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RESEARCH NOTE

FORAGING POPULATION, TERRITORY AND CONTROL OF *Globitermes sulphureus* (ISOPTERA: TERMITIDAE) WITH FPRONIL IN PENANG, MALAYSIA

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There are 175 species of termites in Peninsular Malaysia and they are all social insects (Tho, 1992). In Malaysia, five species of termites that are of economic importance which cause damages to structures and crops are *Coptotermes gestroi*, *C. havilandi*, *C. kalshoveni*, *C. curvignathus* and *C. sepanggiensis* (Sajap and Wahab, 1997). All these species are subterranean termites which do not build mount. Other genera such as *Globitermes*, *Macrotermes* and *Schedorhinotermes* are also crucial pests. *Globitermes sulphureus* can be easily identified by the bright yellow coloured abdomen of its soldier termite restricted to Indo Malaya Region (Tho, 1992). *Globitermes sulphureus* is a significant pest in coconut and palm oil plantation (Harris 1971). Although *G. sulphureus* is an importance pest in agriculture, it had been reported to attack building structure especially around the perimeter of the house and contributed to over a third (36%) of infestations in semi-urban areas in Peninsular Malaysia (Ngee and Lee, 2002; Abdul Hafiz and Abu Hassan, 2005; Kirton and Azmi, 2005 and Abdul Hafiz *et al*., 2007). Most of the infestation was found around the window frames, under the carpet especially infesting the carpet grippers and also found in wooden wall and wooden pillars at Minden and Balik Pulau, Penang, Malaysia (Abdul Hafiz and Abu Hassan, 2009). As *G. sulphureus* can become an important structural pest in the Indo- Malayan region, proper management strategies to control *G. sulphureus* infestation from getting severe are important. Agenda 25EC is one of the slow acting and non-repellant termiticides used to control termites and it contains fipronil as the active ingredient (Cole *et al*., 1993; Hamon *et al.,* 1996). The mode of action is delayed; attributed to the movement of the active ingredient in the colony through trophallaxis and social grooming (Kard, 2003). In the United States, fipronil is used in animal health, indoor pest control (Ibrahim *et al*., 2003). This paper reports the foraging territories, population size, feeding consumption and efficacy of the Agenda 25EC termiticide on controlling *G. sulphureus* colony by creating continuous termiticide barrier around the monitoring stations. The study was carried out in a Plant House at the University Sains Malaysia, Penang, Malaysia. The site has been infested by *G. sulphureus* with its mound. Billets (2.5 cm x 2.5 cm x 15 cm) of pine woods (*Pinus carebea*) were installed in the range of 1.5 m to 3 m in the study area. Approximately 100 survey stakes were used but only four were infested by termites which were replaced with underground monitoring stations. An underground monitoring station used in this research was similar to those described by Su and Scheffrahn (1986, 1988). The underground monitoring station consists of a hollow plastic container (20 cm diameter by 19 cm height) in which a bundle of nine pine billets oven-dried for 48 h at 70ºC, cooled in a tray, and weighed before being placed in the bucket of the underground monitoring stations. The bucket of the underground monitoring station was buried at a depth of approximately 2.5 cm below the lid. There were four selected underground monitoring stations at this site for *G. sulphureus* population. Infested blocks from the underground monitoring stations were brought to the laboratory every two weeks and carefully disassembled. Termites were removed by gently tapping the stakes over a plastic tray. Termites were separated from the remaining debris by allowing access to a stack of five pine blocks (20 cm x 10 cm) that had been soaked in water for 24

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hours. Termites aggregated in the stacks of pine blocks within 4-6 h and were removed (Tamashiro *et al*., 1973). Recovered termites were weighed on an analytical balance and their number estimated based on the weight of 100 workers from the same wood block. All wood blocks were washed, oven-dried and weighed to compute the wood consumption. After the establishment of $\geq$ 2 monitoring stations, a mark recapture program was used to estimate the foraging territory and population size. For each termite collection, mean body weight of termite workers was determined by weighing five groups of 10 individuals each. The numbers of collected workers were determined by the total weight of collected workers and the mean worker weight. Termite workers collected from a station with heavy activity were stained with 0.1% (wt/wt) Nile Blue A by a no choice feeding of stained filter paper (Whatman No. 1, 9.0 cm diameter) for 5 days. Stained termites were released into one of the underground monitoring stations. Each monitoring station was checked and termites were collected 7 days after the release. Model Mean Begon was used to estimate the foraging populations (Begon, 1979; Su and Scheffrahn, 1993). The marked release recapture cycle was repeated three times. The number of marked and unmarked workers were recorded for each cycle. A weight mean model (Begon, 1979; Su and Scheffrahn, 1993) was used to estimate the foraging population (N) and associated standard error (SE);

$$N = (\Sigma M i n i) / [(\Sigma m i) + 1]$$

$$SE = N\sqrt{[1/(\Sigma m i + 1)] + [2/(\Sigma m i + 1)^2] + [6/(\Sigma m i + 1)^6]}$$

Where N is the mean foraging population and SE the the associated standard error for the *i*th cycle, M*i* the total number of marked individuals up to the *i*th cycle, m*i* the number of marked individuals among the captured termites, and n*i* the number captured.

Foraging ranges were delineated by observation of marked termites in monitoring station

The treatment was conducted on 17th week of termite feeding consumption on all four underground monitoring stations with fipronil (Figure 2). One meter square quadrate was made around the underground monitoring station. Twelve holes were drilled around the one meter square quadrate. The distances between holes were 33.3 cm. The termiticide was diluted at a ratio of 1:120 in water. Five liters of solution were injected in each hole. Termite activities were observed and the feeding consumptions were recorded every 2 weeks in all underground monitoring stations after the treatment for a month.

The number of marked termites released, termite recaptured and marked termites among recaptured termites during the triple mark recapture procedures are shown in Table 1. One week after the release, initially marked termites were recaptured from most of the interconnected monitoring stations. The estimated foraging populations for *G. sulphureus* were 6.2312x10^5 ± 0.28178x10^5 with the foraging territory covered an area of 530.40 m^2 (Figure 1 and Table 1).

Table 1. Number of marked termites released (r*i*), number of termites captured (n*i*) and number of marked termites among those captured (m*i*) during a triple mark-recapture program (*G. sulphureus*)

Colony	*i*th mark-recapture	r*i*	n*i*	m*i*	Foraging populations ± Standard Error (SE)
Globitermes sulphureus	1	3,130	31,723	47	6.2312x10^5 ± 0.28178x10^5
	2	31,723	16,512	43	
	3	16,512	18,557	298	

Total wood consumptions for *G. sulphureus* before treatment for undergound monitoring stations number 1, 2, 3 and 4 surveyed every two weeks were 323.4 g, 370.5 g, 328.7 g and 468.7 g respectively. Three weeks after the treatment there were no termite feeding activitiy observed in underground monitoring stations 1, 2, and 3 (Figure 2). The underground monitoring station number four remained active, with *G. sulphureus* activities after the treatment. The feeding consumptions were recorded for all the four underground monitoring station for another four weeks (Figure 1 and Figure 2). After four weeks, only visual observation was being carried out for the termite activities for the underground monitoring station number 4.

Termites activities successfully controlled in underground monitoring station number 1, 2, 3 and 4 due to transfer of the active ingredient of the termiticide among the colony from exposed to unexposed termites through social behaviors such as contact and grooming. Barrier treatment and integration of biocide can be the components of the horizontal transfer contributing to the efficacy of fipronil in the field (Vargo and Parman, 2004; Gurbel and Abu Hassan, 2006; Abdul Hafiz and Abu Hassan, 2006 and 2008; Bagnères *et al*., 2009). Termite activities in underground monitoring station four failed to be stopped by fipronil probably due to the existence of a gap in the termiticide barrier. This gap might influence the termite to move towards the underground monitoring station four. During the application, the texture of the soil may have caused the difficulties in injecting the fipronil solution into the drilled hole in the soil. Some of the fipronil solution had spilled out from the hole,

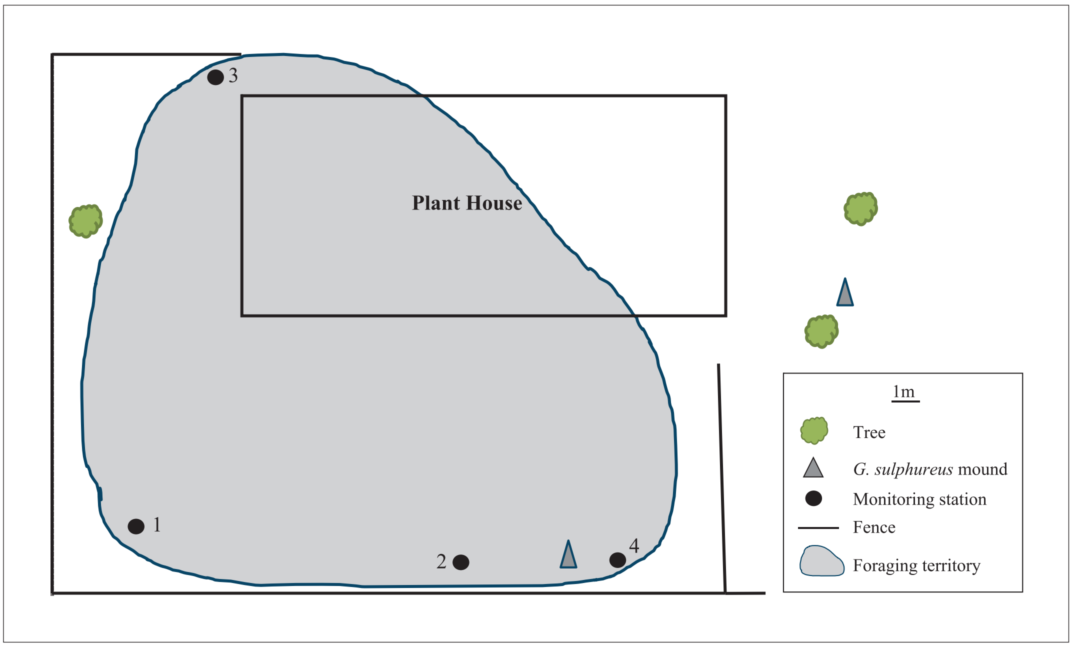

Fig. 1. Location of underground monitoring station, mound and foraging territory of *G. sulpureus*.

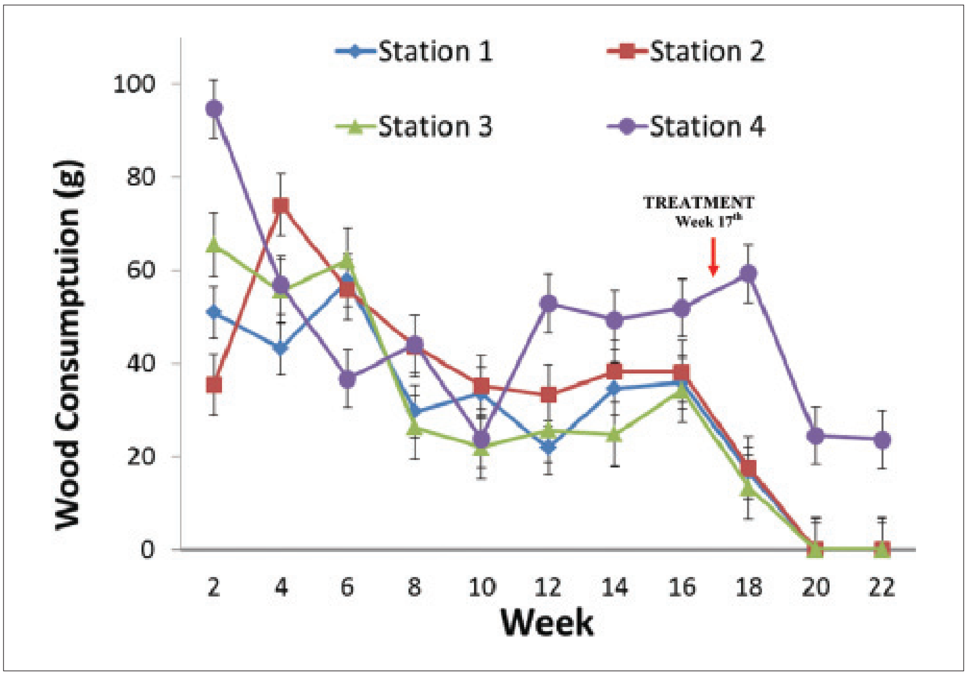

Fig. 2. Total wood consumption of *G. sulphureus* for underground monitoring station 1, 2, 3 and 4 before and after treatment.

reducing the quantity of fipronil solution barrier in the soil. The lack of fipronil solution in the barrier would reduce the efficiency of the barrier in preventing the termites from entering the underground monitoring station. The characteristics of soil such as pH, moisture, temperatures, presence of microorganism, organic materials (Harris, 1972; Tashiro and Kuhr, 1978; Chapman *et al.*, 1982; Macalady and Wolfe, 1983; Felsot, 1989; Wood, 1988) and soil type (Lange and Carlson, 1956; Harris, 1966, 1972; Campbell *et al.*, 1971; Smith and Rust, 1993; Forschler and Townsend, 1996) could affect the tunneling behavior, search and exploitation of termite and the failure to control *G.*

sulpureus completely. In the construction of subterranean galleries, Adamson (1943); Lee and Wood (1971) have suggested that the dense network of subterranean galleries might affect porosity and areolation, infiltration, storage and damage of water, growth of plant roots and the soil as an environment. As a result of these factors, the termiticide that had been injected into the soil probably could run off because of the porosity of the soil. Therefore a good barrier of termiticide was not created around the underground monitoring station.

Knowledge and understanding of subterranean termite foraging biology and ecology could help in their detection and control. This trial has proven that fipronil (Agenda 25SC) has managed to cease feeding activity in the three out of four monitoring stations three weeks after the treatment. The active ingredient, fipronil may have reached the nest through the food brought by the foraging termites and cease the termite feeding activities in the monitoring stations. However due to lack of termiticide application barrier around one of the underground monitoring station, termite feeding activity remained active with reduction of termite feeding consumption after the treatment. Further study is required for better understanding on lack of control using barrier treatment at one of the underground monitoring station.

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