Nutrient Content of Litter Harvested by *Drepanotermes tamminensis* (Hill) in Its Mounds Within a Native Reserve In the Western Australian Wheatbelt

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This study estimated the mound litter biomass and the nutrient content of mound litter in the two study plots in Durokoppin Nature Reserve, Western Australia between 2004 and 2005. There were no significant differences in biomass of litter in individual mounds between the two study plots. Seven components of litter were found in the mounds. The nutrient concentrations were higher in the woodland than in the shrubland plot, although the differences were not statistically tested, and the total amount of each nutrient measured was generally greater in the woodland than in the shrubland plot. The aforementioned results show that *D. tamminensis* harvests various plant material according to biomass availability. The role of this termite takes on particular importance in view of the fact that Western Australian soils are notoriously impoverished in nutrients.

Key words : Nutrient content, litter, termites, *Drepanotermes tamminensis*

Introduction

The termite genus *Drepanotermes* (Isoptera: Termitinae) is confined to the Australian continent [5,6,18]. All species are harvesters and they venture into the open by day or night to gather both freshly fallen and old leaf litter, grass or other vegetable debris which they store in underground nests or in mounds. Therefore, these termites are generally considered to be the insects most effective in breaking down litter and releasing nutrients for re-use by plants in areas of poor soil fertility [4,10,11]. *Drepanotermes tamminensis* (Hill) is confined to the agricultural regions of south-western Australia. It is thus the only species of *Drepanotermes* in Australia that is restricted to a winter rainfall area [17]. *Drepanotermes tamminensis* (Hill) is a mound-building species, and its mounds are irregularly conical or rounded, commonly 0.5-1.0 m high, although they can reach 2m. All mounds are used for storing litter that has been harvested by the termites from the surrounding areas. This species is known to harvest a wide range of material, depending on what is available [17]. Some field observation on foraging activity and harvesting rate by this termite species have already been reported [14]. According to the results, *D. tamminensis* was an important agent in litter harvesting and ultimately in nutrient cycling within this ecosystem [14,16].

In view of the apparent abundance of this species in the study area, this study was performed on its role in the nutrient dynamics of the area. As aforementioned role of termites in nutrient cycling in the ecosystem, the evaluation of litter removal activity and nutrient content of litter harvested by the termites are very important. Thus, the specific objectives of this study were to estimate the quantity of litter stored in the termite mounds, and to estimate the nutrient content of litter stored in the mounds.

Materials and Methods

Study area

This study was carried out near Kellerberrin in Durokoppin Nature Reserve (117° 45′ E, 31° 24′ S), which is located 250 km east of Perth, Western Australia (Fig. 1), between 2004 and 2005. Durokoppin Nature Reserve is an A-class reserve for the conservation of flora and fauna and contains a number of vegetation types, ranging from open low heath to tall woodland. A range of studies on different aspects of biota was performed in this area by the CSIRO,

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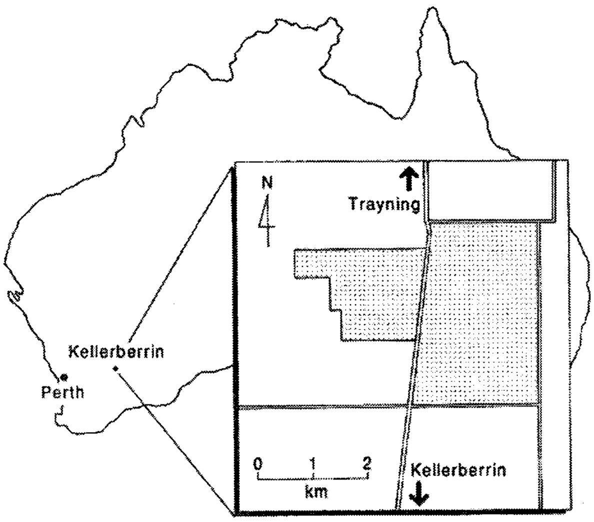

Fig. 1. Location of the study site. □: Farmland; ▦: Durokoppin Nature Reserve.

Division of Wildlife & Ecology as part of the "ecological dynamics of remnant of native vegetation" program. The mean rainfall for the reserve is 333 mm per year and mean minimum and maximum temperatures are 11.3 and 25.0°C, respectively. The most effective rains for plant growth are received in winter, from May to August. Two study plots were selected, one in a representative region of wandoo woodland (mainly dominated by *Eucalyptus capillosa* trees) and the other in casuarina shrubland (dominated by *Allocasuarina campestris* shrubs). Vegetation descriptions were given in Hobbs and Atkins (1988) and Hobbs *et al.* (1989). These plots are hereafter referred to as woodland and shrubland. These areas were selected because the density of termite mounds was high, thus enabling a good variety of mounds to be studied within a small area. The size of each study plot was 2,000 m^2 (40 m×50 m) and each was gridded out at 10 m×10 m intervals. Within each study plot, all termite mounds were counted and a total of 41 and 24 mounds was recorded in the woodland and shrubland, respectively [16].

Biomass and nutrient content of litter in the mounds

In early January 2004, 20 samples were taken from 20 chosen mounds, which were selected at random in each study plot. Each sample was taken from the middle of the mound with the use of a soil-corer (radius=2.5 cm, depth=6.5 cm).

All samples were sorted into identifiable fragments and oven-dried at 60°C for 72 hr. All identified and oven-dried samples were ground up in order to analyse their nutrient content. The samples was then analysed for chemical composition by CSBP and Farmers Ltd, Bayswater, Western Australia. Nitrogen (N) was analysed by NH_3 distillation (Panas-Wagner) after wet mineralization with concentrated H_2SO_4 ($CuSO_4$+K_2SO_4), and catalyzed by selenium. Other elements such as Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphur (S), Sodium (Na) and Chlirine (Cl) were determined by X-ray spectrometry using methods outlined by Hutton and Norrish (1977), Norrish and Hutton (1977) and O'Connell (1977). Significant differences in the proportion of each litter component in the mounds between the two study plots were tested by the t-test. A composition of the proportion of each litter component in the mound between the two study plots was evaluated using the one-way ANOVA followed by the Duncan's multiple comparison test [19].

In order to measure the total amount of litter in the mounds, ten mounds from each of the two vegetation types were selected and dug up from outside of the reserve. All mounds were brought to a laboratory (Curtin University, Perth) where they were broken open and sieved. Sieved material from each mound was soaked in alcohol for 24 hr and then placed into a container of water where flotation and separation of termites and plant material took place. All plant material from each mound was oven-dried at 60°C for 72 hr prior to weighing. Differences in the amount of litter in the mounds between study plots were assessed by the t-test.

Results

The percentage biomass of litter components within mounds in each study plot is listed in Table 1. Mean total biomass of litter in the mounds was estimated as approximately 2.2 kg per mound in the woodland and 2.0 kg per mound in the shrubland plot. There were no significant differences in biomass of litter in individual mounds between the two study plots. Seven components of litter were found in the mounds.

They were classified as leaves (*E. capillosa* leaves in woodland and *A. campestris* shoots in shrubland), bark (*E. capillosa* bark in woodland and *A. campestri* bark in shrubland), twigs (*E. capillosa* twigs in woodland and *A. campestris* twigs in shrubland), other leaves, seeds, fruits & flowers, and grasses. In the woodland plot, the proportion was:

Table 1. Summary of the mean total weight and the proportion of each litter component in mounds. The significant differences were tested by the t-test. Each value is the mean and standard error

Study plot		Total wt. (g)	Proportion (%)						
			Dominant plant			Other leaves	Seeds	Fruits & flowers	Grasses
			Leaves/shoots	Bark	Twigs				
Woodland	Mean	2204.5	67.9	11.5	17.0	1.9	0.4	0.3	1.0
	S.E	265.1	0.3	0.5	0.3	0.4	0.2	0.2	0.5
Shrubland	Mean	2014.8	77.3	5.7	13.4	2.2	0.1	0.4	0.9
	S.E	276.6	0.3	0.7	0.4	0.5	0.1	0.3	0.3
Significance		NS	*	*	NS	NS	NS	NS	NS

*: $P<0.05$, **: $P<0.01$, ***: $P<0.001$, NS not significant.

E. capillosa leaves-67.9%; *E. capillosa* bark-11.5%; *E. capillosa* twigs-17.0%; other leaves (mainly *Borya constrica* Labill. leaves)-1.9%; seeds-0.4%; fruits & flowers-0.3% and grasses-1.0%. In the shrubland plot, the proportion was *A. campestris* shoots-77.3%; *A. campestris* bark-5.7%; *A. campestris* twigs-13.4%; other leaves (a mixture of several species except *B. constrica*)-2.2%; seeds-0.1%; fruits & flowers-0.4% and grasses-0.9%. It appears that *D. tamminensis* harvests plant material according to their availability. The main litter components in the mounds were *E. capillosa* leaves and *A. campestris* shoots in the woodland and shrubland plots, respectively. The proportion of leaves in the mound was significantly higher in the shrubland than in the woodland. However, the proportion of bark was significantly higher in the woodland than in the shrubland plot. For other litter components, there were no significant differences in the proportions between two study plots.

The nutrient concentration (%) in various litter components in the mounds within each study plot is given in Table 2. Overall, the nutrient concentrations were higher in the woodland than in the shrubland plot, although the differences were not statistically tested. The nutrient concentration (%), the proportion of each letter component and total amount of each litter component in mounds (g per mound) were combined in order to express the total amounts of nutrient in the mound (g per mound). This was calculated by the following formula:

$$Nt=[\{(W\times\%\ Pl)/100\}\times\%\ Nc]\times 100$$

where **Nt** is the total nutrient contents in the mound, **W** is total weight of litter in the mound, **% Pl** is the proportion of each litter component in the mound and **% Nc** is the nutrient concentration of each liiter component in the mound. The results indicate that the total amount of each nutrient measured was generally greater in the woodland than in the shrubland plot (Table 3). The total amounts of macronutrients (N, P, K) were for the woodland and shrubland plots, respectively, N- 19.69 g per mound and 15.35 g per mound; P- 0.94 g per mound and 0.49 g per mound and K- 0.84 g per mound and 1.00 g per mound.

Discussion

D. tamminensis harvested mostly leaves, bark and twigs of the dominant plant in both study plots. There were no

Table 2. Macro-nutrient concentration (%) in each litter component in mounds within the two study plots

Study plot		Nutrient concentration (%)						
		Dominant plant			Other leaves	Seeds	Fruits & flowers	Grasses
		Leaves/shoots	Bark	Twigs				
Woodland	N	0.96	0.70	0.81	0.57	0.84	0.72	0.67
	P	0.05	0.02	0.03	0.03	0.03	0.02	0.04
	K	0.03	0.05	0.06	0.02	0.07	0.05	0.08
Shrubland	N	0.72	0.51	1.08	1.10	0.63	0.54	0.51
	P	0.02	0.02	0.05	0.03	0.01	0.02	0.02
	K	0.05	0.01	0.06	0.07	0.03	0.03	0.05

Table 3. Total macro-nutrient content of each litter component in mounds within each study plot

		Total nutrient contents (g per mound)					
		Woodland			Shrubland		
		N	P	K	N	P	K
Dominant plant	Leaves/shoots	14.370	0.748	0.449	11.214	0.312	0.779
	Bark	1.775	0.051	0.127	0.586	0.023	0.012
	Twigs	3.036	0.112	0.225	2.916	0.135	0.162
Other leaves		0.239	0.013	0.008	0.488	0.013	0.031
Seeds		0.074	0.003	0.006	0.013	0.000	0.001
Fruits & flowers		0.048	0.001	0.003	0.044	0.002	0.002
Grasses		0.148	0.009	0.018	0.093	0.004	0.009
Total		19.69	0.94	0.84	15.35	0.49	1.00

significant differences in the mean total mass and the proportion of litter components in the mounds between the two study plots, except for leaves and bark of the dominant plant. The proportion of leaves of the dominant plant was significantly higher in the shrubland than in the woodland plot. The proportion of bark of dominant plant was significantly higher in the woodland than in the shrubland plot. These differences are related to the composition of litter on the ground in each study plot. In the woodland plot, the largest component (by mass) was *E. capillosa* twigs and bark, which accounted for 40-50% of litter. On the other hand, the largest component in the shrubland was *A. campestris* shoots, which comprised 60-70% litter [15].

The total amount of N and P in the mound litter was greater in the woodland than in the shrubland plot. The greater amount of K in the mound litter within the shrubland may be attributed to the amount of K in *A. campestris* shoots and leaves of other shrubs. The differences in the total amount of macro-nutrients in the mound litter between two study plots are due to the differences in litter biomass and nutrient concentration of each litter component within the respective mound. Nutrient concentration of each litter component within the mounds was slightly higher in woodland than in the shrubland plot. This is because of the higher nutrient concentrations in the above-ground plant material within the woodland as opposed to the shrubland habitat [15]. According to the results, 20.1% of N, 15.6% of P and 13.9% of K in the ground litter were contained within the mound in the woodland plot. In the shrubland plot, 10.4% of N, 18.8% of P and 37.5% of K were contained within the mound. Within the shrubland habitat, the quantity of ground litter and associated macro-nutrients is much lower than in the woodland environment [15]. However, except for N, the proportion of macro-nutrients in the mound litter with respect to total macro-nutrient availability in the ground litter, was higher in the shrubland, than the woodland habitat. This difference is due to less macro-nutrient availability in the ground litter within the shrubland than woodland habitat [15].

This paper has indicated the importance of one species of termites as a harvester of vegetation and, ultimately, as an agent of nutrient cycling in the Western Australian ecosystem. The aforementioned results show that *D. tamminensis* harvests various plant material according to biomass availability. The role of this termite takes on particular importance in view of the fact that Western Australian soils are notoriously impoverished in nutrients [3]. Thus, any agent that enhances the return of nutrients, which are locked in the litter, back to the soil is of special importance. Furthermore, *D. tamminensis* is only one of 37 species of litter harvesting or wood-feeding termites in the study area [1,2]. The cumulative role of all these species in recycling nutrients would be considerably higher than the figure given for this species alone.

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초록 : 서부 호주 밀 재배지역 내 자연보호구역에 서식하는 흰개미 *Drepanotermes tamminensis* (Hill) 집에 저장된 식물유체의 영양물질 함량

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본 연구는 서부 호주의 Durokoppin 자연 보호 구역에 서식하고 있는 흰개미에 의해 수확되어 개미집에 저장되어 있는 식물유체와 영양물질 함량을 조사하기 위해 수행되었다. 개미집에 저장된 식물유체의 경우 두 조사지역간의 유의적 차이는 없었으며, 개미집에 저장된 식물유체를 분류한 결과 잎과 가지 등 7가지 종류의 식물 유체로 확인되었다. 개미집 내 저장된 식물유체의 영양물질 함량은 유의적 차이는 없었지만 shrubland 보다 Woodland가 높았으며, 영양물질 총량 역시 shrubland보다 Woodland가 많았다. 연구결과를 종합해 보면 흰개미는 조사지역에서 다양한 종류의 식물유체를 수확하여 이용하고 있으며, 조사지역내 토양 유기물 함량이 적은 점을 고려할 때 생태계 영양물질 순환에 있어서 중요한 역할을 하고 있는 것으로 사료된다.