SAND MOISTURE PREFERENCE, DISTURBANCE EFFECTS AND INTRA- AND INTERSPECIFIC AGGRESSION IN *Microcerotermes crassus* Snyder (BLATTODEA: TERMITIDAE)

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by

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LIST OF ABBREVIATION

gm	grams
mm	millimetres
cm	centimetres
ml	millilitres
°C	degrees Celsius
RH	relative humidity
S.E.M	Standard Error of the Mean
vs.	versus

LIST OF PUBLICATIONS & SEMINARS

Papers presented

1. **Wong, N.** and CY Lee. Distribution and Abundance of Termite Mounds in Universiti Sains Malaysia, Minden Campus, Penang, Malaysia. *In* 11th Biological Sciences Graduate Congress (11th BSGC). Bangkok, Thailand. 15-17 December 2007.
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3. **Wong, N.** and CY Lee. Influence of different sand moisture level on consumption and movement patterns of *Microcerotermes crassus* Synder (Termitidae) and *Coptotermes gestroi* Wasmann (Rhinotermitidae). *In* 12th Biological Sciences Graduate Congress (12th BSGC). Kuala Lumpur, Malaysia. 17-19 December 2007.
4. **Wong, N.** and CY Lee. Effects of induced disturbances on the movement and feeding behaviour of *Microcerotermes crassus* Snyder (Blattodea: Termitoidae: Termitidae). *In* 10th Symposium of the Malaysian Society of Applied Biology. Kuching , Sarawak, Malaysia. 6-8 November 2008.
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Publications

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4. Pest Summit 2006: Targeting Zero Pest Infestation, organized by Pest Control Association of Malaysia & Singapore Pest Management Association, co-

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KELEMBAPAN TANAH, KESAN GANGGUAN DAN KEAGRESIFAN INTRA- DAN INTERSPESIFIK DALAM *Microcerotermes crassus* SNYDER (BLATTODEA: TERMITIDAE)

ABSTRAK

Tesis in bertumpu pada aspek ekologi dan perilaku anai-anai *Microcerotermes crassus* Snyder. Pelbagai substrat telah diuji untuk memastikan kemandirian yang tertinggi bagi anai-anai ini di dalam makmal dan pasir terbukti sebagai substrat yang sangat sesuai. Di dalam pasir, kemandirian anai-anai adalah tinggi dan aktiviti menerowong boleh dilihat dengan jelas. Aktiviti pemakanan secara relatifnya adalah serupa bagi semua substrat yang diuji. Kesan beberapa tahap kelembapan (0, 5, 10, 15, 20 dan 25%) pada pasir diuji terhadap *M. crassus* dan dibandingkan dengan *C. gestroi* dalam suatu eksperimen makmal. Kandungan kelembapan pasir mempengaruhi kadar pemakanan kayu dan mempengaruhi taburan *M. crassus* merentasi suatu gradien kelembapan. Perubahan terhadap parameter kelembapan juga mempengaruhi lokasi *C. gestroi* tetapi kesan kelembapan terhadap kadar pemakanan kayu adalah tidak signifikan. Walau bagaimanapun, *M. crassus* dan *C. gestroi* menunjukkan satu taburan yang berpola serupa berhubung dengan tahap kelembapan tertentu. Kajian perbandingan menunjukkan bahawa *M. crassus* adalah kurang agresif kerana sedikit akitiviti menerowong telah direkodkan. Terowong-terowong yang dibina *C. gestroi* adalah amat bercabang dan luas, manakala *M. crassus* membina terowong-terowong yang lebih sempit dan kurang bercabang. Apabila koloni-koloni anai-anai daripada spesies yang sama atau berbeza berinteraksi, pelbagai kelakuan agonistik boleh terjadi. Dengan menakjubkan, *M. crassus* tidak mempamerkan sebarang kelakuan agresif apabila diletakkan bersama

koloni yang bersamaan spesiesnya dan tiada kematian atau hanya kadar kematian yang rendah dicatatkan. Secara kontras, pelbagai kelakuan agresif telah dipamerkan di dalam kajian interspesifik, mengakibatkan kadar kematian yang tinggi bagi kebanyakan pertemuan yang berlaku. Pertemuan antara *M. crassus* dengan anai-anai spesies yang sama atau berbeza dan dengan serangga-serangga lain seperti semut juga boleh mengakibatkan pertempuran yang kemudiannya mungkin meninggalkan bangkai-bangkai di kawasan bekalan makanan berada. Tambahan pula, *M. crassus* mungkin bertemu dengan bangkai invertebrata yang lain seperti gonggok dan kutu kayu yang boleh ditemui di dalam sarang mereka, di tempat bekalan makanan berada seperti di sekitar bangunan, dan sebagainya. Sepuluh faktor telah diuji ke atas kelakuan *M. crassus*. Taburan *M. crassus* dicatatkan pada hari pertama dan keenam selepas rawatan di antara kawasan yang tidak dirawat dengan kawasan yang dirawat. Pemerhatian menunjukkan bahawa gangguan atau kehadiran bangkai hanya mencegah anai-anai untuk sementara waktu. Walau bagaimanapun, rawatan berterusan dengan *C. gestroi* yang dihancurkan menunjukkan bahawa anai-anai itu juga mengelak daripada kawasan yang dirawat pada hari keenam selepas rawatan. Kemandirian juga adalah terendah dalam piring-piring yang telah dirawat dengan *C. gestroi*. Didapati bahawa kurang kayu telah dimakan anai-anai di kawasan yang mengandungi atau dirawati dengan konspesies yang telah dihancurkan (pekerja atau askar ahli sesarang dan bukan ahli sesarang), atau dengan *C. gestroi* yang telah dihancurkan.

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ABSTRACT

This thesis focuses on the ecological and behavioural aspects of *Microcerotermes crassus* Snyder. Different substrates were tested to ensure the highest survival of these termites under laboratory conditions and sand proved to be very suitable. In sand, survival of termites was high and tunnelling activities can be observed clearly. Wood consumption for the termites was relatively the same for all substrates. The effects of different moisture levels (0, 5, 10, 15, 20 and 25%) of a sand substrate on the behaviour of *M. crassus* were evaluated and compared to *C. gestroi* in a laboratory assay. Moisture content of sand affected wood consumption and influenced the distribution of *M. crassus* across a moisture gradient. Changing the moisture parameters also affected the location preference of *C. gestroi* but the effect on wood consumption was not significant. Nonetheless, *M. crassus* and *C. gestroi* showed a similar distribution pattern of association with particular moisture levels. Comparative studies showed that *M. crassus* was less aggressive as less tunnelling activity was recorded. Tunnels built by *C. gestroi* were highly branched and wide, whereas *M. crassus* built tunnels that were more narrow and less branched. When termite colonies from the same or different species interact, wide range of agonistic behaviours can occur. Remarkably, no aggressive behaviours were displayed by *M. crassus* when placed in different colonies of the same species and no or low mortality was recorded. In contrast, various aggressive behaviours were displayed in the interspecific study, resulting in a high mortality rate in most of the

encounters. Encounters between *M. crassus* with termites of the same or different species and with other insects such as ants may also result in fighting and subsequently carcasses may be left at feeding sites. Moreover, *M. crassus* may encounter other invertebrate carcasses such as millipedes and wood lice that can be found within their nests, at feeding sites around buildings, etc. Ten factors were evaluated on the behaviour of *M. crassus*. The distribution of *M. crassus* was recorded between treated and untreated areas on day 1 and day 6 post-treatment. Observations show that disturbances or the presence of carcasses only deterred the termites temporarily. However, prolonged treatment particularly with crushed *C. gestroi* showed that termites avoided the treated area even at 6 days post-treatment. Survival was also lowest in dishes treated with crushed *C. gestroi*. Termites consumed less wood in the dishes containing or treated with crushed conspecifics (workers or soldiers of nestmates and non-nestmates), or with crushed *C. gestroi*.

CHAPTER ONE

GENERAL INTRODUCTION

In many parts of the world, termites are an important group of insect (Edward and Mill 1986). According to Wagner *et al.* (2008), the presence of termites can hardly go unnoticed to inhabitants and travellers in the tropics. These insects can cause a lot of problems to the users of wood since the termite food is mainly wood and woody tissues. Each year, a great deal of effort and money are spent on attempting to prevent termites from damaging houses, buildings, trees and crops (Edward and Mill 1986).

Around 2200-2700 termite species were identified, covering 7 families and 82 genera (Harris 1971, Edward and Mill 1986, Pearce 1997, Lee and Chung 2003). Tho (1992) classified a total of 175 termite species in Peninsular Malaysia into 42 genera. However, it was reported that less than 10% of the total termite species are pest in the man environment (Lee and Chung 2003).

Termites can be classified into three main categories: drywood termites, dampwood termites and subterranean termites. Drywood termites can be found living entirely within dry wood and usually infesting structures above the soil surface. This group of termites is less dependent on moisture (Edward and Mill 1986). The damages caused by these termites usually go unnoticed as no mud tubes are constructed and their colony size is relatively small (Robinson 1996).

Dampwood termites can be found infesting wood with a high moisture content or has contact with moist soil. They are found to live in old tree stumps, they common in the northwestern United States of America (Edward and Mill 1986).

Subterranean termites build their nests in soil or above ground. This group of termite is prone to desiccation when they are exposed to the air in the open environment. Therefore, mud tubes or covered runways are constructed when they search for food above ground. In urban and suburban environments, subterranean termites are the most destructive and the most frequently encountered structural pest (Lee 2002b, Kirton and Azmi 2005). Subterranean termites from the genus *Coptotermes* are the most destructive species in South East Asia (Kirton *et al*. 2000, Kirton and Wong 2001, Lee 2002a, 2002b, Lee and Chung 2003). In Malaysia, subterranean termites from the genera *Coptotermes*, *Macrotermes*, *Microtermes*, *Globitermes*, *Odontotermes*, *Schedorhinotermes* and *Microcerotermes* are found to infest perimeters of buildings and structures, in gardens and in parklands (Lee *et al*. 2007).

According to Lee *et al. (*2007), secondary pest termites are often encountered in homes in Malaysia. Among these pests includes *Schedorhinotermes*, *Microcerotermes*, *Macrotermes*, *Nasutitermes*, *Globitermes* (Ngee and Lee 2002, Lee *et al*. 2003) and *Odontotermes*. These termite genera have been clasified under the family of Termitidae and are referred to as the higher termites (Krishna 1969). It is the largest termite family containing three-fourths of the known termite species (Krishna 1969). Most of the species, especially from the family Termitidae do not respond well to bait with paper-based matrices. Thus, several months after the elimination of the principal pest species (*Coptotermes* spp.) with bait, other termite species such as *Macrotermes* and *Schedorhinotermes* were found infesting the same structure or building (Lee *et al.* 2007).

Pest control operators usually carry out chemical soil treatment when they encounter a structure infested with higher termites after previously eliminating *Coptotermes* through baiting. It was reported that *Microcerotermes crassus* Snyder would infest structures after the elimination of *Coptotermes* species. Lee *et al.* (2007)

reported that from 2001 until 2004, the succession rate of termites from the genera of *Microcerotermes* after the suppression/elimination of *Coptotermes* spp. is 2.4% in Malaysia. In Australia, localized nests of *Microcerotermes* were found in bait stations after *Coptotermes* is eliminated or suppressed (Lee *et al.* 2007). On the other hand, in Thailand, *M. crassus* has been identified as the predominant termite species that attacks houses in rural areas (Sornnuwat 1996). Therefore, Lee *et al.* (2007) suggested that mounds of higher termite species found along the perimeter of baited homes should be excavated. This approach can help reduce the chances of these species infesting premises upon suppression or elimination of *Coptotermes* species.

In general, efforts of managing multi-genera termite fauna are best done by taking into account the biology of different target species (Lee *et al*. 2007). Detailed studies of various aspects of the biology of only a few termite species have been carried out. Thus, the purpose of this study is to obtain more information on the behaviour of *M. crassus*.

The objectives of this study were;

1. To acquire the most suitable medium that promotes the highest survival and encourages tunnelling of *M. crassus*.
2. To determine and compare the effects of various soil moisture level on the tunnelling activity and wood consumption rates of *M. crassus* and *Coptotermes gestroi* Wasmann and also to compare the tunnelling pattern and feeding behaviour between the two different species.
3. To study the intra- and inter-colony agonistic behaviour of *M. crassus*.
4. To study the effects of various inflicted disturbances on *M. crassus*.

CHAPTER TWO

LITERATURE REVIEW

2.1 Termites in the Order Blattodea

Inward *et al.* (2007) reported that in morphological and molecular phylogenetic analyses, termites are considered as social cockroaches and should no longer be classified under a separate order (Isoptera).

The woodroach *Cryptocercus* was found to share several groups of flagellates with early branching termites (Cleveland *et al.* 1934). In addition, McKitterick (1964) stated that there are morphological similarity between some termite nymphs and *Cryptocercus* nymphs, suggesting a close phylogenetic relationship between the two groups. Inward *et al.* (2007) described termite+Cryptocercus clade as sister to Blattidae. In turn, termite + Cryptocercus and Blattidae are sister to Blattellidae + Blaberidae (Blaberoidea). In Polyphagoidea, Nocticolidae+Polyphagidae are sister to all cockroaches as well as the termites and Mantodea are sister to the cockroaches (Blattodea). The relationships between the sisters groups were shown to have 100% posterior probability. No other relationships were found from the 2501 sampled trees in the Bayesian analysis. Therefore, the odds of termites branching out of the cockroaches are very small. It was proposed that termites should instead be treated as a family (Termitidae) of cockroaches. Therefore, the existing termite taxa would have to be downgraded by one taxonomic rank, such as families become subfamilies, subfamilies become tribes and so on.

Lo *et al*. (2007) commented that ranking termites as a family will destabilize termite nomenclature and disrupt scientific communication. Family would not be an ideal rank for termites as it does not acknowledge the stability of present family