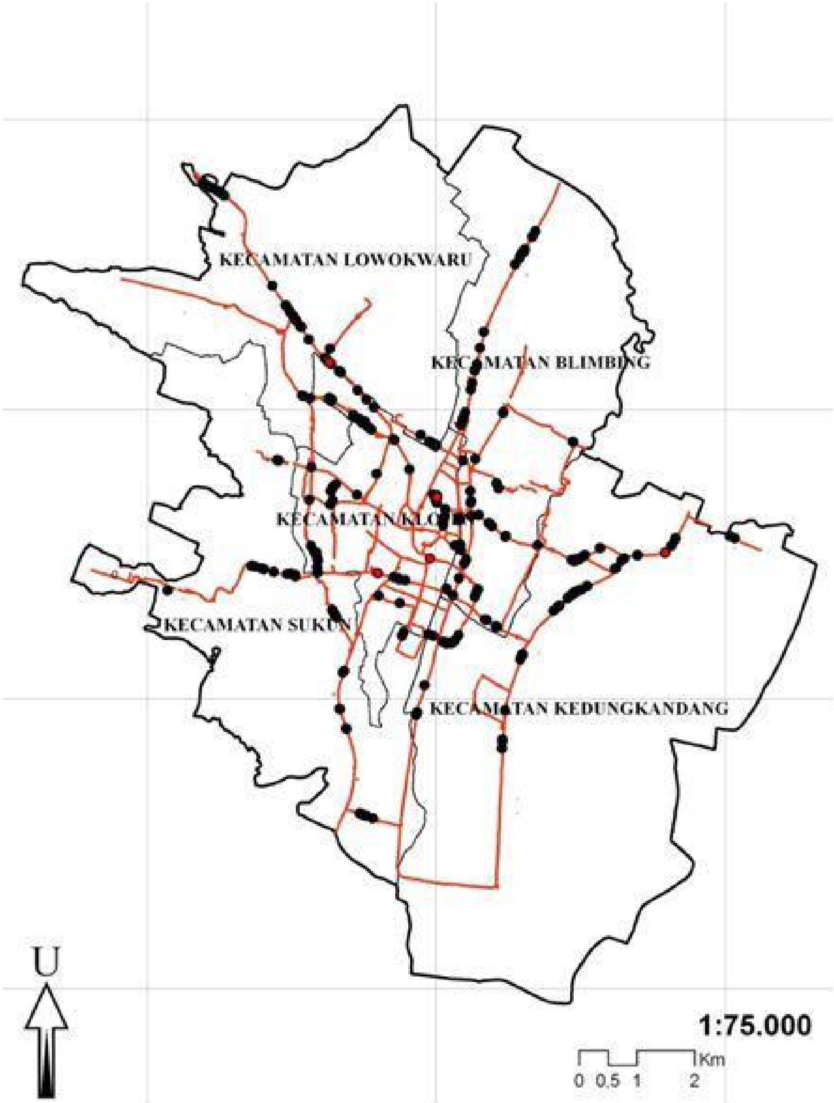

Figure 8. Distribution of dying (with black mark) and attacked (with red mark) trees in June 2012 in Malang city

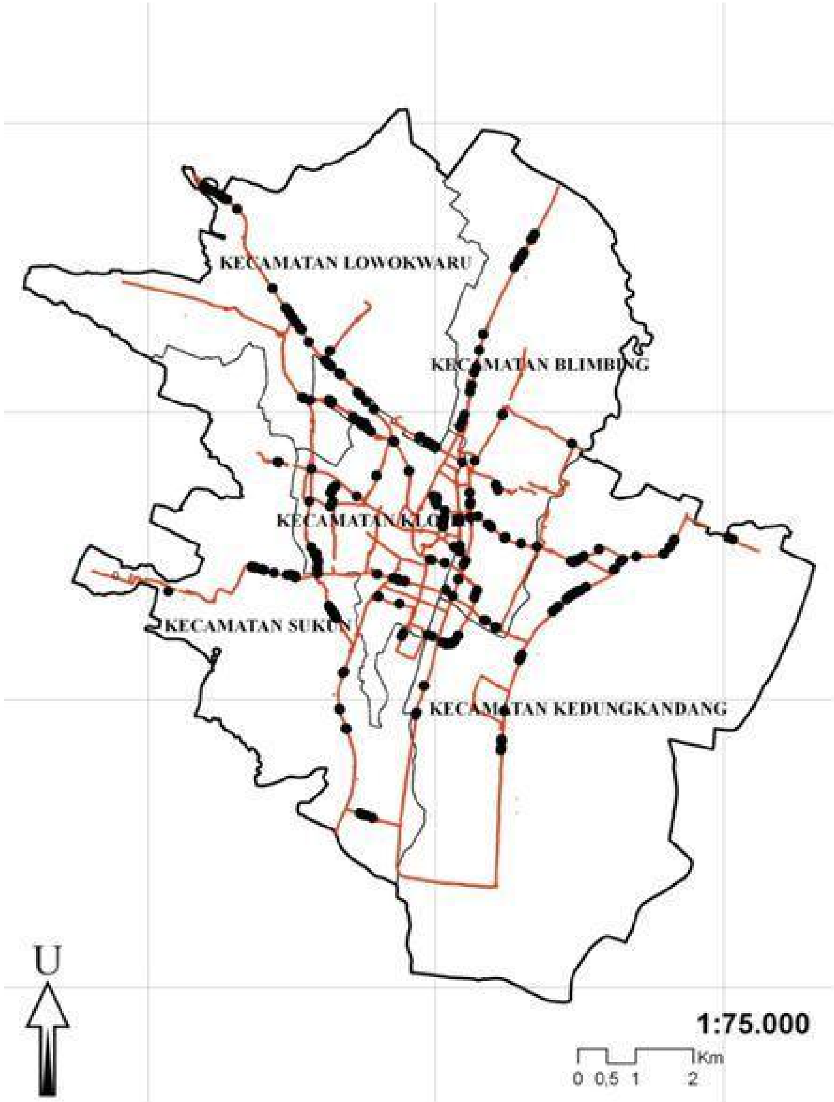

Figure 9. Distribution of dying trees in November 2012 in Malang city

CONCLUSIONS

There were unique damaging characteristic such as dying and then fallen leaves, holes on the stem and branches, and frass production. *Euplatypus parallelus* (F.) was identified as a causal agent of dying sonokembang trees. There were some indications shown by beetles, i.e.: beetles preferred to attack stem sides with much sunlight exposure, upper stem (up to 109 cm from above ground) and medium or bigger size of stem diameter. From 3,206 sonokembang trees on 76 roads in five sub districts of Malang city, 53 roads (69.7%) were found dying trees. In dry season, the intensity of dying trees increased from 261 to 313 (8.14-9.76%). In the rainy season, the intensity of dying trees increased from 329 to 346 (10.26 to 10.79%). Number of attacked trees tends to decrease in the end of dry and rainy season.

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