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Coptotermes sp. (RHINOTERMITIDAE: COPTOTERMITINAE) INFESTATION PATTERN SHIFTS THROUGH TIME IN OIL PALM AGROECOSYSTEM

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ABSTRACT

Status of termite pest infestation as well as the changes through time, corresponding to oil palm conversion from peat in Malaysia can be studied. In accessing the status of palms infested by *Coptotermes* sp., stand scouting method was conducted to map the presence of this genus as well as the infestation status in each palm. The palms were accessed from ground level to hand-reached level and this was done in 24 ha field block with deep peat soil. The presence of *Coptotermes* sp., dead and replaced palms were recorded on census sheet, designed according to the real ground arrangement of the palms. Advanced spatial pattern by distance indices (SADIE) was adapted to generate the indices of aggregation and clustering values for each study sites. These values were exported into SURFER 8 software to generate red-blue contour maps with patches and gaps. Standardized stand scouting method yielded in six *Coptotermes* species collected in peat swamp converted oil palm field. The distribution pattern of *Coptotermes* caused by the environmental influences as well as the availability of wood resources. The patch and gap areas as well as the random areas are not consistently occurred. Small patches divided by gaps indicate one termite colony while larger patches are formed by more than one colony. This study contributes in the information on spatial pattern of termite pest species in oil palm plantation. The latter may present the changes in the status of the species over time.

Key words: *Coptotermes* sp., spatial pattern, infestation, oil palm

ABSTRAK

Status infestasi anai-anai perosal dan perubahan taburan ruang dan masa, kesan daripada perubahan status hutan paya kepada ladang kelapa sawit dapat dikaji. Teknik sensus dijalankan untuk mengenal pasti status pokok sawit yang telah diserang oleh *Coptotermes* Setiap pokok disensus dari aras tanah hingga aras yang tercapai oleh tangan. Kajian ini dijalankan dalam kawasan seluas 24 hektar. Kehadiran anai-anai, pokok mati dan pokok sulam dicatatkan dalam borang sensus yang menunjukkan kedudukan sebenar pokok dalam blok. *Advanced spatial pattern by distance indices* (SADIE) digunakan untuk mendapatkan bacaan indeks pengagregatan dan pengelompokan bagi setiap blok. Bacaan indeks ini dieksport ke perisian SURFER 8 untuk menghasilkan peta kontur merah-biru yang mencirikan tompok dan luang. Terdapat enam spesies *Coptotermes* disampel daripada kajian ini. Perebakan anai-anai ini disebabkan oleh faktor sekitaran seperti ketersediaan sumber kayu. Tompok yang dihasilkan bagi setiap peta adalah tidak konsisten. Tompok kecil yang dibahagi oleh luang menggambarkan kedudukan satu koloni anai-anai manakala tompok yang besar merupakan hasil daripada lebih dari satu koloni. Kajian ini menyumbang kepada maklumat mengenai perebakan anai-anai perosak dalam ladang kelapa sawit dan status perubahannya.

Kata kunci: *Coptotermes* sp., taburan ruang, infestasi, kelapa sawit

INTRODUCTION

Malaysia and Indonesia are the two leading countries in oil palm production from total of 14.5 million hectars oil palm land cover worldwide, especially on 2010, in the Indonesia, the extent of oil palm plantations reached 7.7 Mha of which 78% was found on mineral soils and 22% occurred on peat soils. In Malaysia, it reached 5.4 Mha where 87% occurred on mineral soil and 13% on peat soils (Gunasro et al. 2013; Wendy et al. 2015). However, this achievement is limited by the presence of major termite pest, the subterranean termites which utilize woody materials as their habitat (Lee 2002b; Lee et al. 2007; Tho 1992). Naturally, termites are beneficial creatures assisting in ecological processes which benefit themselves and other organisms around (Miller 2010). As an ecosystem engineer, they act as decomposers for living and dead forest trees (Apolinario & Martius 2004; Black & Okwakol 1997). Besides, they involve in soil modification, nitrogen fixation as well as droppings recycling (De Bruyn & Conacher 1990; Freymann et al. 2008; Lavelle et al. 1997; Lee & Wood 1971; Yamada et al. 2006). Nevertheless, in urban and converted land they are pest to dead logs and living plant tissues (Lee 2002b). Fortunately, among more than 2600 termite species recorded (Thapa 1981; Tho 1992), only 10% are considered as pest (Lee 2002b).

According to Lee & Wood (1971), lower termites i.e. *Coptotermes* sp., *Schedorinotermes* sp., and members of Kalotermitidae are the pest of living trees, specifically wood crops. The most significant termite genus worldwide, *Coptotermes* feeding on living plant tissues as food source (Apolinario & Martius 2004; Lee & Wood 1971). They are the most common issue in oil palm plantation as their occurrence infesting palm trees severely (Lee 2002b). *C. curvignathus* Holmgren is commonly found in oil palm plantation damaging the palm trees (Lee 2002b). Study done by Vaessen et al. (2011) revealed *C. curvignathus* also present in near-natural peat soil type. Biologically, they attack living trees by building soft-brown coloured mound and trails from the core part of the trees and these structures cause damage and destruction to trees (Apolinario & Martius 2004). Study by Apolinario & Martius (2004) revealed that the core part of living trees comprises of stagnant tissues. Thus, this is the best condition for this species to trail into the part and in the same time damaging the tissues (Apolinario & Martius 2004) especially palm trees which are susceptible to pest attack.

Termite spatial patterns are less interested compared to their economic problem and their management practices (Tracy et al. 1998). Besides, most of the study on termite spatial pattern were generated through transect methods as reported by most publications (Davies et al. 2003; Tracy et al. 1998). Thus, we proposed to involve in field based observation in oil palm ecosystem. This research aims to report the shifting in termite pest infestation through time and the changes in the level of infestation.

STUDY AREA

Three study sites in Endau Rompin (ER) Estate, Pahang, Malaysia were chosen i.e. B37Ea, B36Ca and B36Aa (Fig1). The study sites were a peat swamp forest in the first place until in 1995, oil palm plantation was established by Yayasan Pahang Plantation. The mean monthly raining ranged from 191.08 mm to 454.58 mm from year 2007 to 2011. The soil types of this plantation are peat (shallow and deep) and clay. Only the deep peat area is included in the study fields because of the high termite pest infestation reported in these areas (Nur-Atiqah & Faszly 2015). The sampling was conducted in three phases, between year 2005 and 2011, i.e. phase 1: year 2005, phase 2: year 2009 and phase 3: year 2011.

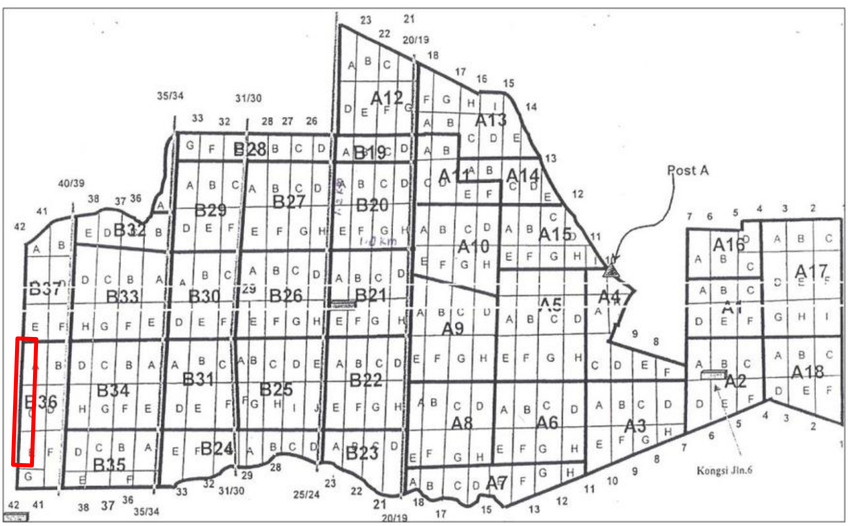

Fig 1. Map of Endau Rompin Plantation. Red box indicates the field blocks involve in this study

The field blocks in ER Estate consist of rows of palm trees, harvesting paths, field drains and stacking rows in a 16-ha field block (245 m x 654 m) (Fig 2). The rows in which palm trees planted are known as the planting rows with maximum of 30 palms per row, planted about 9 m apart. Palm trees were planted alternately in maximum of 80 rows, divided by 19 drains for each block. Each of the two rows is alternated with a harvesting path, an area where the workers performing the harvesting tasks. There are field drains dividing each four rows of palm trees, and stacking rows where the excess vegetations i.e. palm leaves, tree trunks, etc. were placed. Only the west part (14 palms) in each row were included in this study because the blocks are divided by a field drain aligned accross the middle of the blocks.

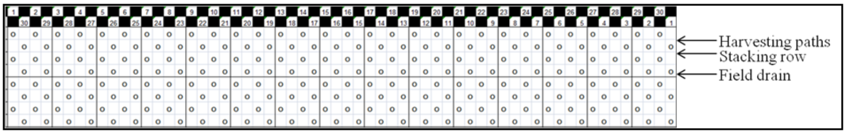

Fig 2. Rows of palm trees with alternating harvesting paths, stacking rows and field drains. Drains located at the middle of the block, dividing the blocks into two parts (B37Ea and B37Eb, B36Aa and B36Ab, and B36Ca and B36b)

MATERIALS AND METHODS

Termite sampling

In this study, termites' infestations were characterized as termite trails, nest structures, or mounds encountered at individual palm tree, from base of the trunk to hand-reached level. The dead and replaced palms were counted as damaged palms infested by termite pests. The scouting was started from the first row of palm trees adjacent to the road and continuously scouted through the block boundary at the end of the rows. The specimens were scooped into cleared plastic bags together with the soils and the fragments. Each plastic bag was labeled with the number of block, tree and row where they were collected.

The presence of termite was marked on a census sheet, designed according to the alternate original stand of palm tree in the block area. The dead and replaced trees were also marked on the census sheet for further reference in analysis of termite infestation.

Sorting was generally conducted in the same day after the census activity to prevent any damage to the specimens. Termites' workers, soldiers and the alates (if present) were preserved in the vials with 70% ethanol. The specimens were again labeled with date, block number, tree and row respectively where they were collected.

Identification of species

The specimens collected were identified to the species level by referring to Tho (1992) and Thapa (1981). The identification was accomplished by comparing the external features of the soldier castes. Then, all the vials with specimens were deposited at the National Centre for Insects Systematic (CIS), Universiti Kebangsaan Malaysia, Selangor, Malaysia.

Data analysis

The palms on census sheet were divided into 8-palms per grid as sampling unit. Each sampling unit received a description of the spatial position through metric coordinates, the x and y. The analyses were focusing on the spatial pattern of the *Coptotermes* sp. communities in the area itself in which an advance spatial pattern analysis, SADIE was adopted for mapping effort for spatial pattern. This analysis can be used to detect any relationship from the different blocks and time as the similar sampling blocks were accessed throughout the study make the analysis possible (Blackshaw & Vernon 2006). SADIEShell version 1.22 (Conrad 2001) was employed to indices for further analyses for the infestation movement of *Coptotermes* sp.

throughout the study. Each sampling unit were placed according to the x and y coordination in the sampling plot.

The infestation count data was interpreted in contour maps for three different sites which are evidently comparable in the contour maps for highly aggregated field blocks in 2005, 2009 and 2011. Patches of infestation is caused by *Coptotermes* sp. detected infesting palm trees (1 point), the dead palms damaged by termite pest species (10 points), and the newly replaced palms (1 point). The poins indicate the intensification of infestation in the estate.

The index are used to determine the local spatial pattern at each sample point (Blackshaw & Vernon 2006). The index of aggregation for random population is in between -1.5 to 1.5. For a clustered population, the index, V_i will be greater than 1.5 (red) while for gap cluster, V_j it will be less than -1.5 (blue). Large counts of infestation are considered as patches while random and small counts are gaps (Blackshaw & Vernon 2006; Donovan et al. 2007). The values of I_a indicate the type of distribution occur in the field, $I_a>1$ (aggregated), $I_a=1$ (spatially random), and $I_a<1$ (regular)(Perry 1998).

In order to generate distribution map, SURFER 8 was employed for generating maps of changes in termite pest infestation pattern. The indices yielded from SADIE were utilized to visualize the clustering patterns by generating the contour map.

RESULT AND DISCUSSION

Standardized stand scouting method yielded in six *Coptotermes* sp. collected in peat swamp converted oil palm field, namely *C. curvignathus, C. kalshoveni, C. sepangensis, C. gestroi, C.*

havilandi and C. travians (Table 1). The number of termite species under genus *Coptotermes* is considerably high when compare with Vaessen et al. (2011) (one species), Kon et al. (2012) (three species) and Bong et al. (2012) (three species).

The most significant species, *C. curvignathus*, and *C. Sepangensis* were found in all three years. Comparing to natural forest, the sampling yielded only one species of termite, *C. Curvignathus* (Hanis et al. 2014; Keng & Rahman 2012). The conversion of peat soil into oil palm plantation maintains *C. curvignathus* as in the natural ecosystem. According to Vaessen et al. (2011) this species was found in near natural peat soil area. As the plantation commenced, this species emerged in an uncontrollable manner and starts infesting palms after decomposing the excess unlogged wood source. But Vaessen et al. (2011) transect protocol revealed that *C. curvignathus* was not found in newly planted oil palm plantation as well as in cleared oil palm estate.

Table 1. *Coptotermes* sp. occurence in all three field blocks from 2005 to 2011

Species/year	2005	2008	2011
C. curvignathus	/	/	/
C. sepangensis	/	/	/
C. kalshoveni	/		/
C. travians		/	/
C. gestroi	/		
C. havilandi		/	

Coptotermes is a wood nester and wood feeders (Rahman & Tawatao 2003). Coptotermes infestation distribution in all study fields are aggregated (I_a>1) and significantly clustered except for B37E in 2009 (P>0.05) (Table 2).

In region B37E, patches of infested regions in 2005 were found in a small patch at the upper center of the block and four years later, the infestation moves slightly to the east, turns out not significantly clustered (Fig 3). The gap area is decreased, leaving more random distribution area. But the patch increase into two small patches. In 2011, termite patches start filling the gap and random areas. Three large patches of infestation observed, one patch in the north area and two separated patches close to the central region of the block, indicating a severe increase in termite pest infestation.

Block B36A shows increase in termite infestation in 2009 compared to 2005 as large infestation patches of *Coptotermes* sp. emerged. But in 2011, a new infestation area in south region was observed as the old infestation area shrinks. The termites start the colonization to a new area at south, most probably because they might have utilized the wood resources in the areas and start shifting.

There was a different infestation shift pattern in block B36C for the three different years. In 2005, infestation areas of *Coptotermes* sp. was observed in west area but in 2009, the infestation become larger and move to the southern part filling the blank random area. In 2011, the infestation at south decreases and the infestation occurs at north with higher area of random distribution.

B36A located exactly at the upper north of B36C. In 2005 and 2009, termite distribution patches at the outer region of these blocks but in 2011, they shift to area between the blocks. In more than five years, they might have used all the wood resources in the area and start shifting, possibly from year 2010. The same pattern occured in B37E where termite distribution start filling the random and gap areas. The distribution pattern of

Coptotermes may cause by the environmental influences as well as the availability of wood resources (Donovan et al. 2007).

The patch and gap areas as well as the random areas are not consistently occurred. This indicate that all areas have no physical barriers for dispersal and are suitable for colonization (Donovan et al. 2007). Besides, moisture level affect the distrbution of termite species but *Coptotermes* may adapt well to many range of moisture in the environment (Gautam & Henderson 2011).

Termite spatial pattern is also affected by the changes of soil and plant covering the areas (Davies et al. 2003). Foraging territory of *C. Curvignathus* is 15 to 50 m^2 while *travians* ranged between 125 - 384 m^2 (foraging distances of 17-32m)(Lee 2002a; Sajap et al. 2000). Small patches divided by gaps indicate one termite colony while larger patches are formed by more than one colony. The patchiness observed in the generated map revealed that dead and replanted palm trees amplify the spatial dynamic to the *Coptotermes* infestation.

CONCLUSION

This study contributesin the information on spatial pattern of termite pest species in oil palm plantation. The latter may present the changes in the status of the species over time.

Table 2. SADIE value for patches of intensification of *Coptotermes* sp., dead palms and replaced palms. *$P<0.05$; I_a = index of aggregation; Mean V_j = average value of Ia for gaps; Mean V_i = average value of Ia for patches

Year	Block	Clustering Index, I_a	P_a	Mean V_j	P(Mean V_j)	Mean V_i	P(Mean V_i)
2005	B37E	1.4910	0.0422*	-1.5150	0.0375	1.4340	0.0550
	B36A	2.0520	0.0018*	-2.0240	0.0022	2.1200	0.0010
	B36C	1.7700	0.0114*	-1.7920	0.0064	1.6670	0.0139
2009	B37E	1.1500	0.1877	-1.1830	0.1644	1.1380	0.2029
	B36A	4.2470	0.0002*	-4.3320	0.0000	4.4240	0.0000
	B36C	4.0230	0.0002*	-4.1520	0.0000	4.1080	0.0000
2011	B37E	2.9760	0.0002*	-3.0030	0.0000	2.8080	0.0000
	B36A	2.1160	0.0010*	-2.0190	0.0022	2.1070	0.0013
	B36C	1.6650	0.0139*	-1.6610	0.0164	1.5950	0.0199

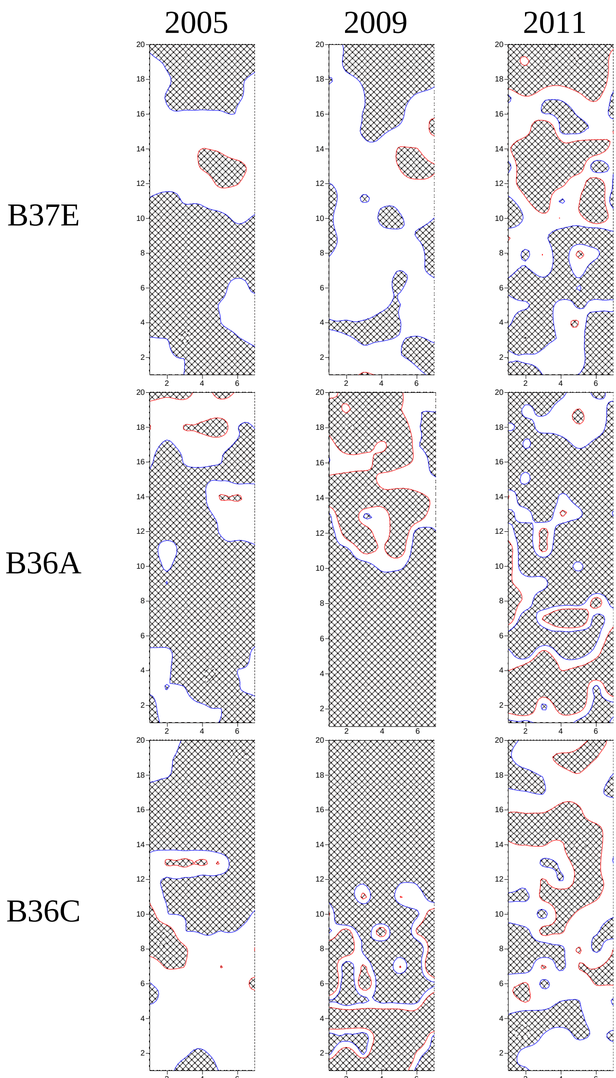

Fig 3. Patches of infestation of *Coptotermes* sp., dead palms and replaced palms in three field blocks in year 2005, 2009 and 2011

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