Journal of Tropical Forest Science 11(4):822–831 (1999)

THE PEST STATUS OF THE TERMITE *COPTOTERMES CURVIGNATHUS* IN *ACACIA MANGIUM* PLANTATIONS: INCIDENCE, MODE OF ATTACK AND INHERENT PREDISPOSING FACTORS

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Received May 1998

KIRTON, L. G., BROWN, V. K. & AZMI, M. 1999. The pest status of the termite *Coptotermes curvignathus* in *Acacia mangium* plantations: incidence, mode of attack and inherent predisposing factors. The incidence and mode of attack by the termite *Coptotermes curvignathus* in *Acacia mangium* plantations were determined in 452 living trees sampled using random plots in one eight-year-old and two four-year-old plantations. The overall incidence of infestations was 2.2%, while the highest infestation rate in a site was 4.5%. A few predisposing factors on the tree trunk of living *A. mangium* trees were observed to facilitate entry of *C. curvignathus* into the wood. These were large pruning wounds, abscission scars resulting from natural pruning and damage by an insect bark borer. Infestations restricted to such injuries were much more frequently encountered than severe attack by *C. curvignathus*, which is characterised by extensive soil cover constructed by the termite on the tree trunk. However, such localised external termite activity is thought to be an indication of heartwood infestations, which have been frequently reported to occur in *A. mangium*. Predisposition of trees to heartwood infestations of termites, as a result of heart rot infection caused by fungi, is examined. The pest status of *C. curvignathus* in *A. mangium* plantations is discussed, and recommendations are given for minimising losses in different end-uses of the wood.

Key words: Termite attack - *Coptotermes curvignathus* - pest status - *Acacia mangium* plantations - predisposition

KIRTON, L. G., BROWN, V. K. & AZMI, M. 1999. Status perosak anai-anai, *Coptotermes curvignathus* di ladang-ladang *Acacia mangium*: insidens, kaedah serangan dan faktor-faktor predisposisi bawaan. Insidens dan kaedah serangan anai-anai *Coptotermes curvignathus* di ladang-ladang *Acacia mangium* telah ditentukan dengan pensampelan sebanyak 452 pokok hidup menggunakan petak-petak rawak di sebuah ladang dengan pokok berumur lapan tahun dan dua buah ladang dengan pokok berumur empat tahun. Kadar insidens infestasi keseluruhannya ialah 2.2%, manakala kadar infestasi paling tinggi ialah 4.5%. Beberapa faktor predisposisi pada batang pokok-pokok hidup *A. mangium* didapati memudahkan kemasukan *C. curvignathus* ke dalam batang kayu. Faktor-faktor tersebut adalah parut-parut besar disebabkan pemangkasan dahan, parut semula jadi dari luruhan dahan dan kerosakan oleh serangga pengorek kulit pokok. Infestasi yang tertumpu pada kecederaan-kecederaan tersebut didapati lebih kerap berlaku dibandingkan dengan penyelaputan menyeluruh dengan tanah pada pangkal pokok yang menjadi petunjuk sesuatu pokok telah diserang dengan teruk oleh *C. curvignathus*. Bagaimanapun, aktiviti anai-anai yang kelihatan tertumpu pada bahagian luar batang yang cedera ini dianggap sebagai satu tanda infestasi kayu teras, yang mana telah kerap dilaporkan berlaku keatas *A. mangium*. Predisposisi pokok-pokok kepada infestasi kayu teras oleh anai-anai sebagai akibat daripada infeksi reput teras diteliti. Status perosak *C. curvignathus* di ladang-ladang *A. mangium* dibincangkan, dan cadangan-cadangan diberikan untuk mengurangkan kerugian dalam kegunaan hasil kayu yang berbeza.

Introduction

The termite *Coptotermes curvignathus* Holmgren (Isoptera: Rhinotermitidae) is considered a very damaging pest of cultivated trees in Southeast Asia because of its ability to kill living trees. Its economic importance, host range, behaviour and control have been reviewed by Tho and Kirton (1990). The termite undermines the bark and outer wood of the tree beneath an extensive, constructed cover of soil and faecal matter or, more rarely, gains access to the core of the tree, with little external indication of its presence. A large number of plant species are attacked including agricultural tree crops such as rubber and oil palm and forest plantation trees, particularly conifers. The termite has also been frequently reported attacking *Acacia mangium* in both East and West Malaysia (Mori 1986, Hamid 1987, Tho & Kirton 1990, Intachat & Kirton 1997).

Acacia mangium Willd. (Leguminosae) was introduced from Australia to Southeast Asia, first as a fire-break and later as a fast-growing forest plantation tree species (Yap 1986). It is now one of the most widely planted forest plantation tree species in Malaysia. In this paper, we report the incidence and mode of attack by *C. curvignathus* in *A. mangium* plantations, and discuss factors predisposing the tree species to attack.

Methods

Three *A. mangium* plantations in Peninsular Malaysia were sampled as part of a larger study to determine the effect of large wood remnants on populations of *C. curvignathus*. The three sites were in Kemasul, Ulu Sedili and Batu Arang. Trees were about four years old at Kemasul and Ulu Sedili, and about eight years old at Batu Arang. Initial planting density was about 900 stems per ha, with a spacing of 3.7 × 3.0 m (Anonymous 1989, Weinland & Ahmad Zuhaidi 1991). Sampling was carried out in each site using 25 10 × 10 m plots located 10–40 m from the edge of access roads at random distances along a sampling transect of about one kilometre. Detailed sampling methods and characteristics of each site are given in Kirton *et al.* (1999). Trees occurring within each plot were inspected for the presence of active *Coptotermes* infestations. A tree was considered to have an active infestation if it had termites present under soil cover or runways on the tree trunk, or in dead branch stubs or exposed wood of the living tree. A heavy knife was used to prise open bark or wood that could harbour infestations in the tree trunk. A small voucher collection of soldier termites was, as far as possible, obtained for each infestation, so that identification could be confirmed in the laboratory. A count was made of the number of infested and uninfested *A. mangium* trees in each plot.

In addition to the systematic survey conducted in these three plantation sites, other field visits to these or different sites were made, and the observations during these visits are also discussed. Most of the visits were in response to specific requests of State Forest Departments to investigate deaths of *A. mangium* trees attributed to termite attack.

Results and discussion

Incidence and mode of attack

The overall incidence of infestations of *C. curvignathus* on living trees in the sampling plots was 2.0%, ranging from 4.5% in Ulu Sedili to no infestations in Batu Arang (Table 1). Thinning had been carried out in Batu Arang and, thus, there were fewer trees in the sampling plots in comparison to Ulu Sedili and Kemasul. There was only one dead tree in which mortality may have been due to *C. curvignathus.* This tree, which had the surface of the trunk covered with soil, was in Batu Arang. The only other species of *Coptotermes* that infested living *A. mangium* trees was *C. kalshoveni,* found only once in the hollowed base of a tree trunk in Ulu Sedili. This species has also been found feeding on a dead portion of a living *A. mangium* tree trunk in Kemasul, and feeding in the heartwood of a living tree felled in Batu Arang. Species from other termite genera may also infest the heartwood of *A. mangium*; we have found at least one other termite species in the heartwood of *A. mangium* logs.

Table 1. Incidence of *C. curvignathus* infestations in living *A. mangium* trees at three plantation sites

Site	No. of trees sampled	Incidence of infestations (%)
Kemasul	184	1.6
Ulu Sedili	155	4.5
Batu Arang	113	0.0
Total	452	2.0

Acacia mangium appears to be as susceptible as many conifer species to infestations of *C. curvignathus*, but the infestations do not appear to be as severe, and the resulting mortality is much lower (Kirton *et al.* 1999). Most of the infestations on living *A. mangium* trees in the sampling plots were indicated by runways leading to localised infestations, with little soil cover of the tree trunk. Only one of the ten living trees on which *C. curvignathus* was found had extensive soil plastering the tree trunk. Such soil cover, typical of severe attack by *C. curvignathus*, is more readily detected by cursory observation than are localised infestations. Thus, severe attack was observed on several occasions outside the sampling plots in all of the three sampling sites. It was also observed in Bukit Tarek and in other areas where *A. mangium* is grown in the three sampling sites. It is probable that infestations which appeared localised were external indications of more extensive internal infestations of the heartwood, such as is shown in Figure 1. They may also have occurred in trees which had no external signs of termite activity, if the termites gained access through the roots. Thus, the figures reported in the present study may underestimate the incidence of heartwood infestations by *C. curvignathus*. Internal termite infestations have been widely reported to occur in thinned or harvested *A. mangium* trees. As many as 17% of 264 five-year-old *A. mangium* thinnings have been found to have internal termite infestations (Chew 1987 in Weinland & Ahmad Zuhaidi 1992). Mahmud *et al.* (1993) reported an overall incidence of 4% termite infestation of the heart-wood in a sample of 195 six- to nine-year-old *A. mangium* trees felled from seven sites in Sabah, East Malaysia. The highest incidence in a site was 23%. These studies enumerated heartwood infestations by termites in general. Hollow cores more specifically attributed to *Coptotermes curvignathus* were found in 6% of a sample of 115 *Acacia mangium* logs in Sabah (Chan 1986).

Figure 1. Cross section of a termite infested *A. mangium* tree trunk in Batu Arang, showing damage to the heartwood

Predisposing factors inherent in plantation A. mangium

A number of predisposing factors on the tree trunk of living *A. mangium* trees were observed to facilitate entry of *C. curvignathus* into the wood. Some of the common factors are shown in Figure 2, and Table 2 gives a breakdown of the number of infestations resulting from different predisposing conditions in trees within the sampling plots. Infestations of *C. curvignathus* localised on some form of injury to the wood or bark accounted for 80% of the ten trees with infestations (Table 2). This was significantly greater than the proportion of trees which had infestations on bark that had no visible injuries (binomial test, $p < 0.06$, $\alpha = 0.10$). There was, therefore, a tendency for the termites to infest injured parts of the tree trunk.

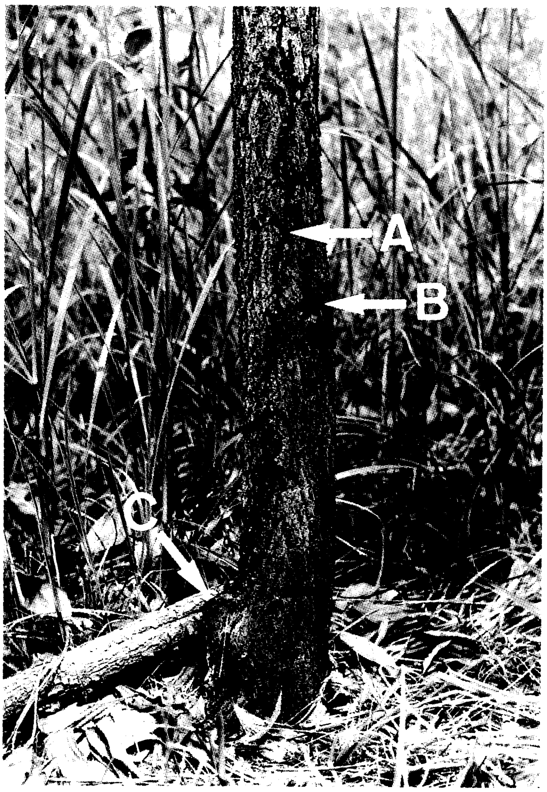

Figure 2. Trunk of a living *A. mangium* tree with an infestation of *C. curvignathus* in Kemasul, showing some common predisposing factors: A. furrows in the bark, probably caused by a Cerambycid beetle; B. scar left by a dead branch, where the termite appears to have penetrated the heartwood of the trunk; C. pruning wound (the pruned stem can be seen lying on the ground beside the tree)

Table 2. Number of trees infested by *C. curvignathus* within the sampling plots as a result of different predisposing factors. Data have been pooled for the three plantation sites.

Part of tree infested	No. of trees
Pruning wound	4†
Abscission scar exposing wood	3†
Bark damaged by insect borer	1*
Bark damaged by other forms of jury	1
Non-damaged bark	2

† One tree had infestations of both a pruning wound and abscission scars;
* termite infestation associated with borer attack was also observed outside the plots.

Pruning wounds were most common in Ulu Sedili, where multiple leaders or side branches of significant size had been pruned. These wounds left the wood of the tree exposed and vulnerable to infestation. In Peninsular Malaysia, *A. mangium* is prone to heavy early branching, resulting in the formation of multiple leaders from the base of the tree if pruning is not carried out (Yong 1985, Mead & Speechly 1991). Hence, recommendations by the Forest Department of Peninsular Malaysia for the silviculture of this species emphasise pruning, which is carried out four months, one year and four years after planting (Anonymous 1989, Weinland & Ahmad Zuhaidi 1991). In spite of the early pruning at four months to leave a single leader (singling), low branching still occurs and results in large wounds from later pruning exercises (Figure 2). Although wound dressings are used for large pruning wounds, these did not provide long-term protection against termites. One pruning wound was observed to be infested in spite of a visible coat of wound dressing.

Abscission scars resulting from natural pruning also exposed the wood of the tree, though not usually as extensively as pruning wounds. Canopy closure had already occurred in most areas of the four-year-old *A. mangium* plantations sampled. Rapid canopy closure in *A. mangium* plantations results in death of the numerous lower branches, which persist on the trunk for years (Weinland & Ahmad Zuhaidi 1991, Lee & Arentz 1997). These branches eventually break off, and the branch stubs decay, leaving a scar that serves as an entry point for termites (Figure 2).

Pruning wounds and abscission scars were the most common causes of infestation (Table 2). However, damage caused to the bark by a borer also appeared occasionally to predispose trees to attack by *C. curvignathus*. The long furrows left in the bark and outer wood (Figure 2) suggest the borer was probably the larva of a Cerambycid beetle which fed beneath the bark. Damage by the borer was most frequently observed in Kemasul. The species may have been *Xystocera globosa* (Cerambycidae), which has been recorded as a pest of *A. mangium*, tunnelling in the inner bark of the trees (Hutacharern 1993). Damage by a borer, thought to be *Xystocera globosa*, has also been reported from three *A. mangium* plantations in the Peninsula, with severe damage resulting in withering and death of some trees in Ulu Sedili (Lee 1997).

The means by which *C. curvignathus* frequently gains access into the wood is paralleled by heart rot infection in *A. mangium*, which is associated with a number of Basidiomycete fungi of the Hymenomycete group (Lee *et al.* 1988, Lee & Maziah 1993). Pruning wounds, branch stubs and dead branches which expose the heartwood or sapwood of the tree are the most common entry points for heart rot fungi in *A. mangium* (Lee *et al.* 1988, Mahmud *et al.* 1993), particularly since *A. mangium* has a poor wound response, making it susceptible to invasion of the xylem by fungal hyphae (Schmitt *et al.* 1995). There are also sufficient data to suggest an association between heart rot in *A. mangium* and termite damage to the heartwood (Mahmud *et al.* 1993) (Table 3). Although heart rot frequently occurred without termite damage, the latter was largely associated with the former, suggesting that heart rot predisposes the tree to heartwood infestation by termites. Many termite species are attracted to fungus-decayed wood. The relationship between Basidiomycete fungi, the chemical products of decay and termite behaviour have been extensively reviewed (e.g. Amburgey 1979, Gilbertson 1984). Decayed wood is known to contain chemicals that influence shelter tube formation, orientation and trail following in termites. However, decay is not a prerequisite for termite infestation of the heartwood, as one of the trees cored by termites had no fungal decay (Table 3). Termite species were not distinguished by Mahmud *et al.* (1993), and it is likely that *C. curvignathus*, with its ability to attack and kill living trees, infests trees both with and without heart rot.

Table 3. Contingency table, based on data of Mahmud *et al.* (1993) for data in Telupid, Sabah, where there was a sufficiently high incidence of heartwood infestations by termites to show its relationship with heart rot. There is a significant association between the two factors (Fisher exact p = 0.025, α = 0.05)

	Heart rot present	Heart rot absent	Total
Termites present	5[†]	2[†*]	7
Termites absent	5	18	23
Total	10[†]	20	30[†]

[†]Value given by Mahmud *et al.* (1993); *one tree had another form of decay, but the number of trees with other forms of decay was not stated for trees in which termites were absent.

Lee and Arentz (1997) have put forth a hypothesis to explain the high incidence of heart rot infestations in *A. mangium* in Peninsular Malaysia. This hypothesis can also explain the ease with which *C. curvignathus* infests *A. mangium* trees through abscission scars. They suggest that *A. mangium* is physiologically adapted to a climate with an annual period of low rainfall which triggers the development of a cleavage zone at the base of dying branches of *A. mangium*, where abscission eventually takes place. This cleavage zone, which is thought to develop better in the East Malaysian state of Sabah, where there is greater rainfall seasonality than in Peninsular Malaysia, would result in the production of periderm tissue which protects underlying wood from infection by decay-causing micro-organisms. The absence of strong rainfall seasonality in Peninsular Malaysia prevents this natural abscission process from taking place and, thus, results in the exposure of the wood to infection by decay fungi and infestation by termites.

Pest status and management in A. mangium plantations

Coptotermes curvignathus has been described as the most important pest of *A. mangium* and other fast-growing tree species planted under the compensatory forest plantation scheme (Yong 1985). This reputation has probably been attained by virtue of it being one of the few pest species that kill mature trees. While significant losses may occur in localised areas of *A. mangium* plantations (Yong 1985, Intachat & Kirton 1997), overall losses due to tree mortality are relatively low by comparison to conifers, which are inherently more susceptible to severe attack (Kirton *et al.* 1999). Most infestations of *A. mangium* in the sampling plots were localised in dead tissue of living trees, or in the heartwood, and did not become more extensive.

In the establishment of conifer plantations and early *A. mangium* plantations, seedlings were protected by prophylactic treatment of the soil with granular heptachlor applied into the planting hole during transplanting (Tho 1976, Yong 1985). In *A. mangium,* the treatment was ineffective in providing long-term protection (Chew 1987 in Weinland & Ahmad Zuhaidi 1992), and has been said to last only about two years (Yong 1985). The breaching of this soil barrier by the termites after two years makes it unlikely that the chemical would have affected the incidence or mode of attack in four- and eight-year-old *A. mangium* sampled in this study. The practice of prophylactic soil treatment was later discontinued, with a shift towards remedial chemical control of infestations (Tho & Kirton 1990). In view of the relatively low susceptibility of *A. mangium* to severe attack, this has probably been an economically sound decision. There has not, thus far, been any report of severe, widespread losses in more recently established, untreated *A. mangium* plantations.

Although significant losses due to tree mortality caused by *C. curvignathus* occur only in localised areas of *A. mangium* plantations, damage due to heartwood infestations by *C. curvignathus,* or other termite species, is a more widespread problem. Heartwood infestations reduce the quality of the wood and may render it unusable when the damage is severe, particularly if the wood is to be used for sawn timber. When the wood is to be used for pulp in the manufacture of paper, or for chipboard, as is generally the case at present in Malaysia, heartwood infestations are a less serious defect. In this case, the problem of heartwood infestations can be reduced by avoiding late pruning of low stems that have reached the size of a large leader. Pruning can be carried out more frequently when a clear bole is required for sawn timber, so that stems are pruned while still young. This is thought to facilitate better healing of pruning wounds (Lee *et al.* 1988). Wound dressings in current use in *A. mangium* plantations do not provide sufficient protection against heartwood infestations. Site matching of *A. mangium* to areas with strongly seasonal rainfall, as proposed for the prevention of heart rot (Lee & Arentz 1997), may also minimise heartwood infestations by termites through the formation of a physiological abscission zone at the base of dying branches. This is because termites and the fungi that cause heart rot have common entry points into the wood and, furthermore, heart rot predisposes the heartwood to termite infestation.

Acknowledgements

We are grateful to the Director General of the Forest Department of Peninsular Malaysia for permission to conduct these studies in the *Acacia mangium* plantations. We are also thankful for support and assistance rendered by the plantation managers and staff of the Compensatory Forest Plantations of Batu Arang, Kemasul and Ulu Sedili. The first author gratefully acknowledges the advice of S. G. Khoo.

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