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Common *Coptotermes* spp. and other Termites Associated with Oil Palm in Riau, Sumatra

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There are many species of termites associated with oil palm planted on peat soil. Most of them are beneficial to the ecosystem and harmless to the crop. Four subterranean termite species of Coptotermes *are commonly found in oil palm planted on peat soil,* viz. Coptotermes curvignathus, C. sepangensis, C. travians *and* C. kalshoveni. *The only species infesting living palm is* C. curvignathus. *The other genera of termites such as* Schedorhinotermes, Parrhinotermes *and* Nasutitermes, *in which are some very common species in oil palm plantations, are harmless to the palm. Accurate identification of termite species to distinguish between the pest and non-pest species should be emphasised to prevent wrong application of pesticide against beneficial termites in the field. This paper provides a pictorial guide for the identification of common termite species in oil palm planted on peat soil.*

Keywords: *Subterranean termites,* C. sepangensis, C. curvignathus, C. travians, C. kalshoveni.

Termites are social insects, living in communities with specialised caste or form, comprising worker, soldier, reproductive male and female (the king and the queen). Termites are found in a wide range of terrestrial environments and are distributed throughout the tropical, subtropical and temperate regions of the world (Krishna & Weesner, 1970; Pearce, 1998). The frequency and severity of attack make some species serious pests and economically significant wherever they occur. There are at least 2 937 described species in the world with 104 of them considered as pest species (Krishna *et al.*, 2013).

Coptotermes Wasmann [Blattodea (Isoptera): Rhinotermitidae] is one of the most economically important subterranean termite genera (Edwards & Mill, 1986; Su & Scheffrahn, 1988, Chouvenc *et al.*, 2015). Subterranean termites live in subterranean or underground nests, or in trees, and connect to moisture sources through mud tubes (Krishna, 1970). Generally, subterranean termites will not separate themselves from their underground nests due to their moisture requirement. Moisture is vital to the survival of subterranean termites. Due to their small size and relatively unsclerotised body, water loss is a common problem facing all termite species, and they must locate and utilise water resources to prevent desiccation (Zukowski & Su, 2017). They obtain most of their moisture from the soil and must maintain contact with the soil in the field. Subterranean termites construct mud tunnels, which provide protection and prevent excessive water loss.

The occurrence of *Coptotermes curvignathus* Holmgren termites attacking oil palm has been reported by Wood (1968), Sudharto *et al.* (1991), Lim and Silek (2001),

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Faszly *et al*. (2003), Cheng *et al*. (2008) and Cheong *et al*. (2017). Lim and Silek (2001) reported this species infesting 8-9 per cent of 3-year-old palm and causing 2-3 per cent of palm death. Lim and Silek (2001) and Faszly *et al*. (2003) reported that some of the termite infestation in young palm to young matured palm (3-6 year-old palms) started from the spear region downward. *Coptotermes curvignathus* is able to forage above ground for sources of cellulosic materials (e.g. the palm's spear). In order to protect themselves from predation by ants and maintain their connection to the soil while searching for food above ground, termites build mudwork out of soil and fecal material. This needs to be stressed as plantation workers might only treat the spear region without treating the basal region of the infested palms. Generally, *C. curvignathus* infested young palms show visible sign of infestation with the presence of mudwork either at frond bases, inflorescences, developing bunches and spear (*Figure 1*). Termite infested matured palm could be hard to detect in the early stage, as this species could infest them through underground tunnels, penetrate into the stem from the root region, or they may move out above the ground by building mudwork at the basal region (*Figure 2a*) to cover themselves and penetrate laterally from the stem. Sometimes they may be able to reach the lower frond region (*Figure 2b*). Usually, sign of mudwork on termite infested matured palm indicates the palm has been attacked for quite some time, with hollows and small cavities in the inner stem eaten by the termites. The presence of mudwork on mature palm usually indicates the palm is at an intermediate or advanced stage of infestation.

Identification of *C. curvignathus* is generally based on behaviour of the soldier caste, which is very common in all *Coptotermes* spp. A soldier caste of *Coptotermes* spp., when disturbed, bites an intruder with its mandibles and secretes a white liquid (*Figure 3*) from a gland in the body, through an opening in the front of the head, which is called the fontanelle (*Figure 4*). This common behaviour of *Coptotermes* spp. should be one of the criteria to prevent the error in species identification by a less experienced worker, which usually leads to application of

Figure 1 A young palm with signs of termite infestation, i.e. the presence of mudwork on the frond bases, inflorescences, developing bunches and the base of the spear region

Figure 2 Mature palm with signs of termite infestation, i.e. the presence of mudwork on (a) the basal stem region and (b) the upper stem region, reaching the lower frond

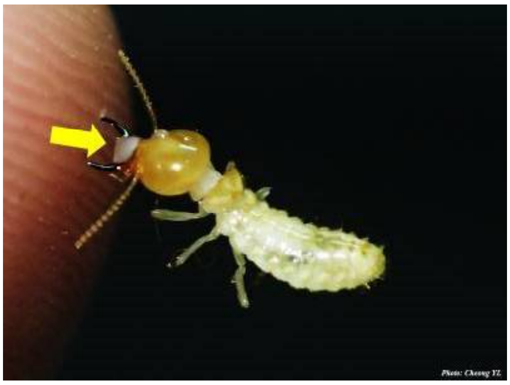

Figure 3 *A soldier of* C. curvignathus *secreting white milky liquid (arrow) while biting an intruder*

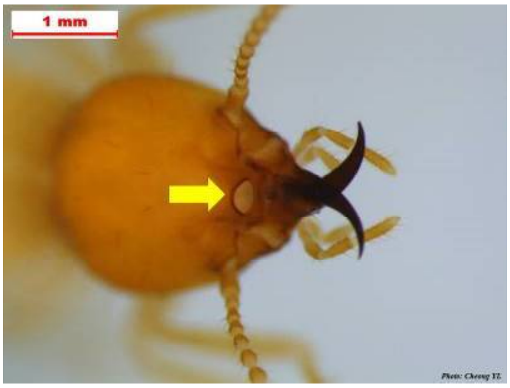

Figure 4 *Anterior-dorsal view of the head of a* C. sepangensis *soldier with yellow arrow indicating the position of the fontanelle, a large frontal glandular opening, which is a characteristic of all termite species in this genus*

termiticide against non-target species and an increase in costs as a result of unnecessary treatment.

In this paper, several pictorial guides with measurements of common *Coptotermes* spp. and common non-pest species associated with oil palm in peat soils are provided, making it easier to distinguish them and prevent wrong application of termiticide against non-target species.

MATERIALS AND METHODS

Rapid termite sampling protocol

A rapid termite sampling was conducted at three locations, H55 (00°02'32.1"S, 102°00'06.3"E), H57 (00°02'52.4"S, 101°59'47.0"E), and H58 (00°03'01.8"S, 101°59'56.9"E) in a 14-year-old oil palm plantation planted on peat soil using the sampling protocol described by Jones and Eggleton (2000), which has often been used as a standard for termite sampling. This entailed a 100 m belt transect divided into 20 sections of 5 m x 2 m contiguous quadrats (*Figure 5a*). Within each section, two experienced collectors worked continuously for 30 minutes, giving a sampling effort of one man-hour per quadrat and a total of 20 man-hours of sampling. Termites within the transect were collected from the soil up to 10 cm depth (*Figure 5b*). Accumulation of litter and humus at the base of the buttresses were dug up, wood items were broken open, mounds were cracked and sampled, and any termite tracks up to 2 m high were scraped off. Termites were thoroughly searched for along transects to collect as many species of termite as time allowed in each section (*Figure 5c*) following Davies *et al*. (2003b). Time of sampling was restricted to 7.00 a.m. to 10.00 a.m. because termites are less active when the soil temperature is high and will move deeper into the soil, further away from the heat generated by the sun at the surface of the soil. As the species can only be separated accurately with the aid of a microscope, collectors were trained to sample specimens from every group of termites encountered. Priority was given to finding soldiers as these are the easiest to identify, but workers and alates were also collected if present because these could be used in future taxonomic studies. Each group of termites found in a different microhabitat was recorded

Figure 5 Collecting termites: (a) 100 m belt transect in the interrow of oil palm stands; (b) searching for termites and collecting them; (c) termites were thoroughly searched for along transects; and (d) separating the collected termites from soil and placing them in vials

as one encounter. The number of termites groups encountered served as a surrogate to relative abundance (Davies *et al.*, 2003a). The termites were sorted from soil and placed in vials of 70 per cent ethanol and labelled with the section number (*Figure 5d*).

Identification of species was done using the descriptions by Tho (1992) and Kirton and Brown (2003). Only *Coptotermes* spp. were further examined by measuring the head of the soldier castes. All measurements were made using a stereo microscope (Leica M165C), with an attached microscope camera (Leica MC170 HD) and Leica Application Suite (LAS) version 4.6.2 software. *Coptotermes* spp. and other termite species found in this study were classified according to functional group, which is an interchangeable term with feeding group and functional taxonomic group (FTG), following Donovan *et al.* (2001) and Davies *et al.* (2003a). These authors classified termite feeding groups according to their gut contents and functional morphology as follows:

Group I: taxa with relatively simple guts, and including all lower termites. Termites feed on least humified substrates such as undecayed dead wood (only in non-Termitidae);
Group II: these higher termites have a more complex gut, but still feed on substrate from decayed wood to very decayed wood/humus (only in Termitidae);
Group III: having a similarly complex gut to Group II, they feed on pure humus and humus particles in the soil (only in Termitidae); and
Group IV: these have a highly complex gut and are true soil-feeders, feeding on the most nutrient poor organic material in the soil (only in Termitidae).

Groups I and II are wood feeders, and groups III and IV are soil feeders. The FTGs found in this study are: Rhinotermitidae-I, Termes group-III and Nasutitermes group-II. Feeding behaviour is a good indicator of lifestyle and ecology (Eggleton & Tayasu, 2001), and can be used as an indicator to determine whether the termite species is harmful to oil palm.

RESULTS AND DISCUSSION

Species richness and termites associated with oil palm planted on peat soil

The termite species collected, with their respective functional taxonomic group, feeding group, and nesting group, together with the number of encounters for each species at each location are shown in *Table 1*. This comprise 13 species from eight genera and two families in three FTGs. Total encounters of FTGs composed of Rhino-I (334 hits; 77.3 %), Nasuti-II (77 hits; 17.8 %) and Termes-III (21 hits; 4.9 %). The family Rhinotermitidae dominated the species richness, with *Schedorhinotermes medioobscurus* (Holmgren) being the most dominant termite species in terms of frequency of encounters (27.8 % of all samples) (*Table 1*).

Schedorhinotermes spp. are common in peat soil. Cheng *et al*. (2008) reported a similar result as they found the incidence of *Schedorhinotermes* in plant residues was high (90.3 %) and their occurrence on palms was low (live palm: 6.9%; dead standing palm: 2.8%). In this study, three transects were selected in the palm interrow with adequate canopy cover to increase the possibility of termite presence. These transects were dominated by the light-tolerant fern, *Nephrolepis biserrata*, which provide shelter to soil macrofauna such as termites. We also found a lot of wood residues within the transects, which might be the reason for the presence of Rhinotermitidae, particularly *Schedorhinotermes* and *Parrhinotermes*, dominating the study sites. *Schedorhinotermes* spp., which were wrongly classified as termite pests of oil palm, were observed to be the main successor to *C. curvignathus* infestations. This has also been observed by Cheng *et al.* (2008). It is highly likely that *Schedorhinotermes* spp. invaded the dead palms killed by *C. curvignathus* and did not cause the death of the palms.

As cellulose decomposers, termites are usually viewed in a negative perspective regardless of species and their true role in the ecosystem. Another example, the mound building termite, *Macrotermes*, often builds its nest close to the trunk, giving the appearance of attacking the palm tree (*Figure 6*). They actually do not attack the palm directly, but sometimes their feeding and nesting behaviour could weaken the root system or soil structure, and their nests exert weight on the palm, making the palm fall by uprooting in the field. This phenomenon has been reported by Sudharto *et al.* (1991), who stated that *Macrotermes gilvus* Hagen was found to disturb the root system, sometimes causing the palm to collapse (*Figure 7*). An unidentified species of *Nasutitermes* was reported recently in Central Kalimantan as infesting the oil palm trunk from the basal region, feeding on the trunk tissue and nesting inside the trunk. Using the feeding groups devised by Donovan *et al*. (2001), *Nasutitermes* is a group-II wood feeder, as are *Macrotermes*, *Odontotermes*, *Hypotermes*, *Microcerotermes*, *Globitermes* and *Prohamitermes*. Since these termites are known to feed on substrates ranging from decayed wood to very decayed wood or humus, it is unlikely that a species of *Nasutitermes* would attack and damage oil palm in a manner

TABLE 1
TERMITE SPECIES COLLECTED FROM TRANSECT H55, H57 AND H58.

Species	*Oil palm pest species*	*No. of encounters H55*	*H57*	*H58*	*Nesting group*	*Lifeway*	*Feeding group*	*FTG*	*Shannon-Wiener diiversity index "H"*
Rhinotermitidae									
Coptotermitinae									
Coptotermes curvignathus Holmgren*	Yes	[91]	[103]	[87]	w	Int(I)	*w*	*Rhino-I*	nil
Coptotermes sepangensis Krishna	No	1	3	8	w	Int(I)	*w*	*Rhino-I*	0.100
Coptotermes kalshoveni Kemner	No	2	0	1	w	Int(I)	*w*	*Rhino-I*	0.035
Coptotermes travians (Haviland)	No	9	28	0	w	Int(I)	*w*	*Rhino-I*	0.210
Rhinotermitinae									
Parrhinotermes aequalis (Haviland)	No	20	5	36	w	Int(I)	*w*	*Rhino-I*	0.276
Parrhinotermes pygmaeus (John)	No	24	12	46	w	Int(I)	*w*	*Rhino-I*	0.315
Schedorhinotermes medioobscurus (Holmgren)	No	11	14	95	w	Int(I)	*w*	*Rhino-I*	0.356
Schedorhinotermes sp.A	No	0	7	12	w	Int(I)	*w*	*Rhino-I*	0.137
Termitidae									
Termitinae									
Termes group									
Termes rostratus (Haviland)	No	0	4	0	w/i	(III)	*w/s*	*Termes-III*	0.043
Pericapritermes semarangi (Holmgren)	No	0	12	0	s	(III)	*s*	*Termes-III*	0.100
Pericapritermes mohri (Kemner)	No	0	5	0	s	(III)	*s*	*Termes-III*	0.052
Nasutitermitinae									
Nasutitermes group									
Nasutitermes havilandi (Desneux)	No	19	11	0	a/w	Int(II)	*w*	*Nasuti-II*	0.185
Bulbitermes germanus (Haviland)	No	0	24	0	a	Int(II)	*w*	*Nasuti-II*	0.161
Havilanditermes proatripennis Ahmad	No	1	20	2	s	Int(II)	*w/l*	*Nasuti-II*	0.156
Total		87	145	200					2.216

Shannon-Wiener Diversity Index "H" = 2.216, Species Evenness = 0.866

The nesting groups are: nest in wood or tree (**w**); subterranean nest: nests below ground surfaces (**s**); arboreal nest: nests totally above ground (**a**); and inquiline (sharing the nests built by another species of termite) (**i**). The lifeway are: Int(I): Intermediate-nester Group-I wood-feeding termite; Int(II): Intermediate-nester Group-II wood/litter termite and (III): all Group-III soil-feeding termite (Eggleton and Tayasu, 2001). The feeding groups are: wood-feeder (***w***); litter-feeder (***w/l***); soil-feeder (***s***); wood-soil or intermediate-feeder (***w/s***) (Donovan *et al*., 2001). Functional taxonomic groups (FTG) follows by convention the taxonomic position along humification gradient where generally group I and II are wood feeders, and group III and IV are soil feeders (Donovan *et al*., 2001 and Davies *et al*., 2003). The number of each species encounter and collected from each site is given.

* *Coptotermes curvignathus* is a major pest species in sampling area (*Cheong et al*., 2017) but was not found in transects. It was listed here as reference and comparison species to other *Coptotermes* spp. Square brackets indicate species collected off the transects, during the additional search. These data are not included in the calculation of the indices.

Figure 6 A termite mound of Macrotermes gilvus *(yellow arrow) attached to the trunk of oil palm*

Figure 7 A young matured palm collapsed (yellow arrow) due to the excavation of soil for mound building under the root system by Macrotermes gilvus

similar to *C. curvignathus*. *Nasutitermes* may infest decayed or highly decayed tissue in an unhealthy palm (*Figures 8 & 9*), but they are highly unlikely to be the main cause of palm death. A similar view is shared by Wood (1968) and Sudharto *et al*. (1991). The former stated that *Macrotermes gilvus*, *Nasutitermes havilandi* and *N. matangensiformis* (Holmgren) are common in oil palm, prefering to feed on dead tissues and decaying cellulosic material, but do not enter the living tissue. The latter observed that *N. havilandi* (Desneux) fed on the dry male inflorescences or on the fragments of the leaves or flowers accumulated at the axils of

Figure 8 Soil tunnels or mud tubes (yellow arrow) built by Nasutitermes havilandi *on decaying fronds*

Figure 9 Mudwork built by Nasutitermes havilandi *at the base of the lower frond. The arrow points to physical damage of the frond, possibly due to harvesting operations*

the fronds, and further confirmed that it was harmless to the palm. Kalshoven (1981) also stated that *Nasutitermes* are common in fruit, shade and park trees but not harmful as they do not penetrate deeply into the wood.

The major termite pest species, *C. curvignathus* was not encountered in the transect. This might be due to the lack of suitable food sources along the transect, or high inter-species competition from other termites, particularly from *Schedorhinotermes* spp. and *Parrhinotermes* spp. In the sampling site, *C. curvignathus* preferred the least decayed substrates, such as undecayed dead wood and living or undecayed dead standing palms. Cheng *et al.* (2008) reported that 83.6 per cent of their occurrences were on live or dead standing palm and they were rarely found on plant residues.

A small number of wood-soil feeders and soil feeders from Termes group-III were encountered (4.9% of all termite encounters). According to Jones *et al.* (2003), soil feeding termites (group-III and group-IV) can be used as an indicator of land-use disturbance. The extreme change in microclimate from conversion of the original habitat to oil palm plantations may have greatly affected their microhabitat, abundance and population. Usually, fewer of these termites are to be expected in agricultural land. In contrast, most termite pests are group-I wood feeders, such as *C. curvignathus, C. gestroi, C. formosanus* Shiraki and *Reticulitermes flaviceps* (Oshima). *Coptotermes gestroi, C. formosanus* and *R. flaviceps* (all Rhinotermitidae-I), are economically important structural insect pests in the urban environment.

Species identification: *Coptotermes* spp. associated with oil palm

There have been several updates and revisions of the genus *Coptotermes*. In 2003, Kirton and Brown determined that "Haviland's subterranean termite," *C. havilandi* Holmgren, was a synonym of *C. gestroi* (Wasmann). Tho (1992), the primary reference for identification of *Coptotermes* in the region based on the soldier caste, was revised as follows: "The description and illustration of *Coptotermes travians* (Haviland) as given by Tho in fact refers to *Coptotermes gestroi* (Wasmann), and the description and illustration of *Coptotermes havilandi* Holmgren is in fact that of *Coptotermes travians* (Haviland)." Later, Krishna *et al.* (2013) reviewed *Coptotermes* species names worldwide and their work was further reviewed by Chouvenc *et al.* (2015). Krishna *et al.* (2013) and Chouvenc *et al.* (2015) reverified the validity of the given species names of *Coptotermes* based on comparisons of the original and later descriptions and genetic data from the studies of various termite specialists.

Before the review was carried out by Krishna *et al.* (2013) and Chouvenc *et al.* (2015), there were at least twenty-two species of the genus *Coptotermes* known from the Indo-Malayan region (Snyder, 1949; Roonwal & Chhotani, 1962; Krishna, 1956; Ahmad, 1965). The number of *Coptotermes* species names after review by Krishna *et al.* (2013) and Chouvenc *et al.* (2015) was reduced to only eight species, *viz. C. elisae* (Desneux), *C. gambrinus* Bourguignon and Roisin, *C. gestroi* (Wasmann), *C. grandiceps* Snyder, *C. kalshoveni* Kemner, *C. pamuae* Snyder, *C. sepangensis* Krishna and *C. travians* (Haviland). The well-known *Coptotermes* pest species, *C. curvignathus,* was considered of uncertain status. This is due to recent morphological and genetic investigations of *C. elisae* from New Guinea, which matched the morphology and genetic sequences available for *C. curvignathus,* thus it is most probable that *C. curvignathus* is a junior synonym of *C. elisae* as suggested by Chouvenc *et al.*

(2015). However, at this point *C. curvignathus* is yet to be confirmed as a junior synonym of *C. elisae* (Thomas Bourguignon, pers. comm.). In this paper, the species name of *C. curvignathus* Holmgren is used for this common oil palm termite pest.

Termite species identification is commonly based on the soldier caste of the termite. *Coptotermes curvignathus* (a pest species) can be differentiated from the other three *Coptotermes* species (harmless species) based on size. The soldier caste of *C. curvignathus* is distinctly larger in size than *C. sepangensis*, *C. travians* and *C. kalshoveni* (*Table 2, Figures 10, 11 & 12*). It also has strongly incurved mandibles (*Figure 13*). Identification of *C. sepangensis*, *C. travians* and *C. kalshoveni* is more challenging. The specimens need to be examined under a microscope by a termite taxonomist. The mandibles of the termite are another criterion to further confirm the species *C. sepangensis*, *C. travians* and *C. kalshoveni*, as has been explained by Tho (1992).

General information of *Coptotermes* spp. associated with oil palm

Coptotermes curvignathus* Holmgren – *Major oil palm pest

Coptotermes curvignathus Holmgren is a major termite pest reported in Malaysia and Indonesia, attacking living plants in suburban and urban environment, infesting ornamental trees, oil palm and rubber trees (Wood, 1968; Kalshoven, 1981; Tho, 1992; Sajap & Wahab, 1997; Cheong *et al*., 2017). This species was reported to infest trees in gardens, attacking living trees and infesting dead trees in lowland and highland conifer plantations. It also causes hollows in the heartwood of living trees in primary and secondary lowland forests, as well as in rubber and oil palm (*Figure 14*).

Coptotermes travians* (Haviland) – *Non oil palm pest

A non-pest species of oil palm. The head of the soldier is ovoid in shape, much longer than

TABLE 2
MEASUREMENTS OF THE HEAD OF *COPTOTERMES* SPECIES FOUND IN THIS STUDY, COMPARED WITH KNOWN MEASURMENTS

Species	*Length of head to base of mandibles (mm)*		*Width of the head at the widest point (mm)*	
	Mean	*Range*	*Mean*	*Range*
*C. curvignathus** (n=50; 5 colonies)	1.34	1.19 – 1.47	1.17	1.07 – 1.25
*C. sepangensis** (n=50; 5 colonies)	0.94	0.83 – 1.06	0.79	0.72 – 0.84
*C. travians** (n=50; 5 colonies)	1.01	0.99 – 1.03	0.82	0.81 – 0.83
*C. kalshoveni** (n=29; 3 colonies)	0.85	0.78 – 0.86	0.78	0.77 – 0.79
Species Measurements by Tho (1992)				
C. curvignathus (n=50; 10 colonies)	1.68	1.51 – 1.85	1.34	1.28 – 1.57
C. sepangensis (n=50, 10 colonies)	1.23	1.08 – 1.31	0.93	0.85 – 1.08
C. travians (n=12, 2 colonies)	1.33	1.28 – 1.37	1.08	1.02 – 1.14
C. kalshoveni (n=50, 10 colonies)	1.14	1.02 – 1.20	0.91	0.81 – 1.02

**Note*: Definitions of measurements followed that of Tho (1992).
Source: Tho (1992)

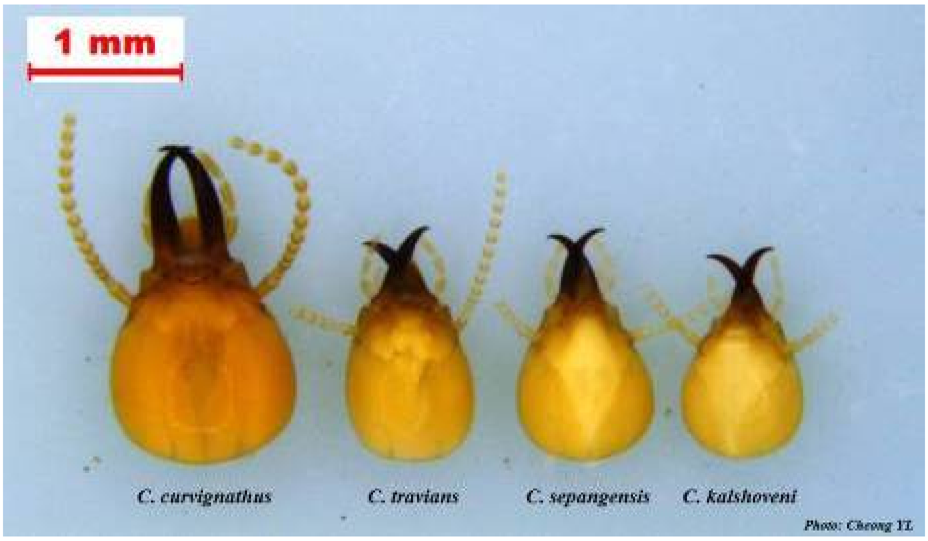

Figure 10 General comparison of soldier caste head between C. curvignathus, C. travians, C. sepangensis *and* C. kalshoveni. *(Note that the colour of the termites' head in this picture cannot be used as comparison criterion as discolouration occurred after the specimens were immersed in 70 per cent alcohol).*

Figure 11 Dorsal view of the soldier caste head of C. curvignathus, C. travians, C. sepangensis *and* C. kalshoveni

Figure 12 Lateral view of the soldier caste head of C. curvignathus, C. travians, C. sepangensis *and* C. kalshoveni

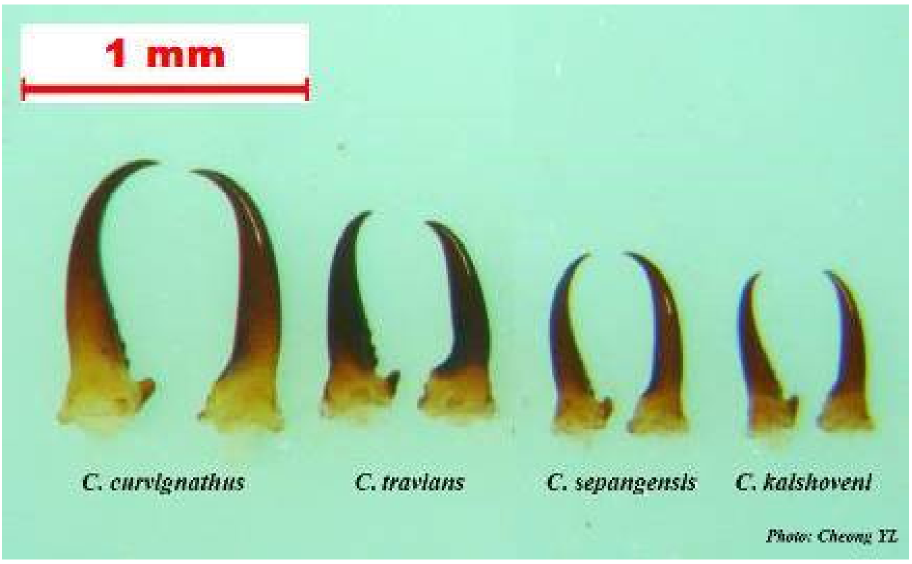

Figure 13 The mandibles of the soldier caste C. curvignathus, C. travians, C. sepangensis *and* C. kalshoveni

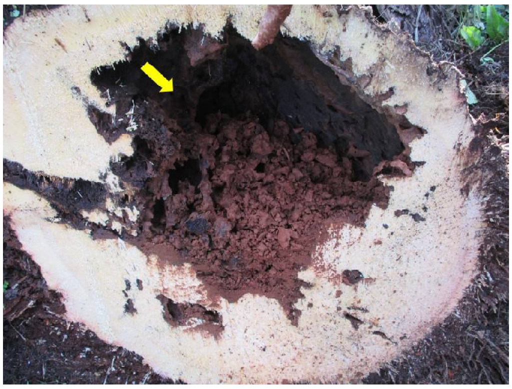

Figure 14 Cross section of a mature oil palm trunk infested by subterranean termite, C. curvignathus

wide, narrowed anteriorly, yellow-orange to orange; mandibles broad, weakly curved (Tho, 1992). Tho (1992) also noted that *C. travians* can be distinguished by its broader and less curved mandible, as shown in *Figure 13*. This species was recorded feeding on fallen trees. An examination of the original specimens on which Haviland based his description showed that *C. travians* was a species that had not been found in houses, but instead occurred only in forested areas (Kirton & Brown, 2003). Most of the old references that stated that this particular species infested woodwork in buildings and was responsible for the damage of timber and timber products in fact referred to the species now known as *C. gestroi* (which has also been referred to as *C. havilandi*). *Coptotermes gestroi* was wrongly identified as *C. travians*. In addition, in Peninsular Malaysia, the true *C. travians* has been wrongly called *C. havilandi*, while in Borneo, it has been described again under a different name, *C. borneensis* (Thapa, 1981). In oil palm plantations, this species was reported "infesting" 15-year-old palms in deep peat soil by building its nests in the trunks of matured palms, but did not cause death. They primarily infested plant and wood residues (Cheng *et al*., 2008).

Coptotermes sepangensis Krishna – *Non oil palm pest*

A non-pest species of oil palm. The soldier caste has a pear-shaped head, generally much narrowed anteriorly; colour of head ranging from yellow-orange to orange-brown; mandibles slender and strongly curved (Tho, 1992). It is usually found infesting suburban and rural structures, and feed on dead and living trees (most likely referred as coexistence and harmless) in garden and pine plantations (Tho, 1992). Cheng *et al*. (2008) stated that this species was found in moderately deep to deep peat soil in 15 to 20-year-old plantings, formed small, localised infestations inside the living trunk but lacked the ability to kill oil palm trees. Cheong *et al*. (2017) reported that *C. sepangensis* is not a pest of oil palm and did not damage the living tissues of oil palm. It primarily infests plant and wood residues (Cheng *et al*., 2008).

Coptotermes kalshoveni Kemner – *Non oil palm pest*

A non-pest species of oil palm. This species is so far the smallest known species of *Coptotermes* in Malaysia. The head colour of the soldier caste ranges from yellow to orange-brown. The shape of the head is generally very narrowed anteriorly and laterally very rounded (Tho, 1992). *Coptotermes travians* and *C. kalshoveni* were reported to infest living trees in urban dwellings (Tho, 1992). However, it has usually been reported to feed on fallen trees, stumps or wood in the garden.

CONCLUSION

Coptotermes curvignathus is the sole termite pest of oil palm. Other termite species associated with oil palm are harmless and beneficial. Most of the termites have been studied globally for decades as beneficial macrofauna for their ability to decompose decaying matter, aid in nutrient recycling, and form new soil. They feed on highly decayed wood and cellulosic material. The harmless termites are unlikely to change their behaviour and food preference, becoming a pest that attack oil palm even in extreme condition (i.e. no food source). If so, they would have been reported as pest species considering oil palm cultivation in Malaysia and Indonesia is about a century old. Thus, accurate termite species identification, their feeding group and FTG are carefully determined and studied to avoid indiscriminate killing of the harmless and beneficial termites in the field.

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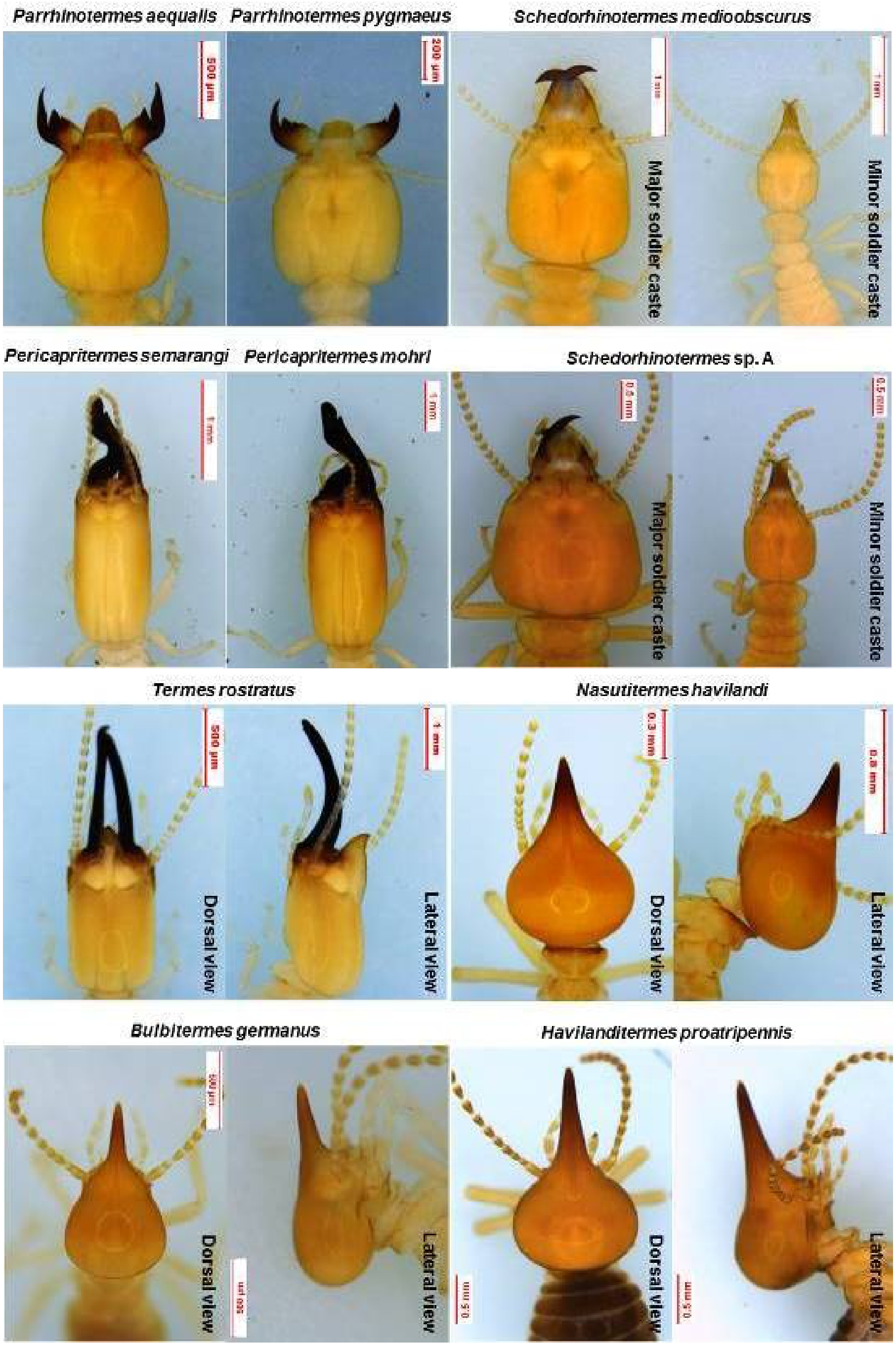
APPENDIX



*Pictorial guide on the common termite species in peat soil (non-*Coptotermes*)*