

## Chapter 6

# Termite: Friend or Foe? Conservation Values of Termites in Tropical Peat Systems



Kok-Boon Neoh, Ahmad Muhammad, Masayuki Itoh, and Osamu Kozan

**Abstract** Termites are the major ecosystem service providers and contribute significantly to soil processes and nutrient cycling in tropical ecosystems. The ecological services provided by termites are often discredited due to their commonly-regarded status as pest in human-dominated landscapes, however. In order to understand the potential roles of termites in peatland ecosystems, termite samplings were conducted in abandoned degraded peatland and peatland cultivated with oil palm in Riau, Sumatra. Surveys found a total of six species of termite of the family Rhinotermitidae. (*rhinotermitid*) in study plots of disturbed lands. In particular, *Coptotermes* spp. are notorious pests to oil palm, and may also be a potential pest in indigenous tree replanting programs. Based on analysis of termite feeding groups and documentation of wood susceptibility to termite attack, this study provides a reference of tree species that must be avoided in indigenous tree replanting programs so that the trophic relations of termite populations are of most benefit to peatland soil biodiversity and thereby to resilient peatland ecosystems.

**Keywords** Pest · Termite damage · Wood susceptibility · Ecosystem service · Oil palm

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## 6.1 Introduction

Insects contribute significantly to vital ecological functions such as pollination, decomposition, maintenance of wildlife species, and as biological control agent for crop pests (Losey and Vaughan 2006). At the same time, insects can be pests. If they appear at the wrong place or time they can threaten economic wellbeing and human health. This is particularly true when their natural habitat is disturbed by urbanization or other landscape modification, and when they are mismanaged.

Termites are major ecosystem service providers and contribute significantly in soil processes and nutrient cycling in tropical ecosystem (Holt and Lepage 2000). This vital role in ecological processes is often underacknowledged, as 5% of the 2300 termite species in the world are pests known to have negative economic impact on human settlements or agriculture (Su and Scheffrahn 2000). Recent increases in land-use intensity have elevated termites' pest status.

The Indo-Malayan region contains 62% of global tropical peatlands (Page et al. 2006). These peatlands have long served as a biodiversity hotspot for many endemic species of flora, fauna, and microbes (Yule 2010). Peatland ecosystems have also supported local community livelihoods based on long-term coexistence with peatland forests. Political policy, urbanization, and agricultural intensification, which came on the heels of increased global demand for food and fuel, resulted in the clearing of 80% of Southeast Asian peat swamp forest to make way for agro-industrial plantations (Mishra et al. 2021). In the early 2000s, 6% of tropical peatlands in the Indo-Malayan region was converted to oil-palm plantations (Koh et al. 2011), as abandoned secondary peatland increased 15% since the 1990s (Miettinen and Liew 2010). Both processes of land modification pose considerable risks to biodiversity. Even such little-regarded species as earthworms, which make similar contributions to soil processes as do termites, are disturbance-sensitive (Blanchart and Julka 1997). Owing to the unusual peat ecosystem that is highly acidic, anaerobic, and sensitive to fire and disturbed conditions, earthworms are nearly absent from disturbed peat (Cotton and Curry 1982). Termites, which tend to be much more resilient to land disturbance than are earthworms and other related species, could therefore be seen as a major soil engineer if their services could be harnessed efficiently.

As a first step toward understanding the potential roles of termites in the peat system, this study conducted termite samplings in abandoned degraded peatland and peatland cultivated with oil palm in Riau, Sumatra. The authors also combined the dataset of previous reports in disturbed and peatlands cultivated with oil palm. Based on analysis of termite feeding groups and documentation of wood susceptibility to termite attack, this study provides a reference of tree species that must be avoided in indigenous tree replanting programs so that the trophic relations of termite populations are of most benefit to peatland soil biodiversity and thereby to resilient peatland ecosystems.

## 6.2 Materials and Methods

An abandoned degraded peatland site and a peatland currently cultivated with 5–6 year old oil palm were selected for this study (Fig. 6.1). The sites are located in the transition zone of the GiamSiak Kecil–Bukit Batu Biosphere Reserve ( $0^{\circ}44'–1^{\circ}11'N$  and  $0^{\circ}11'–102^{\circ}10'E$ ) lying between 0 and 50 m above sea level. The study sites were 2 km apart, allowing the authors to exclude any major discrepancy in hydrological and climatic patterns, with the principal exception of canopy openness. The canopy cover in oil palm plantation registered an average of  $37.8\% \pm 14.1$  ( $\pm SE$ ); in contrast, the abandoned degraded peatland was open shrubland.

Termite samplings were carried out in November 2012 using a standardized belt transect as described by Jones and Eggleton (2000). The belt transect comprised a survey area of  $100 \times 2$  m and was divided into 20 sections of  $5 \times 2$  m. A collector spent an hour on each section to collect the soldiers and worker termites from termite potential habitats such as dead tree branches, tree logs, soil under logs, termite galleries and nests. Collected termites were stored in 80% ethanol until identified. The termites were sorted to species level based on identification keys on the termite fauna in the Indo-Malayan region (Thapa 1977; Tho 1992; Gathorne-Hardy 2004).

Termite species richness was estimated using Chao 2, Incidence-based coverage estimator (ICE) and Jackknife 1, and the diversity indices (Shannon and Simpson Indices) were generated using EstimateS Version 8.2 (Colwell 2009). The relative abundance of termites was generated based on the encounter rates of termite over 20 sections. The relative abundance in abandoned land is relative to the value in oil palm cultivated land transect (relative abundance = 1).

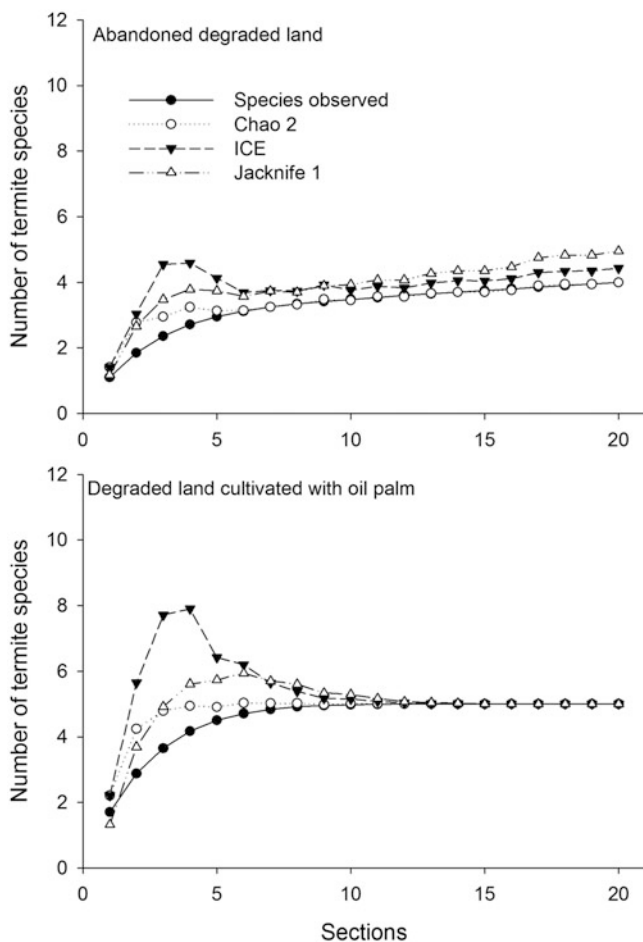


**Fig. 6.1** Abandoned degraded peatland (left) and peatland cultivated with 5–6 year-old oil palm (right) were selected as study sites. Both landscapes were dominant in transitional area of the GiamSiak Kecil-Bukit Batu Biosphere Reserve

### 6.3 Results

The observed species richness accumulation curve for both study sites reached an obvious asymptote close to estimated species richness curves (i.e., Chao 2, Incidence-based coverage estimator and Jackknife 1) (Fig. 6.2). In addition, all termite species were consistently encountered throughout the sampling as evidenced from no termite species only found once or twice (Singletons = 0; Doubletons = 0).

A total of six species of termite, which comprised a single family Rhinotermitidae, two subfamilies (i.e., Rhinotermitinae and Coptotermitinae) and



**Fig. 6.2** Species accumulation curves of termites sampled in abandoned degraded peatland and peatland cultivated with oil palm in Riau, Indonesia. Species observed is the number of termites that were collected in the 100 m belt transect of 20 sections, and the numbers of termite species that were beyond observation were predicted using Chao 2, ICE and Jackknife 1

three genera (i.e., *Coptotermes*, *Schedorhinotermes*, and *Parrhinotermes*) were collected in both study sites. *Coptotermes gestroi* (Wasmann) was found only in abandoned degraded peatland, but *Parrhinotermes pygmaeus* (John) and *Schedorhinotermes malaccensis* (Holmgren) were absent compared to that termite assemblage in degraded peat land cultivated with oil palm (Table 6.1).

Overall, the relative abundance of termites in abandoned degraded peatland was 65% of that in degraded peatland cultivated with oil palm (Fig. 6.3). In the abandoned degraded peat *Coptotermes kalshoveni* (Kemner), *Parrhinotermes aequalis* (Havilandi) and *Schedorhinotermes medioobscurus* (Holmgren) were predominately found (Shannon<sub>exp</sub> index: 3.34; Simpson index: 3.45), with relative abundances of 23%, 41%, and 32%, respectively. In contrast, the termite dominance in oil palm is even (Shannon<sub>exp</sub> index: 4.93; Simpson index: 5.50). Each species registered approximately 20% of encounter rate in the transect sampling (Table 6.2). All termite species found were wood feeders and wood-nesting termites.

## 6.4 Discussion

The termite assemblage in the transition zones of the GiamSiak Kecil-Bukit Batu Biosphere Reserve contained only a single family of lower termite–Rhinotermitidae (rhinotermitids), which consist of two subfamilies (Coptotermitinae and Rhinotermitinae), three genera, and six termite species. The result accords closely with the termite assemblage sampled in newly cleared land (Vaessen et al. 2011). The low termite-species richness in the present study sites might be the result of land disturbance during the clearing process or repeated fires, causing the collapse of susceptible termite species. Only wood-nesting termites survived at post disturbance (Neoh et al. 2016). However, this result needs to be viewed with caution, as it was based only on a single landscape. A study at a 2 year-old oil plantation conversion from mixed swamp forest in Sri Aman District, Sarawak, documented two subfamilies of higher termites (i.e., Nasutitermitinae and Termitinae) and a subfamily of lower termite (Rhinotermitinae) (Vaessen et al. 2011). Another study of 5–7 year-old and 13–15 year-old oil palm plantation sites recorded more than 12 species, which comprised two subfamilies of lower termites (Coptotermitinae and Rhinotermitinae), and four subfamilies of higher termites (Nasutitermitinae, Termitinae, Amitermitinae, and Macrotermitinae [only found in 15–17 year-old plot]). These findings indicate that the assemblage of termites shifts from a single dominant family to multiple families (i.e., rotten-woody feeder and soil feeder) along with the age of plantation. Kon et al. (2012) attributed this phenomenon to the improvement of soil condition across time, which favored the termite colony and territory expansion. In addition, incremental increases of dead wood, woody-plant basal area, and canopy height (as the plantation aged) may also be associated with the presence of multiple woody and soil feeders taxa in disturbed areas (Jones et al. 2003).

Termite species richness and relative abundance typically decline following logging and land-clearing activity (Jones et al. 2003). The lack of termite assemblage



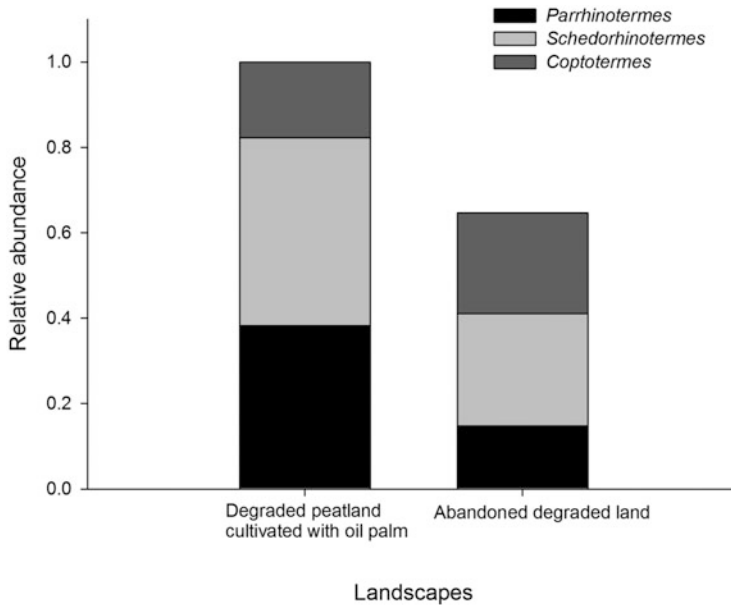
TERMITIDAE	Feeding group <sup>a</sup>	Riau <sup>b</sup>		Sarawak <sup>c</sup>				Perak <sup>d</sup>				Pahang <sup>e</sup>		
		ADL	5 years	CL	2 years	5-7 years	13-15 years	4 years	8 years	15 years	20 years	21 years	6-17 years	
AMITERMITINAE														
<i>Globitermes</i>														
<i>G. sulphurues</i>	W								✓					✓
<i>G. globosus</i>	W							✓						✓
Amitermes														
<i>A. dentatus</i>	W							✓						✓
<i>A. minor</i>	W													✓
<i>Microcerotermes havilandi</i>	W													✓
Taxonomic group														
NASUTITERMITINAE														
<i>Bulbitermes</i>														
<i>B. borneensis</i>	W				✓									
<i>B. constrictus</i>	W				✓									
<i>B. germanus</i>	W													✓
<i>B. singaporensis</i>	W													✓
<i>B. conirictiformis</i>	W													
<i>B. neopusillus</i>	W													
<i>Nasutitermes</i>														
<i>N. matangensisiformis</i>	W				✓				✓					✓
<i>N. proatripennis</i>	W				✓									✓
<i>N. havilandi</i>	W				✓								✓	✓
<i>N. rectangularis</i>	W				✓									✓
<i>N. johoricus</i>	W													✓
<i>N. longinus</i>	W													✓

(continued)









**Fig. 6.3** Relative abundance of termite sampled in abandoned degraded peatland and peatland cultivated with oil palm in Riau, Indonesia. Relative abundance in abandoned land is relative to the value in oil palm cultivated land transect (relative abundance = 1)

**Table 6.2** Termite species richness and diversity indices for degraded peat land and degraded peatland cultivated with oil palm

Species richness and diversity indices	Degraded peat	Degraded peat cultivated with oil palm
$S_{obs}$	4.00	5.00
Chao 2	4.00	5.00
ICE	4.43	5.00
Jackknife 1	4.95	5.00
Singletons	0	0
Doubletons	0	0
Shannon <sub>exp</sub>	3.34	4.93
Simpson	3.45	5.50

in burned peatland may have reduced the functional groups of termites that are essential to soil processes. Okwakol (2000), who studied land conversion from natural forest to banana-cultivated land, has suggested that a drastic reduction of 40% of the original termite diversity potentially alters ecological processes and reduces farmland productivity over time. In the present study, termite species richness fell to one family, Rhinotermitidae. It is still difficult to estimate what rates of termite abundance and diversity can elicit significant ecosystem function in a given area. However, termite groups with proven ecosystem functionality (e.g., Macrotermitinae [Beaudrot et al. 2011], Nasutitermitinae [Jiménez et al. 2008]) were

not found in our study sites. Several management practices are therefore required to maintain termite diversity when peatland is disturbed. These management techniques include: (a) using low-impact land-clearing techniques and leaving tree residues in the disturbed area (rather than burning them) in order to maintain termite populations (Bourguignon et al. 2018); and (b) maintaining patches of intact forest within a disturbed area (Neoh et al. 2017). These methods would promote the survival of termite species vulnerable to land disturbance and help restore termite biodiversity in degraded lands (Jones et al. 2003).

In mineral soils, termites are known to make subterranean tunnels that improve soil water infiltration rates, while their role in decomposing plant litter and mound building via soil translocation enriches soil nutrients and improves soil bulk density, respectively (Holt and Lepage 2000). In the Indo-Malayan region, the termite assemblage in peatlands is mainly comprised of decayed-wood feeders and soil feeders (Table 6.1). Black and Okwakol (1997) have noted that wood and soil feeders generally contain high levels of organic carbon in their nests; the latter's nest, in particular, is rich in nitrogen due to their habit of feeding on highly decaying soil-like cellulose materials. A study on soil-feeding termites in the Colombian savanna revealed that the group was reputedly more important in soil nutrient enrichment than ants (Jiménez et al. 2008). Studies on soil impact by *Nasutitermes* sp. revealed that termite mounds can act as source of nitrogen available to plants in nutrient-depleted savanna systems (López-Hernández 2001; Jiménez et al. 2006). The presence of other feeding groups in the peat system (Table 6.1) may also be vital in the optimal functioning of the ecosystem and peat restoration.

In savanna systems, grass-harvesting termites are believed to play an important role in fire management, especially when they remove grass and plant litter that could act as fuel during fire events (Davies et al. 2010). Though grass-harvesting termites are not found in the Indo-Malayan region, the presence of wood feeders of multiple taxa potentially reduces the availability of fuel materials in the peatlands.

Fire disturbance and land conversion in the peatlands under study have caused a drastic collapse in the termite assemblage, leaving only rhinotermitids behind. Although the termite assemblages reported by Vaessen et al. (2011) and Kon et al. (2012) were diverse, the relative abundance of rhinotermitids in a young oil palm plantation of 5–7 years-old was generally high compared those found of other families, as rhinotermitids account for more than 70% of the total termite encounter.

*Coptotermes* are highly destructive termite species in Southeast Asia. Studies conducted on oil palm growth in peatlands in peninsular Malaysia and Sarawak reported that *Coptotermes curvignathus* (Holmgren) is a major pest that causes death in both mature and young oil palm trees (Kim Huan and Silek 2001; Cheng et al. 2008; Kon et al. 2012). Similarly, approximately 14% of rubber tree planted on peat soil were attacked by *C. curvignathus* (Indrayani et al. 2022). Rasmussen et al. (1982) suggested that an abundance of food sources from the incomplete removal of timber residue during forest clearing could account for the high prevalence of *C. curvignathus* attack on new plantation plots. This premise has been discounted, however, as no clear relationship between the termite attack and plant residue was found in an oil palm plantation on mineral soil (Kirton et al. 1999), which could be

the result of the dominance and resilience of *C. curvignathus* in newly cleared land (Cheng et al. 2008). *Coptotermes sepangensis* Krishna, *C. borneensis* Oshima, *C. gestroi*, and *C. kalshoveni* were also found in oil palm plantations, but the species generally nest in rotten wood and rarely cause tree death. Nevertheless, *C. gestroi* and *C. kalshoveni* are notorious for damaging building structures in the tropics (Kirton and Azmi 2005). Other termite species *Schedorhinotermes* spp., *Globitermes globosus* (Havilandi), and *G. sulphurues* (Havilandi) were occasional pests in oil palm plantations (Harris 1969). Their pest status may be elevated if their food sources and habitats are further disturbed.

Replanting fast-growing indigenous tree species in abandoned degraded peatland such as *Dyera lowii*, *Tetramerista glabra*, *Palaquium sumatranum*, *Palaquium burckii*, *Cratoxylon arborescens*, and *Callophyllum lowii* is favored in peat rehabilitation programs; it can also be a key element in local community activities and source of livelihood (Gunawan et al. 2011, 2013). Nevertheless, some of these tree species are susceptible to termite attack (Table 6.3). Thus we do not rule out potential termite attacks in community-planted forests, just as have occurred in oil palm plantations. To ensure the survival and growth of newly-planted trees, farmers must take into account species selection and wood resistance to termite attacks. Otherwise, sustainable pest management and preventive measures should be devised before termites become a serious threat to newly re-planted peatlands.

## 6.5 Conclusion

In Southeast Asia, termites are generally thought of as pests, and their ecological services to farmlands is underappreciated. With little awareness of the potentially vital role in nutrient management these soil-dwelling insects could play, farmers have often applied chemical pesticides to control termite populations in peatland oil palm plantations. Farmers drench the soil with chemicals or directly spray infestations. In most cases, these methods are repeatedly applied, as termite infestations generally reoccur after the chemical effect dissipates. Such intensive chemical interventions have wider impact on soil communities; they do not only kill pest termite species, i.e., *C. curvignathus*, but also beneficial wood- and soil-feeding termites as well as other arthropods (e.g., beetles and ants) providing natural ecosystem services. It is interesting to note that farmers in Africa possess comprehensive knowledge of termite ecology, termite species, and utilize various traditional eco-friendly control practices (Sileshi et al. 2009). Our study demonstrates that sustainable pest management and preventive measures such as tree-selection programs should be devised before termites pose a serious threat to newly planted trees.

**Table 6.3** Resistance of Indonesian natural/planted timbers to termite attack

Tree species	Common name/local name	Weight loss (%)	Resistance class <sup>a</sup>	References
<i>Eusideroxylon zwageri</i>	Ulin	2.47	I	Wardani et al. (2009)
<i>Manglietia glauca</i>	Manglid	2.1	I	Hadjib et al. (2012)
<i>Acacia mangium</i>	Akasia	11.6	II	Arinana et al. (2012)
<i>Araucaria</i> sp.	Alau	4.52	II	Wardani et al. (2009)
<i>Arthocarpus odoratissimus</i>	Terap	3.82	II	Wardani et al. (2009)
<i>Elmerrillia papuana</i>	Wau Beech	7.27	II	Hadi et al. (2012)
<i>Calophyllum</i> sp.	Bintagur	4.77	II	Hadi et al. (2012)
<i>Swintonia glauca</i>	Sumpung	7.42	II	Wardani et al. (2009)
<i>Pometia pinnata</i>	Taun	6.40	II	Hadi et al. (2012)
<i>Garcinia</i> sp.	Garcinia	6.09	II	Hadi et al. (2012)
<i>Melia azedarach</i>	Mindi	10.3	III	Hadi (2014)
<i>Peronema canescens</i>	Sungkai	12.46	III	Wardani et al. (2009)
<i>Canarium</i> sp.	Canarium	7.99	III	Hadi et al. (2012)
<i>Dyera costulata</i>	Pantung	15.12	IV	Wardani et al. (2009)
<i>Durio zibethinus</i>	Durian	15.52	IV	Wardani et al. (2009)
<i>Mangifera</i> sp.	Mangga	14.80	IV	Wardani et al. (2009)
<i>Anthocephalus macrophylla</i>	Red Jabon	16.61	IV	Wardani et al. (2012)
<i>Pinus merkusii</i> Jungh	Pine	16.9	IV	Jasni and Rachman (2009)
<i>Shorea acuminata</i>	Meranti merah	20.86	IV	Wardani et al. (2009)
<i>Elmerillia ovalis</i>	Cempaka Hutan	19.4	V	Hadjib et al. (2012)
<i>Elaeis guineensis</i>	Oil palm	26.29	V	Dungani et al. (2013)
<i>Ochroma lagopus</i>	Balsa	37.2	V	Hadi et al. (2012)
<i>Hevea brasiliensis</i>	Rubber	19.40–39.89	V	Wardani et al. (2009), Hadjib et al. (2012), and Wardani et al. (2012)
<i>Anthocephalus cadamba</i>	White Jabon	32.40	V	Wardani et al. (2012)
<i>Peronema</i> sp.	Pulai	36.4	V	Hadi (2014)

(continued)

**Table 6.3** (continued)

Tree species	Common name/local name	Weight loss (%)	Resistance class <sup>a</sup>	References
<i>Paraserianthes falcataria</i>	Sengon	23.10–37.3	V	Wardani et al. (2009), Arinana et al. (2012), and Hadi (2014)

<sup>a</sup>Wood resistance to termite attack based on the weight loss of wood consequence upon termite attack set by Standard Nasional Indonesia (SNI 2006)

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