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Response of laboratory groups of *Reticulitermes speratus* (Kolbe) to different quantities of food

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ABSTRACT

As part of a project aimed at improving understanding of the foraging biology of Japan's most widespread wood-destroying termite, different sized groups of *Reticulitermes speratus* (0.5; 1 and 2g) from two colonies were kept on 16 or 64 cm^3 of sapwood of *Cryptomeria japonica* for 12 weeks in the laboratory. Patterns of wood consumption, wood consumption rates and survival are discussed.

KEYWORDS - subterranean termites, Isoptera; wood consumption, wood consumption rates, survival; Japan

1. INTRODUCTION

Features of the food resources available to a termite colony can influence many aspects of its biology, for example: foraging patterns; feeding preferences; growth rate; and caste development (La Fage and Nutting 1978; Waller and La Fage 1987; Lenz 1994). While some of these aspects may have been of more academic interest in the past, more detailed understandings of the impact of the quantity and quality of food resources on termite biology are now of growing practical importance in the context of modern termite management technology such as the use of baits and aggregation devices (Lenz and Evans 2002).

Reticulitermes speratus (Kolbe) is distributed over much of Japan. It is of major economic importance (Takahashi and Yoshimura 2002). In fact most incidences of termite damage to buildings are caused by this species, although the attack can often be less severe than that inflicted by *Coptotermes formosanus* Shiraki. Despite the economic importance of *R. speratus* and its wide distribution, comparatively little is known about its foraging biology. In Japan, similar to the rest of the world, there are increasingly moves to termite management practices which rely less and less on broad-scale applications of insecticides, and bait technology is receiving more consideration. However, the success of any bait system for a given species of termite requires information on feeding preferences, the size of bait matrix volumes to attract adequate termite numbers to ensure fast transfer of active ingredients to the colony (Tsunoda *et al.* 1998), and any longer-term impact food source characteristics may have on termite colony dynamics (Lenz and Evans 2002).

We report here on a laboratory study with *R. speratus* which examined the response of groups of different size to a small and a larger food supply. Wood consumption and survival were recorded.

2. MATERIALS AND METHODS

Groups of 0.5g, 1.0g and 2.0g of termites from two colonies of *R. speratus* were established and kept for 12 weeks in 350ml plastic containers with screw-on lids. Containers were filled with 15g of vermiculite (sourced from Australia) moistened to 175% (m/m) with water. Termites received either 4 or 16 blocks, each measuring 20mm x 20mm x 10mm of *Cryptomeria japonica* D. Don sapwood, *i.e.* volumes of 16 or 64 cm^3 of food. *C. japonica* sapwood is the standard and readily consumed source of timber for experimental groups of subterranean termites in Japan. Containers were stored in a room kept at 28ºC and >85% r.h.

Termites of colony A were extracted from a pine log collected from the forest floor about 2.5km distance from the Uji campus of Kyoto University. The log did not contain any functional reproductives, hence it had served primarily as a feeding site with the nest either in the soil or within other neighbouring pieces of forest timber. In the 10 days between isolating termites in the log from the nest (containing the reproductives) and extracting termites for the experiment, several of the nymphs in the population had moulted into secondary reproductives (neotenics) as reflected in the figures for the average caste composition of 0.5 g samples (n = 5): 8.4 soldiers, 241.4 workers, 16.2 nymphs and 1.6 neotenics.

Termites from colony B were collected on the Uji campus of Kyoto University from aggregation devices, consisting of layers of several beams of softwood LVL. Termites were used for the experiment within a day from the time of collection. The caste composition of 0.5g groups (n = 3) was: 4 soldiers, 295.3 workers and 11.3 nymphs. Groups from colony A may therefore have had an advantage over those from colony B in establishing themselves quicker with functioning reproductives since they already contained freshly moulted reproductives when the experiment commenced.

Each combination of termite group size and timber volume was set up with five replicates per colony. The only exception was that the numbers of termites allowed for only four replicates of 2g groups of colony B for both food resource volumes.

C. japonica blocks were oven-dried for five hours at 105ºC before and after exposure to termites. The weight differences allowed the determination of wood consumption. At the end of the experiment termites were carefully separated from the timber and vermiculite and their live weight recorded. Survival is expressed as a percentage of the original live weight. Termite groups were preserved in 70% ethanol to allow for later determination of caste composition, especially the presence of reproductives and brood.

Wood consumption and proportional survival were compared between group sizes and timber volumes using a two-way ANOVA nested for colony. Wood consumption data were natural log transformed and survival data were arcsine transformed to meet assumptions of the analysis.

3. RESULTS

3.1 Wood consumption

There was a significant interaction between group size and wood volume, ($F_{2, 52} = 25.8$, $p < 0.001$), as the largest groups of termites (2g) reduced their consumption of wood on 4 blocks compared with 16 blocks by about 35%, whereas other group sizes reduce their consumption by only about 5-10% (see fig. 1). There was significantly different wood consumption between group sizes ($F_{2,\ 52}$ = 318.4, p < 0.001), with more wood eaten in the 2g groups compared with the 1g groups, which in turn ate more wood than the 0.5g groups. There was significantly more wood eaten in the 16 timber blocks than the 4 timber blocks ($F_{1,\ 52}$ = 45.4, p < 0.001). There was no significant difference between colonies ($F_{2,\ 52}$ =2.52, p = 0.090). The effect of group size was more important than that of timber volume, as indicated by the larger F value for the former (ca. 7 times larger). The r^2 value for the analysis was 0.93, therefore the two treatments explained 93% of the variation observed in wood consumption.

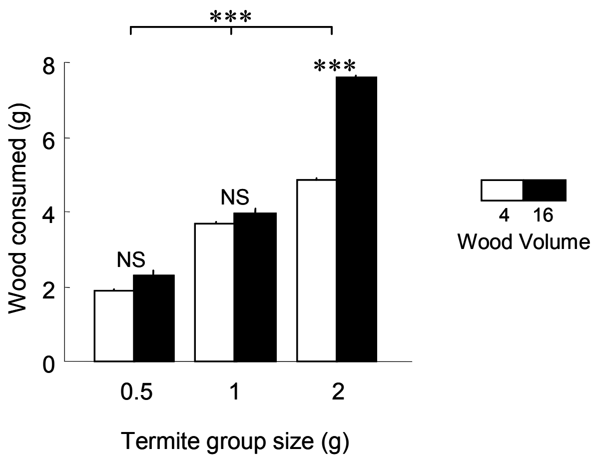

Fig 1. The amount of wood consumed (mean ± std error) for each group size and wood volume (number of blocks). NS = not significant, *** = p < 0.001.

3.2 Wood consumption rate

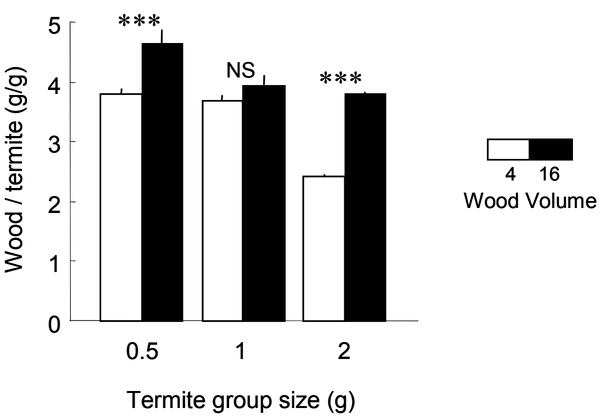

Fig 2. The amount of wood consumed per gram of termites in the initial group (mean ± std error) for each group size and wood volume (number of blocks). NS = not significant, *** = p < 0.001.

These patterns were similar, but had greater differences, when wood consumption was considered per gram of termites in the initial group size. Again, there was a significant interaction effect ($F_{2,\ 52}$ =15.7, p < 0.001), as consumption was considerably higher (~20%) for the 0.5g groups on the 16 wood blocks compared with the 4 wood blocks, whereas it was similar for the 1 g groups on both wood volumes, and wood consumption was considerably lower (~35%) for the 2g groups on the 4 blocks, compared with the 16 wood blocks (Fig. 2). Significantly less wood was eaten, per gram of termites present, in the larger groups than the smaller ($F_{2,\ 52}$ =45.4, p < 0.001), and less was eaten, per gram of termites present, in the 4 blocks compared with the 16 blocks ($F_{1,\ 52}$ =72.6, p < 0.001). There was no difference between colonies ($F_{2,\ 52}$ =3.06, p = 0.055).

3.3 Survival

As seen for wood consumption, there was a significant interaction between group size and wood volume for termite survival; due almost entirely to the very poor survival of termites in the 2 g group size fed on 4 wood blocks (large group size and small food resource) ($F_{2,\ 52}$ =

250.9, $p < 0.001$). Group size was significant ($F_{2, 52} = 346.9$, $p < 0.001$), as was wood volume ($F_{1, 52} = 340.0$, $p < 0.001$) (but note the relative size of the F value to the interaction). There was lower survival for those termites on 4 timber blocks compared with 16 timber blocks ($F_{1, 52} = 28.4$, $p < 0.001$) (fig. 3).

There was no effect of colony ($F_{2, 52} = 0.22$, $p = 0.805$).

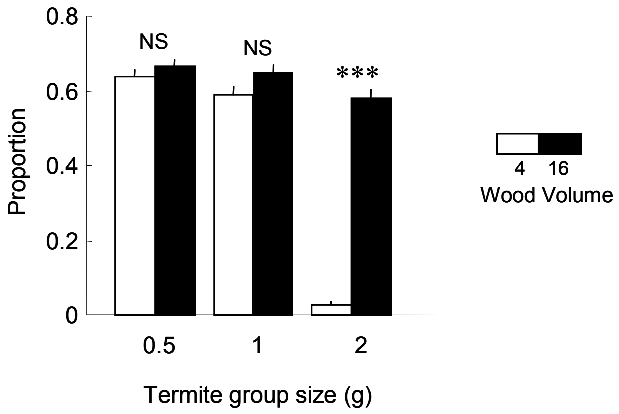

Fig 3. The proportion of termites surviving (mean ± std error) for each group size and wood volume (number of blocks). NS = not significant, *** = $p < 0.001$.

4. DISCUSSION

There was no significant difference in the behaviour of termites from both colonies of *R. speratus* under the experimental conditions; hence data for both termite sources could be combined.

Most of the results are not unexpected: As the size of the termite groups increased more wood was consumed in absolute terms (Fig. 1). The 2g groups experienced a food shortage by the end of the experiment when provided with only 4 blocks of wood. This lowered the survival rate significantly (Fig. 3).

However, wood consumption rates (g wood eaten/g of termites) for the different combinations of wood volume and termite group size are of great interest (Fig. 2). The smallest groups on 16 blocks consumed the most wood on a per termite basis, in fact 20% more than when kept on 4 blocks, and more than in any other group size/block number combination. This confirms earlier work with the American species *Reticulitermes flavipes,* indicating that termites vary their feeding in response to the specific conditions of their food supply (review in Lenz 1994; M. Lenz & S.C. Jones unpubl.). That is, foragers have a basic wood consumption rate which is adequate for them and enables them to provide for some dependents, but in the presence of abundant food supplies, foragers can increase wood consumption significantly. The extra food would be directed into colony maintenance and growth. Groups of 1g and 2g on 16 blocks of wood did not raise their consumption rates to the level of the 0.5g groups despite the fact that large amounts of wood were still left at the end of the experiment (*i.e.* there was no shortage of food).

The ratio between the size of the termite groups and the volume of available food may be the critical factor in determining the extent termites raise wood consumption rates (Lenz 1994). Equivalence in feeding rates between all three group sizes of 0.5g, 1g and 2g may have occurred if wood volumes would also have been doubled with every twofold increase in group size, or at least been of a significantly greater volume.

Field and laboratory observations show that not only wood consumption rates, but also other aspects of termite foraging are influenced by the quantity of a food source. These include: the extent of exploratory tunnelling; higher recruitment to favourable, *i.e*. more voluminous, food sources; prolonged persistence at such sites; and greater tolerance to disturbance (Waller and La Fage 1987; Lenz 1994; Lewis et al. 1998; Hedlund and Henderson 1999; Lenz et. al. 2000; Evans 2002; Lenz and Evans 2002).

It is quite clear that bait system design would be benefited by taking these correlations between food and termite behaviour into account. Bait stations which offer large amounts of a favoured matrix (either single large stations or clumped placement of several smaller stations) are more likely to be: located by termites; have higher recruitment rates; have the treated matrix removed at greater rates (although removal of treated matrix does not necessarily equate to matrix consumption); and visiting termites will show greater site tenacity and tolerance to disturbance, *i. e*. will be less likely to abandon a station after the disturbance of inspections. The extent to which these insights into termite foraging biology are currently reflected in the design and application of bait system varies, however, significant improvements are still possible.

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