Soil Arthropods Associated with Termite Bait Monitoring Stations in Malaysia

by

Boon-Hoi Yeoh[1] & Chow-Yang Lee[1,2]

ABSTRACT

A field study to determine soil arthropods associated with termite monitoring stations (Sentricon®, Dow AgroSciences, Indianapolis, Indiana, U.S.A.) was conducted on Penang Island, Malaysia. The effects of environmental parameters and wood species [namely southern yellow pine (*Pinus* sp.), rubber (*Hevea brasilliensis*), jelutong (*Dyera costulata*) and terentang (*Campnosperma aunculata*)] as monitoring stakes on the abundance of soil arthropods in the monitoring stations were studied. A total of 16 types of arthropods were found, with acarines (mites) being the most abundant (59.8 ± 9.9 % of the total of 72 stations). Other arthropods that were also frequently found included collembolans (springtails), isopods (sowbugs and pillbugs), formicids (ants), chilopods (centipedes), diplopods (millipedes) and aranea (spiders). Some environmental parameters affected the prevalence of soil arthropods in monitoring stations. Collembolan prevalence decreased significantly ($P < 0.05$) with increasing rainfall. Aranea and formicid prevalence decreased with increasing soil moisture, while aranea were more abundantly found in monitoring stations with increasing soil temperature. We also found interaction between soil pH and soil organic matter content affecting the abundance of four arthropod groups (acarines, chilopods, diplopods and formicids). Different wood species used as monitoring stakes did not appear to affect the prevalence of soil arthropods in monitoring stations.

Keywords: termite, monitoring station, arthropods, environmental parameters, wood species

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

[1]To whom reprint request should be addressed. Email: chowyang@usm.my

INTRODUCTION

Subterranean termites are an important group of insect pests in tropical South East Asia. In Malaysia, termite control accounted for about 50% of the total business turnover of the pest control industry (Lee 2002a). Amongst the various methods of subterranean termite control, baiting is becoming a popular post-construction method and is currently about 15% of the total termite control business in Malaysia.

Presently, the Sentricon® Termite Colony Elimination System (Dow AgroSciences LLC, Indianapolis, Indiana) is the only termite baiting system available commercially in Malaysia. In this baiting program, cylindrical-shape plastic monitoring stations are deployed along the building perimeter. Since they are installed below the ground surface for a period of time, they may become attractive to other non-targeted invertebrates (Scharf *et al.* 2002). Sentricon® manufacturer's reference manual described that the existence of slugs and other insects (such as ants and cockroaches) in the monitoring station may create an environment that is not conducive to termites (Dow Agrosciences 1996). Gulmahamad (1996) and Scharf *et al.* (2002) reported various invertebrate faunas found in the Sentricon® monitoring stations in California and Indiana, respectively. However, little is known about the types of soil arthropods that are associated with termite bait monitoring stations in the tropics.

This study was initiated to determine the soil invertebrates (mainly arthropods) that are normally associated with termite monitoring stations around the perimeter of three types of habitat (old building, new building and natural habitat), and also to determine the impact of environmental parameters such as rainfall, soil type, soil moisture, soil temperature, soil pH and soil organic matter on their abundance. In addition, effects of different wood species used as monitoring stakes on invertebrate abundance in the monitoring station was also determined.

MATERIALS AND METHODS

Three types of habitat were selected for this study, namely new buildings (< 5 years), old buildings (10 – 60 years) and natural habitats. A total of three sites were chosen for each habitat, and all sites were located in the Universiti Sains Malaysia main campus on Penang Island, Malaysia. Eight in-ground monitoring stations were installed at each site surrounding the above-mentioned compound. The locations of stations were equally distributed to avoid irregularities due to direct sun exposure or shade.

Monitoring stations were inspected once every two weeks up to five months. The monitoring wood stakes were removed from the station carefully and both stakes were knocked gently into a 16-cm diameter polyethylene container to collect the soil arthropods. All collected arthropods were brought to laboratory and kept in 70% ethanol for identification at a later date. In addition, the soil temperature, moisture, pH and organic matter were also determined at each inspection.

For the determination on the effects of wood species of the monitoring stakes on invertebrate abundance, two sampling grids measuring 6 x 18 m were established in a natural habitat. Sixteen monitoring stations were installed at each grid, using four wood species: southern yellow pine (*Pinus* sp.), rubber wood (*Hevea brasilliensis*), jelutong (*Dyera costulata*) and terentang (*Campnosperma aunculata*). Four replicates of each wood species were tested in each grid, with their location being arranged systematically to avoid positional bias. The distance interval between two stations was standardized at 3 m. Inspection was made weekly up to 5 weeks post-treatment.

All data in percentage were subjected to arc-sine transformation before analyses. Regression and correlation between various environmental parameters and arthropods' abundance was analyzed using general linear model-repeated measurements. One-way analysis of variance was executed to determine the influence of different wood species on soil arthropods, and means were separated with Tukey HSD. All analyses were performed using statistical software SPSS Version 11.0.

RESULTS AND DISCUSSION

All sites were found to be comprised of sandy loam, with a pH ranging between 4.54 and 6.24, and 0.96 – 1.38% (± 0.31) organic matter. Soil temperatures were found to be relatively consistent throughout the study (Table 1). It was found that soil moisture changed with monthly rainfall, as the main water source in soil in the tropics generally comes from rain precipitation (Fitzpatrick 1986). While the soil pH varied depending on the types

Table 1. Mean monthly (July – November 2003) soil temperatures and moistures in the three habitats studied.

Environmental parameter	Habitat (Mean ± S.E.M.)		
Month (2003)	New building	Old building	Natural habitat
Soil temperature (°C)			
July	29.9 ± 0.8	29.9 ± 0.5	29.8 ± 1.1
August	29.9 ± 0.2	31.2 ± 0.8	29.4 ± 0.5
September	30.0 ± 1.2	30.7 ± 1.0	29.8 ± 1.5
October	28.7 ± 0.6	30.4 ± 0.3	28.9 ± 1.9
November	28.3 ± 0.6	29.6 ± 1.1	29.7 ± 1.5
Soil moisture (%)			
July	20.1 ± 1.6	20.5 ± 4.7	18.4 ± 1.2
August	18.8 ± 1.8	19.2 ± 3.8	19.0 ± 2.6
September	18.9 ± 2.8	18.9 ± 1.4	17.8 ± 0.5
October	24.1 ± 1.6	23.1 ± 3.1	25.9 ± 4.1
November	23.8 ± 2.5	29.6 ± 5.8	27.2 ± 2.5

of vegetation and mineral content in the soil, the pH and organic matter is relatively consistent in all the monitoring stations in an area.

Various arthropods were found in the monitoring stations, especially non-targeted ones like collembolans, acarines and diplopods. Other non-target arthropods found included ants, spiders, sowbugs, pillbugs, earthworms, snails, centipedes, cockroaches, crickets, slugs, beetles, pseudoscorpions, hemipterans, diplurans and subterranean termites of less or non-economic importance. These animals used the monitoring stations as harbourage, food source and also for nesting purposes (Gulmahamad 1998).

Few species of ants and termites had been collected. *Tapinoma melanocephalum* (Fabricius) was the most abundant ant species (8.3 ± 1.6%) (Table

Table 2: Ant species collected in monitoring stations, and their prevalence (n = 72) over the study period (July – November 2003).

Species	Mean ± S.E.M. (%)
Tapinoma melanocephalum	8.3 ± 1.6
Paratrechina longicornis	4.2 ± 1.2
Anoplolepis gracilipes	3.1 ± 1.0
Solenopsis geminata	3.1 ± 1.0
Camponotus sp.	1.7 ± 0.5
Prenolepis sp.	0.3 ± 0.3
Odontomachus sp.	0.3 ± 0.2

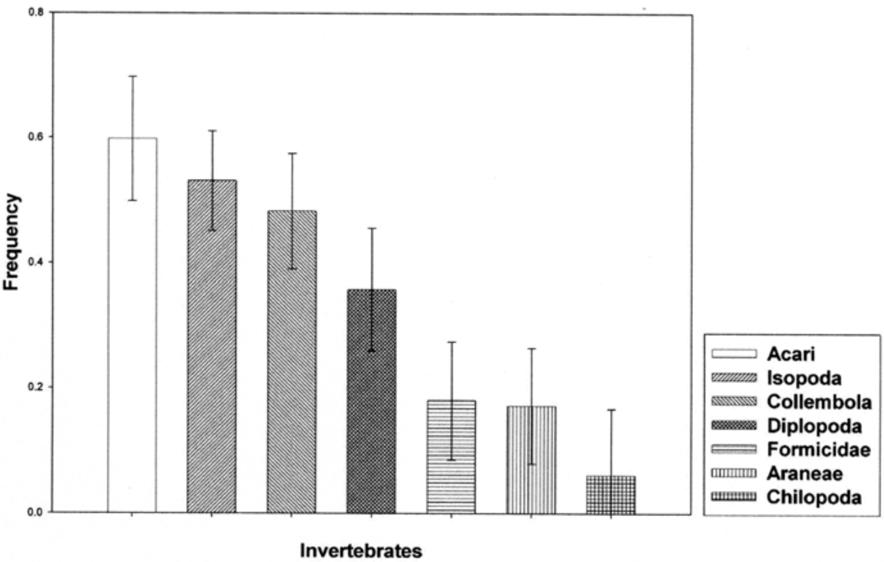

Fig. 1. Frequency of seven major groups of soil arthropods found in this study.

2), followed by *Paratrechina longicornis* (Latrielle) and *Anoplolepis gracilipes* (Fr. Smith) with frequencies of 4.17 ± 1.2% and 3.1 ± 1.0%, respectively. *T. melanocephalum* is sensitive to dessication (Appel *et al.* 2004). This may explain why they were abundantly found and attracted to nest inside the monitoring stations. Most ants were found nesting inside the monitoring stations, similar to that reported by Scharf *et al.* (2002). Other species (eg. *Solenopsis geminata*, *Prenolepis* sp., *Camponotus* sp. and *Odontomachus* sp.) were found at much lower frequencies (Table 2). The species found in this study corresponded well with those reported by Lee *et al.* (2002) and Lee & Tan (2004) on the species diversity of pest ants found in the urban and suburban areas in Malaysia and Singapore, respectively.

On the other hand, *Macrotermes gilvus* Hagen was found to be the most abundant subterranean termite species found in all three types of habitat, followed by *Microtermes pakistanicus* Ahmad which was only collected in the natural habitats. Lee (2002b) reported that both *M. gilvus* and *M. pakistanicus* are common subterranean termite species that can be found along building perimeters in the urban and suburban environment in Malaysia.

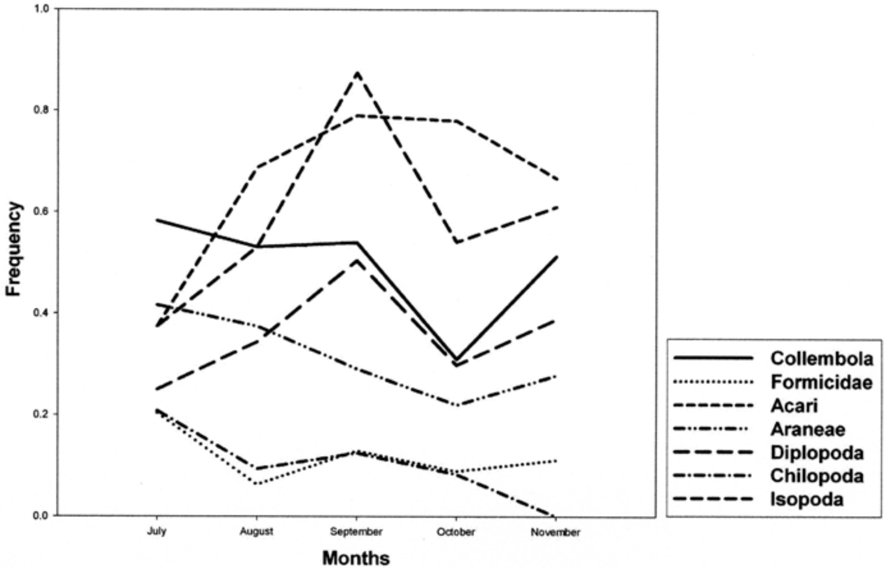

Fig. 2. Prevalence of seven major groups of soil arthropods in new building habitats.

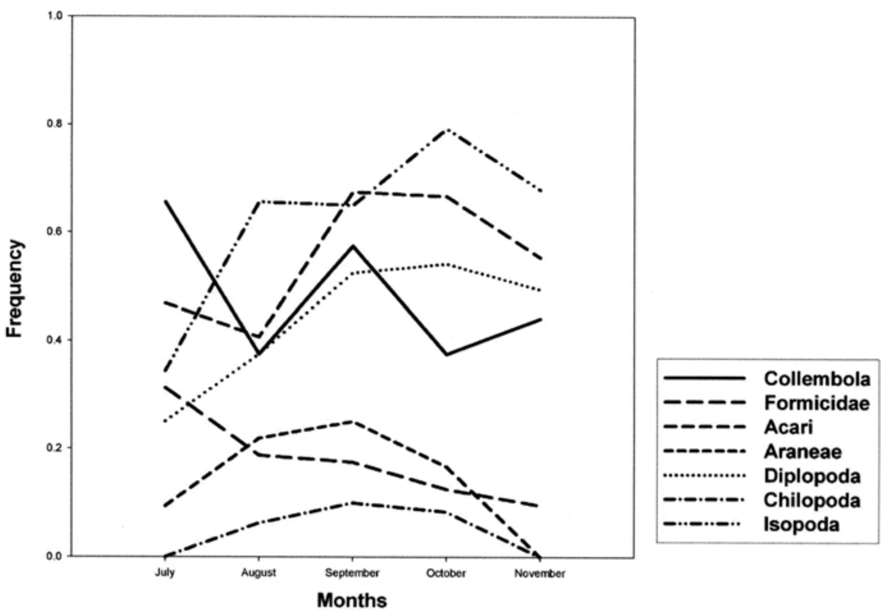

Fig. 3. Prevalence of seven major groups of soil arthropods in old building habitats.

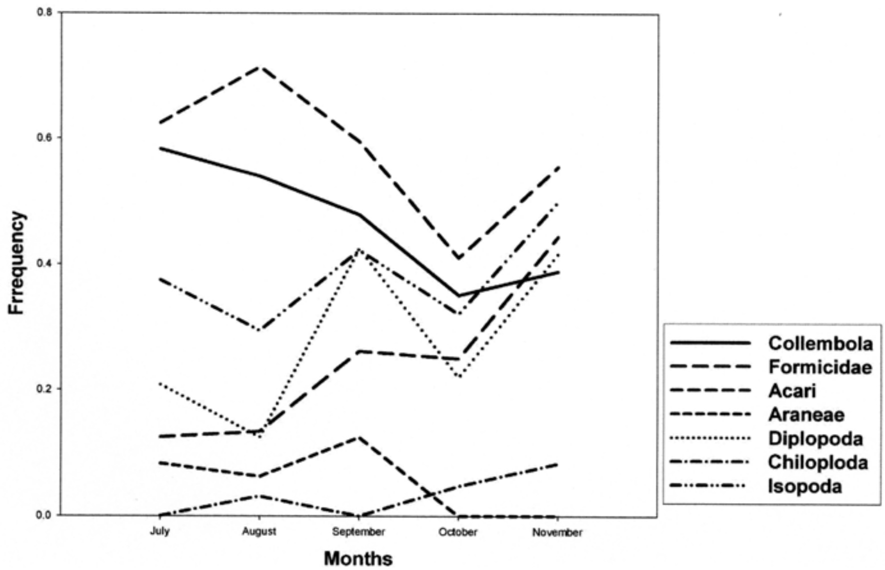

Fig. 4. Prevalence of seven major groups of soil arthropods in natural habitats.

In this study, only seven groups of arthropods that were abundantly found were taken into account, i.e. acarines, collembolans, isopods, ants, chilopods, diplopods and aranea (Fig. 1). Acarines were most abundant in monitoring stations of both new buildings and natural habitats with a frequency of 0.7 ± 0.1 and 0.6 ± 0.01, respectively. In contrast, isopods were the most abundant arthropods in monitoring stations near old buildings with a frequency of 0.6 ± 0.01. Pinto (1990) and Lavelle & Spain (2001) reported that isopods prefer habitats with shade. Old buildings in this study matched the above mentioned criteria, as they were surrounded by trees with dense canopy and the blankets of fallen leaves. Isopods often make use of corridors and patios as their home range where moisture can be sustained (Scharf *et al.* 2002). In addition, diplopods were collected from old buildings (frequency = 0.4 ± 0.6) (Figs. 2 – 4).

In this study, we also found other invertebrates such as mollusks (snails and slugs) and annelids (earthworms) in the monitoring stations. However, their numbers were minimal, and thus, they were not included in the data

Table 3. Effects of soil pH and soil organic matter on the abundance of invertebrate groups in monitoring stations.

Invertebrate	Parameter	*SS/MS*	*df*	*F*	*P*
Acarines	pH	820.35	1	7.20	0.055
	organic matter	4120.75	1	36.15	0.004*
	pH x organic matter	6177.05	1	54.19	0.002*
Chilopods	pH	1192.27	1	9.30	0.038*
	Organic matter	464.66	1	3.62	0.130
	pH x organic matter	2107.66	1	16.43	0.015*
Diplopods	pH	1118.45	1	22.18	0.009*
	Organic matter	341.75	1	6.78	0.060*
	pH x organic matter	3867.84	1	76.69	0.001*
Formicidae	pH	1602.53	1	38.61	0.003*
	Organic matter	0.03	1	0.00	0.980
	pH x organic matter	802.46	1	19.33	0.012*

*denotes a significant effect ($P < 0.05$) on the abundance of the invertebrate group.

analysis. There were also two incidences where garden snakes were found in monitoring stations.

Influences of environmental conditions

Monthly rainfalls were found to affect the abundance of collembolans, especially around new building habitat. The prevalence of collembolans in all monitoring stations (y) decreased with increasing rainfall (x): $y = 68.5 - 0.4x$ where $x \leq 1714.25$ mm, $r^2 = 0.97$, $P < 0.05$.

With the exception of aranea abundance in old building habitats, soil temperature did not affect invertebrate abundance in monitoring stations. In old buildings, aranean prevalence in all monitoring stations (y) increased with increasing soil temperature (x): $y = -402.7 + 13.7x$, where x $29.3 < x < 31.2$, $r^2 = 0.83$, $P < 0.05$.

Some arthropods showed low tolerance to chemical contents in soil. Chemicals such as sodium carbonate, calcium and magnesium may affect the presence of soil arthropods (Hausenbuiller 1985; FitzPatrick 1986). In this study, it was shown that soil pH had an effect on the prevalence of chilopods, diplopods and ants in monitoring stations (Table 3). Diplopods generally prefer soil with higher calcium content and polyphenol (Crossley & Coleman 2000, Lavelle & Spain 2001).

With the exception of acarines ($F = 36.15$, $P < 0.05$), the amount of organic matter in soil did not affect the abundance of any invertebrate group (Table 3). However, interaction between pH and organic matter content significantly affected ($P < 0.05$) the prevalence of four major invertebrate groups, i.e. acarines, chilopods, diplopods and formicids (Table 3).

Soil moisture (x) was found to affect the prevalence of araneans (y) in old buildings ($y = 67.6 - 2.3x$; $18.9 \leq x \leq 29.6$, $r^2 = 0.97$, $P < 0.05$) and natural habitat ($y = 29.8 - 1.1x$; $17.8 \leq x \leq 27.2$, $r^2 = 0.88$, $P < 0.05$), and the prevalence of ants in old buildings ($y = 35.2 - 0.9x$; $18.9 \leq x \leq 29.6$, $r^2 = 0.85$, $P < 0.05$). These arthropods were found to decrease with increasing soil moisture (%).

Influence of different wood species

In this study, we did not find any significant effect ($P > 0.05$) among different wood species used as monitoring stakes on the prevalence of overall or any particular group of soil arthropods in monitoring stations. However, certain wood species such as rubber wood and pine were found to be prone to fungal infestation which can be observed as early as one week after installation, and this may deter the foraging termites from feeding on the monitoring stakes.

SUMMARY AND CONCLUSION

This paper provides an insight into the common soil arthropods that can be found inside termite monitoring stations, and how environmental parameters affected their prevalence. Collembolan prevalence decreased significantly ($P < 0.05$) with increasing rainfall. Aranea and formicid prevalence decreased with increasing soil moisture, while aranea were also more abundantly found in monitoring stations with higher soil temperature. We also found interaction between soil pH and soil organic matter content that affected the abundance of four arthropod groups (acarines, chilopods, diplopods and formicids). Different wood species as monitoring stakes did not appear to have any effect on the prevalence of soil arthropods in monitoring stations. More studies should be conducted to determine the effects of these arthropods on the feeding activity of subterranean termites on monitoring stakes in future.

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