Jpn. J. Environ. Entomol. Zool. 14 (2) : 105－112 (2003)
環動昆 第14巻 第2号：105－112 (2003)

Foraging Colonies of a Higher Mound-building Subterranean Termite, *Globitermes sulphureus* (Haviland) in Malaysia

Chow-Yang Lee *, Jocelyn Yap, Peng-Soon Ngee and Zairi Jaal

Urban Entomology Laboratory, Vector Control Research Unit, School of Biological Sciences,
Universiti Sains Malaysia, 11800 Penang, Malaysia

(Received : February 12, 2003 ; Accepted : April 5, 2003)

マレーシアにおける塚構築地下生息性高等シロアリ *Globitermes sulphureus* (Haviland) の採餌コロニー． Chow-Yang Lee, Jocelyn Yap, Peng-Soon Ngee and Zairi Jaal (マレーシア理科大学生物学部)

標識再捕集法を用いて，塚構築地下生息性高等シロアリ *Globitermes sulphureus* (Haviland) コロニーの採餌活動における特徴について検討した．実験に使用した3コロニー (A, BおよびC) のうち、コロニーBは最大の採餌個体数 (86万9千頭) を示し，その採餌範囲は50.59 m²であった．一方，コロニーAとCでは，採餌個体数はそれぞれ54万4千頭と51万4千頭であった．また，採餌範囲は，コロニーAが42.53 m²，コロニーCが5.90 m²と，8倍程度の差が認められた．さらに，*G. sulphureus* 3コロニーにおける採餌最大距離は，4.2mから16.0mであった．本研究で得られた結果および既往の結果から，一般的に高等シロアリのほうが下等シロアリよりも小さい採餌範囲と採餌距離を有することが推察された．

A study was conducted in a university campus to characterize foraging colonies of a higher mound-building subterranean termite, *Globitermes sulphureus* (Haviland) using a triple mark-recapture method. Of the three termite colonies (A, B & C) characterized, colony B was found with the highest number of foragers (8.69×10^5) and covered a foraging area of $50.59 m^2$. For colony A and C, relatively similar colony sizes were estimated at 5.44×10^5 and 5.14×10^5, respectively. Foraging territory of colony A ($42.53 m^2$) was approximately 8 times larger than colony C ($5.90 m^2$). Maximum foraging distances of the *G. sulphureus* colonies in this study ranged between 4.2 m and 16.0 m. The results obtained were compared with studies reported earlier for lower termite species and was speculated that higher termite species generally has a smaller foraging

* Corresponding author: chowyang@usm.my

territory and shorter foraging distance when compared to the latter group.

Key words: *Globitermes sulphureus*, Foraging colony, Foraging territory, Colony size, Malaysia

Introduction

Termites are an important group of insect pests in tropical Malaysia (Lee *et al.*, 1999). Lee (2002 a) reported 50% of total business turnover of the pest control industry in Malaysia are termite control related which accounted approximately US $ 8-10 million. A total of 175 species of termites have been reported in Malaysia (Tho, 1992; Kirton and Wong, 2001; Lee *et al.*, 2003 a), but only 5 species of them (*Coptotermes* spp.) are causing more than 90% of total termite damages in Malaysia (Lee, 2002 b). Other peridomestic species such as *Globitermes sulphureus* (Haviland), *Macrotermes gilvus* (Hagen), *Microtermes pakistanicus* Ahmad and *Microcerotermes* spp. have also been reported to have limited effects to urban structures.

G. sulphureus is generally restricted to Indo-Malaya region. Identification can be made easily based on the bright yellow coloured abdomen of its soldier termite. This species is an important pest in agricultural sectors particularly in coconut and oil palm plantations (Harris, 1971). Despite its peridomestic foraging behaviour in the urban environment (particularly those that were developed from plantation lands) which poses its potential as a pest species, very limited information are available on the biology and ecology of this species. In this paper, we present our findings on characterization of several foraging colonies of *G. sulphureus* in a university campus using triple mark-recapture technique.

Materials and Methods

Three natural colonies of *G. sulphureus* (A, B and C) located in Universiti Sains Malaysia Minden campus, Penang, Malaysia, were selected for the study. Oven-dried rubber (*Hevea brasiliensis* Mueller) sapwood (4 x 2.5 x 30 cm) were driven into ground within the vicinity of *G. sulphureus* mounds to intercept the foraging territory of the colony. They were checked once every two weeks and replaced with a monitoring station [a rectangular polyethylene container (35 x 25 x 17 cm) baited with rubber wood blocks] upon being attacked by the termites.

After several weeks, a monitoring station with the highest termite numbers (based on visual inspection) was selected and all termites in that station were brought back to the laboratory, separated according to method of Tamashiro *et al.* (1973) and force-fed with 0.1% w/w Nile Blue A in saw dust (<40 mesh) for three days (Ngee and Lee, 2002). Dyed termites were counted before they were released back to their initial monitoring station. Subsequently after two weeks, termites from all monitoring stations were collected, inspected and stations with dyed termites were considered to belong to the same colony as the initial monitoring station. The insects were separated, dyed and then released back into the stations where they were initially collected and the process was repeated for three cycles. Colony size was estimated using weighted mean model (Begon, 1979; Su *et al.*, 1993): $N = (\Sigma\ M_i n_i) / (\Sigma\ m_i) + 1$, where, for each i th cycle, n_i = the number of termites captured; m_i = number of marked individuals among captured termites; and M_i = total number of marked individuals up to the i th cycle. Standard error (S. E.) $= N \{ [1/(\Sigma mi + 1)] + [2/(\Sigma mi + 1)^2] + [6/(\Sigma mi + 1)^3] \}^{1/2}$

Results and Discussion

A total of 11 monitoring stations each were set up to characterize colony A and B, while only three stations were used to study colony C. In all cases, a *G. sulphureus* mound was located within or near the characterization sites. Results indicated that foraging territory for colony A, B and C were 42.5 m², 50.6 m² and 5.9 m², respectively (**Table 1; Figs. 1-3**). This concurs well with our earlier report that foraging territories of *G. sulphureus* ranged between 25.8 m² and 61.9 m² (Ngee and Lee, 2002). In addition, we also demonstrated earlier another higher mound-building termite species, *M. pakistanicus* which possessed foraging territory within the above range (30.5 m² - 54.2 m²) (Lee *et al.*, 2003 b). In another study, Badawi *et al.* (1984) revealed that foraging territories of an arboreal nest builder termite species *Microcerotermes* sp., and *Microtermes* sp. to be 31.8 m² and 18.2 m², respectively. On the contrary, lower termite species which do not build mound such as *Reticulitermes flavipes* Kollar and *Coptotermes* spp. showed a relatively larger foraging territory [eg. up to 2361 m² for *R. flavipes* (Grace *et al.*, 1989; Su and Schreffrahn, 1988; Su *et al.*, 1993; Su, 1994); 125-384 m² for *Coptotermes travians* (Haviland) (Lee, 2002 a)].

In this study, foraging distance for the three colonies (A, B and C) were 7.1 m, 16.0 m and 4.2 m, respectively (Table 1). The results obtained supported those of Ngee and Lee (2002) who found foraging distance of *G. sulphureus* to range between 3.5-15.0 m. Relatively similar to *G. sulphureus*, *M. pakistanicus* has a foraging distance between 5.7 and 10.5 m (Lee *et al.*, 2003 b). Compared to the higher termites, it was suggested that lower termites generally tend to have a longer foraging distance based on studies published earlier [eg. 100 m for *C.*

Table 1 Colony size, foraging territory and foraging biomass of three *Globitermes sulphureus* colonies (A, B & C) in a university campus based on weighted mean model

Colony	cycle	$[r_i]$ 1)	$[n_i]$ 2)	$[m_i]$ 3)	N 4)	± SE 5)	L 6) (m²)	B 7) (kg)	D 8) (m)	WCR 9) (g/2 weeks/station)
A	1	5532	6249	128						
	2	5807	15107	383	5.44×10^5	0.18×10^5	42.5	1.7	7.1	104.0 ± 48.7
	3	14043	11456	403						
B	1	5249	21125	164						
	2	20692	10976	310	8.69×10^5	0.30×10^5	50.6	2.9	16.0	114.0 ± 30.7
	3	10760	9118	365						
	1	2616	15594	88						
C	2	14832	20676	598	5.14×10^5	0.12×10^5	5.9	1.4	4.2	87.9 ± 45.45
	3	19048	14543	1128						

1) Total numbers of stained termite released.
2) Total number of termites recaptured.
3) Total number of stained termites in n_i.
4) Population estimate.
5) Standard error.
6) Foraging area.
7) Foraging biomass.
8) Foraging distance.
9) Mean wood consumption rate.

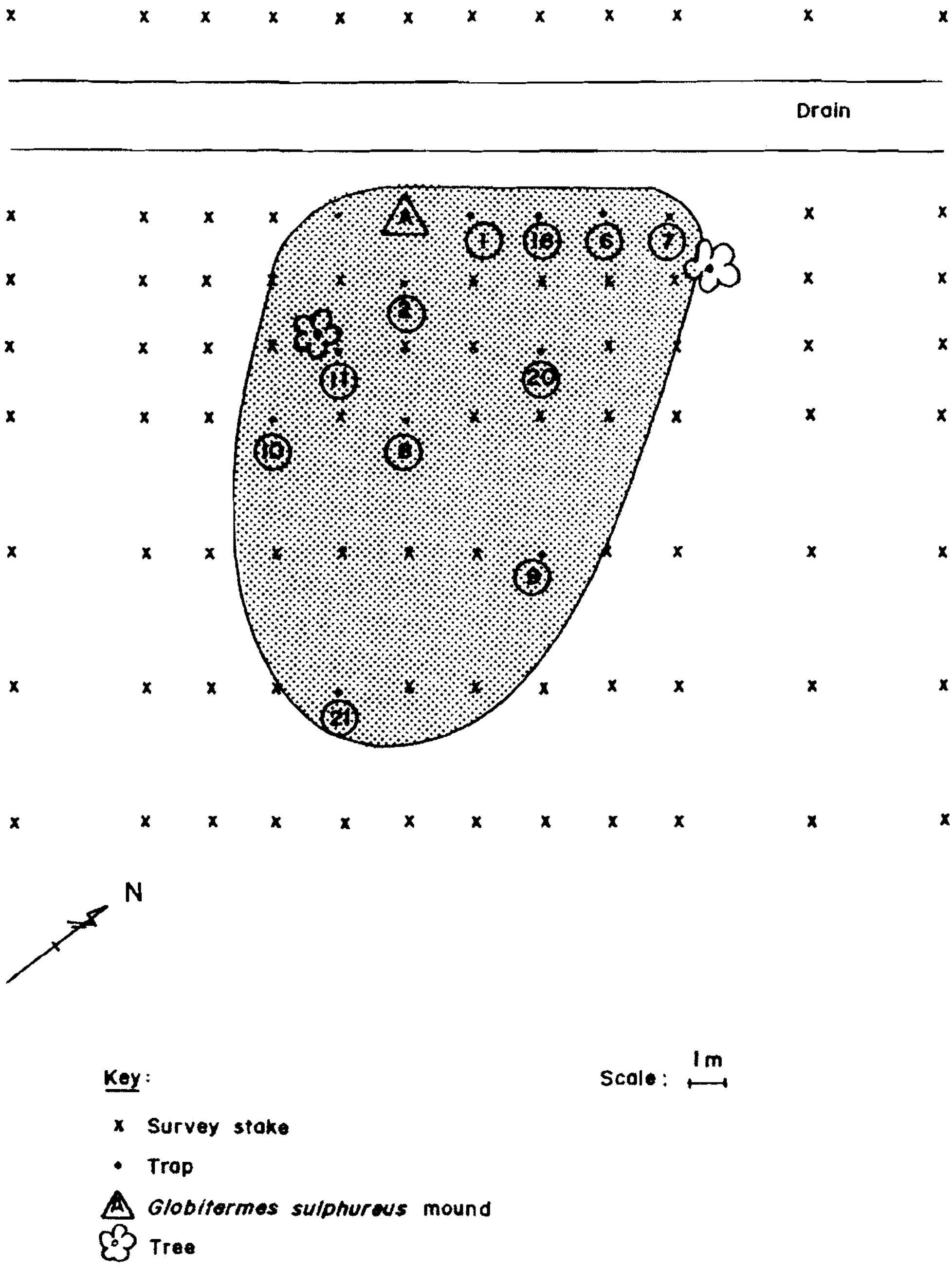

Fig. 1 Foraging colony and territory of *Globitermes sulphureus* (colony A).

formosanus (Lai, 1977), 48-79 m for *R. flavipes* (Grace *et al.*, 1989; Su *et al.*, 1993) and 32 m for *C. travians* (Lee, 2002 a)], with exception to *Reticulitermes speratus* (Kolbe) (Tsunoda *et al.*, 1999). However, it is also noted that other factors such as colony age and environmental conditions may also

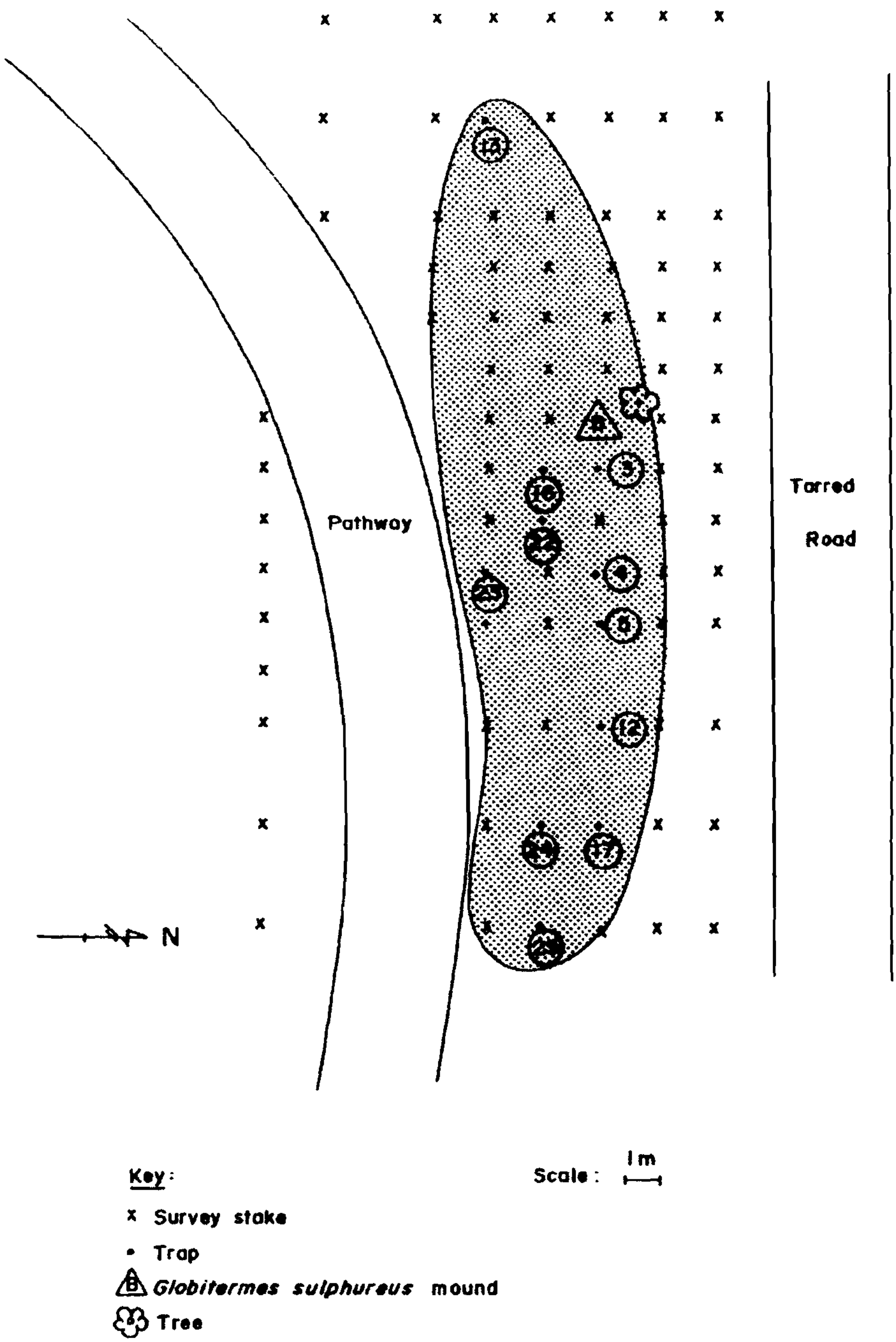

Fig. 2 Foraging colony and territory of *Globitermes sulphureus* (colony B).

affect foraging distance, as well as foraging territory size.

Triple-mark recapture estimated the colony size to range between 5.14×10^5 and 8.69×10^5 (**Table 1**). This finding is lower by one magnitude when compared to an earlier study which estimated

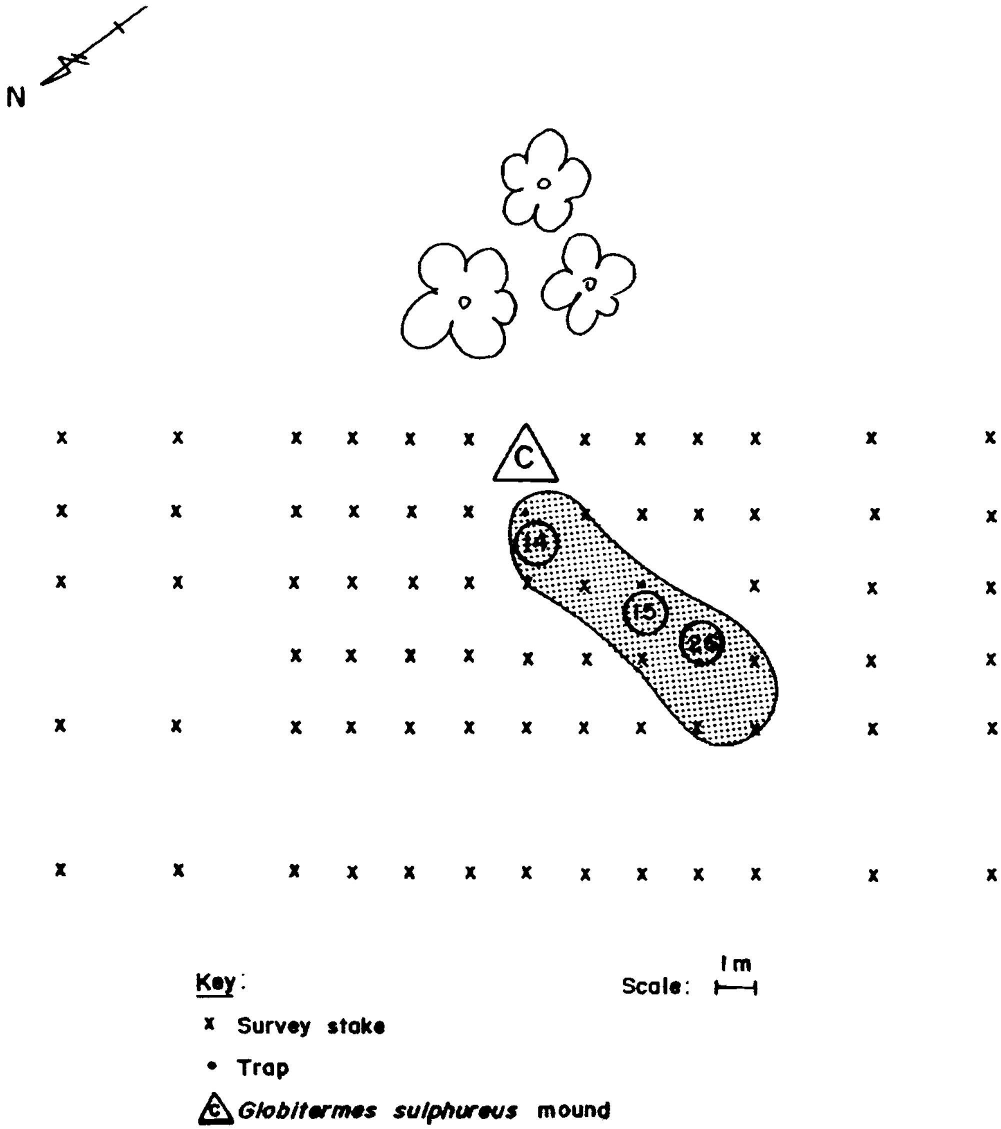

Fig. 3 Foraging colony and territory of *Globitermes sulphureus* (colony C).

foraging colonies of *G. sulphureus* using modified single-mark-recapture technique at $1.2-4.02 \times 10^6$ (Ngee and Lee, 2002). The difference may be due to differences in sampling technique (modified single mark-recapture vs. triple mark-recapture), in addition to other factors such as vegetation, existence of other termite species, etc. Previous studies had revealed that colony size varied with species [eg. *C. formosanus*-$1.8-4.4 \times 10^6$ (Su *et al.*, 1984), *Coptotermes gestroi* (Wasmann)-$1.13-2.75 \times 10^6$ (Sornnuwat *et al.*, 1996), *Coptotermes curvignathus* Holmgren-$0.1-0.7 \times 10^6$ (Sajap *et al.*, 2000) and C. travians-$0.3-1.3 \times 10^6$ (Lee, 2002 a), *R. flavipes*-5.0×10^6 (Su *et al.*, 1993), *R. flavipes*-$2.1-3.2 \times 10^6$ (Grace *et al.*, 1989), *Reticulitermes hesperus* Banks-$0.7-0.8 \times 10^6$ (Haagsma and Rust, 1995), *R.*

speratus-0.1-0.4 x 10^6 (Tsunoda *et al.*, 1999)], and possibly colony age and environmental conditions as noted by Tsunoda *et al.* (1999) and Sornnuwat *et al.* (1996).

This study provided an insight into some important characteristics of foraging colonies of *G. sulphureus*. More studies should be conducted to further substantiate current findings.

Acknowledgements

The authors acknowledged research grants provided by Universiti Sains Malaysia and Dow Agrosciences Asia to the senior author (CYL) that have resulted this study.

References

Badawi, A., A. A. Faragalla and A. Dabbour (1984) Population studies of some termites in Al-Kharj Oasis, central of Saudi Arabia. *Z. angew. Entomol.* 97 : 253-261.

Begon, M. (1979) *Investigating animal abundance: capture-recapture for biologists.* University Park, Baltimore, Maryland.

Grace, J. K., A. Abdallay and K. R. Farr (1989) Eastern subterranean termite (Isoptera: Rhinotermitidae) foraging territories and populations in Toronto. *Can. Entomol.* 121 : 551-556.

Haagsma, K., M. K. Rust, D. A. Reierson, T. H. Atkinson and D. Kellum (1995) Formosan subterranean termite established in California. *Calif. Agric.* 49 : 30-33.

Harris, W. V. (1971) *Termites: Their recognition and control.* 2nd edition. Longman Group Ltd., London.

Kirton, L. G. and A. H. Wong (2001) The economic importance and control of termite infestations in relation to plantation forestry and wood preservation in Peninsular Malaysia - An overview. *Sociobiology* 37 : 325-349.

Lai, P. Y. (1977) *Biology and ecology of the Formosan subterranean termite,* Coptotermes formosanus *and its susceptibility to the entomogenus fungi,* Beauveria bassiana *and* Metarrhizium anisopliae. Ph D Thesis. University of Hawaii.

Lee, C. Y. (2002a) Control of foraging colonies of subterranean termites, *Coptotermes travians* (Isoptera: Rhinotermitidae) in Malaysia using hexaflumuron baits. *Sociobiology* 39 : 411-416.

Lee, C. Y. (2002b) Subterranean termite pests and their control in the urban environment in Malaysia. *Sociobiology* 40 : 3-9.

Lee, C. Y., P. S. Ngee, L. C. Lee and J. P. S. Na (2003a) Survey of termite diversity in Pantai Acheh Forest Reserve, Penang Island, Malaysia. *J. Biosci.* (submitted).

Lee, C. Y., P. S. Ngee and L. C. Lee (2003b) Foraging populations and territories of a mound-building subterranean termite, *Microtermes pakistanicus* (Isoptera: Macrotermitinae). *Sociobiology* 41 : 307-316.

Lee, C. Y., H. H. Yap, N. L. Chong and J. Zaal (1999) *Urban Pest Control-A Malaysian Perspective.* Universiti Sains Malaysia.

Ngee, P. S. and C. Y. Lee (2002) Colony characterization of a mound-building subterranean termite, *Globitermes sulphureus* (Isoptera : Termitidae) using modified single-mark recapture technique. *Sociobiology* 40 : 525-532.

Sajap, A. S., S. Amit and J. Welker (2000) Evaluation of hexaflumuron for controlling the subterranean termite *Coptotermes curvignathus* (Isoptera: Rhinotermitidae) in Malaysia. *J. Econ. Entomol.* 93 : 429-433.

Sornnuwat, Y., K. Tsunoda, T. Yoshimura, M. Takahashi and C. Vongkaluang (1996) Foraging populations of *Coptotermes gestroi* (Isoptera : Rhinotermitidae) in an urban area. *J. Econ.*

Entomol. 89 : 1485-1490.

Su, N. Y. (1994) Field evaluation of a hexaflumuron bait for population suppression of subterranean termites (Isoptera: Rhinotermitidae). *J. Econ. Entomol.* 87 : 389-397.

Su, N. Y. and R. H. Scheffrahn (1988) Foraging population and territory of Formosan subterranean termite (Isoptera: Rhinotermitidae) in an urban environment. *Sociobiology* 12 : 299-304.

Su, N. Y., P. M. Ban and R. H. Scheffrahn (1993) Foraging populations and territories of the Eastern subterranean termite (Isoptera: Rhinotermitidae) in Southeastern Florida. *Environ. Entomol.* 22 : 1113-1117.

Su, N. Y., M. Tamashiro, J. R. Yates and M. I. Haverty (1984) Foraging behavior of the Formosan subterranean termite (Isoptera: Rhinotermitidae). *Environ. Entomol.* 4 : 1466-1470.

Tamashiro, T., J. K. Fujii and P. Y. Lai (1973) A simple method to observe, trap, and prepare large numbers of subterranean termites for laboratory and field experiments. *Environ. Entomol.* 2 : 721-722.

Tho, Y. P. (1992) Termites of Peninsular Malaysia. *Malayan Forest Records* 36 : 1-224.

Tsunoda, K., H. Matsuoka, T. Yoshimura and M. Tokoro (1999) Foraging populations and territories of *Reticulitermes speratus* (Isoptera: Rhinotermitidae). *J. Econ. Entomol.* 92 : 604-609.