Nesting Site Selection by *Coptotermes gestroi* (Insecta: Isoptera)

by

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ABSTRACT

Aiming to reveal whether *Coptotermes gestroi* Wasmann alates were able to choose between substrate types in order to select their nesting site, a lab experiment was carried out, using alates collected in a swarm release hole, in Viçosa, Southeastern Brazil. Alates were placed in nine **gerboxes**, where they were given the choice between two substrates: (i) pure sand and (ii) sand and garden soil mixed so as to make up one of the following proportions of soil: 14, 20, 27, 40, 47, 60, 67, 80 and 100 %. We found that the number of holes dug in the mixture sand+soil was significantly higher than the number of holes dug in pure sand. Conversely, the number of holes dug did not correlated to the proportion of soil in the mixture sand+soil. In addition, the number of dealated termites increased as soil proportion increased in the substrate. Such results indicate that alates of *C. gestroi* are able to select among different substrate types, preferring to stop their search (as indicated by dealation) when finding a substrate richer in soil as opposed to sand. However, they do not stay in the fist dug hole if it is not wholly suitable. We conclude that *C. gestroi* termites effectively search for nesting sites and start their colonies in more favorable places, using local cues, rather than proceeding randomly.

Keywords: wood feeding termites, nesting site, local cues, soil.

INTRODUCTION

One of the mechanisms which account for colony reproduction in termites involves the production of alates and subsequent dispersion flight. After the flight, landing adults find a partner and then the couple start looking for a suitable place where the nest could be built. Such a selection of substrate is

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gerboxes cannot be found in our Dictionaries. Please define and/or use a different word.

thought to rely on some cues, which are not completely understood yet.

Alates of wood nesting termites seem to be attracted either by the odors produced by freshly exposed wood, or by substances resulting from fungus infecting the wood (Nutting 1969). In fact, alates of wood nesters such as *Zootermopsis nevadensis* Hagen, are able to discriminate between logs according to their nitrogen content, preferring to found their colonies in nitrogen-richer ones (Shellman-Reeve 1994). More interestingly, such alates do not show preference for large but nitrogen-poor logs, reinforcing the idea that nest site selection in these wood feeding, one-piece nesting termites, is constrained by limited nutrients (Nitrogen) rather than by physical space to build the nest.

Similarly, soil-nesting termites are suspected to be able to select locations for nesting, since their mounds may be distributed in sunny or shady areas accordingly to local climate (Lee & Wood 1971). In addition, as noted by Lepage & Darlington (2000), mounds are usually not randomly distributed, but tend to be grouped in certain areas, and that may indicate that some localities are more attractive for mound establishment than others.

Such observations, on their own, do not allow conclusions to be drawn whether or not soil nesters select nest location based on local (rather than –or in addition to– broad scale) constraints. However, since local cues do affect nest site selection by wood nesting termites, it is plausible to suspect that the soil nesting ones should also be able to gather such information from the substrate.

Therefore, the present work aims to test the hypothesis that soil-nesting wood-feeding *Coptotermes gestroi* Wasmann termites actively choose their nesting site based on local cues.

MATERIAL & METHODS

Coptotermes gestroi (Isoptera: Rhinotermitidae), a termite species native to Southeast Asia and Indonesia was first recorded as '*Coptotermes havilandi*' in Brazil in 1958 (Gay 1967; Kirton & Brown 2003), now being one of the most important wood pest in southeastern Brazil (Costa-Leonardo 2002). This species is known to attack a variety of items, from wood and leather to paper, plastic, rubber and electric cables (Costa-Leonardo 2002). Although considered a soil nesting species, *C. gestroi* is known from experimental studies to be able to found a new and successful colony in laboratory, in substrates as diverse as sawdust, vermiculite, filter-paper and sand (Ferraz & Cancello 2001).

Experiments aimed to reveal whether *C. gestroi* alates are able to distinguish among substrates whose soil content varied. As an indication of such a distinction, we used (i) the proportion of dealated termites and (ii) the proportion of burrowed termites in the substrate. This first metric has been chosen because termites –at least *Z. nevadensis*– are known to hold their wings after landing, before making a decision on where to start digging a nest (Shellman-Reeve 1994). The second metric could reveal the actual suitability of the chosen substrate to hold a successful colony.

In order to setup the experiment we used *C. gestroi* alates, which have been collected on the ground close to a swarm release hole, at the Federal University of Viçosa, southeastern Brazil, in September 2005. Alates were transported in a plastic bag to the laboratory where they were placed in gerboxes containing equal volumes of two substrates placed side-by-side. In order to simulate soil content variation in the substrate, garden soil was 'diluted' in sand at known proportions, thereby allowing the same soil to be used throughout the experiment, preserving its other traits. In doing so, we intended to minimise errors which could arise if different soils were used.

Gerboxes were kept in the dark at room temperature. Each of the nine gerboxes (11×11×4cm) used held a pair of substrates, arranged side-by-side, each substrate occupying half of the container. Each pair of substrates was composed by (i) 150mL sand only and (ii) 150mL soil plus sand so as to make up one of the following proportions of soil: 14, 20, 27, 40, 47, 60, 67, 80 and 100 % (such percentages have been used to ease volumetric measurements). Termites always had, therefore, a choice to dig nests in either a substrate holding 0% soil (i.e., sand only) or a substrate holding one of the above proportions of soil. Roughly speaking, this is also a choice between zero and increasing organic matter content.

Five alates were placed in each gerbox. Such individuals have not been sexed because, as with several other termite species, alates *C. gestroi* are very active at swarming, which prevents manipulation of individuals without chemical (e.g. CO) or physical (e.g. chilling) procedures to reduce their activity. Because such procedures may affect behavior, thereby inflicting extra error to the experiment, we decided to not sex them. Since such species normally shows a sex ratio of 1:1 (Ferraz & Cancello 2001), using five individuals improves the chance of getting at least a couple in each gerbox. In fact, after the experiment was finished, we could observe such among the remaining termites which were recovered intact.

After 136h from the beginning of the experiment, we counted the number of dealated termites in each gerbox, and the number of couples burrowed in each substrate.

Data Analyses

All analyses were processed under R (R Development Core Team 2005). We tested the preference of the couples for the given substrate using a Wilcoxon test. The effect of soil content in the substrate, on the choice of termites for a nesting site, was tested using generalized linear models (GLM) in which the explanatory variable was the percentage of soil in the gerbox and whose response variables (y) were: (1) mean number of dealated individual and (2) mean number of burrowed individuals for each gerbox. The full models used in the hypotheses test are therefore:

$$\text{Mean number of dealated termites} = \%\text{soil} + \%\text{soil}^2$$

$$\text{Mean number of burrowed termites} = \%\text{soil} + \%\text{soil}^2$$

In the models, a plus sign (+) denotes the addition of a variable to the model. Error distribution used was Binomial and minimum adequate model (MAM) was obtained by extracting non-significant terms ($p < 0.05$).

RESULTS

We observed, after 136 hours, the presence of six incipient colonies. They were present in five of the nine treatments (=gerboxes), two of them being on the treatment with 100% of soil. A single one of these colonies was found on pure sand, while all the others were on the side containing soil.

The results from the Wilcoxon test showed, as expected, a clear preference of termites in making holes in the side of the gerbox containing the mixture of soil and sand when compared to the side with pure sand (P=0.0045, Fig. 1).

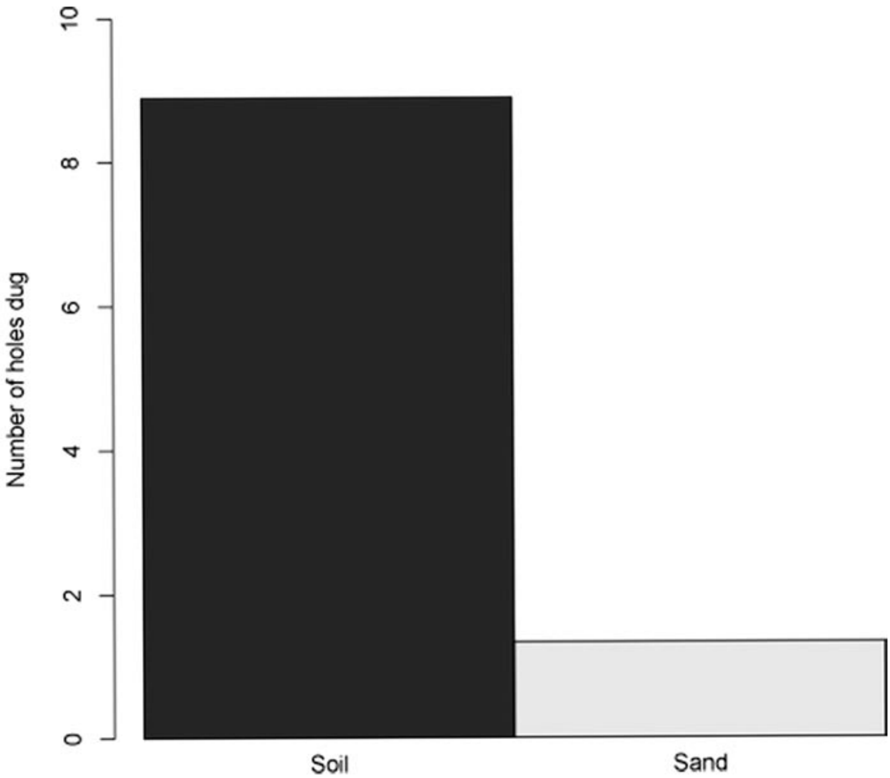

Fig. 1. Total number of holes dug by *Coptotermes gestroi* Wasmann alate termites, when confined for 136h in gerboxes and given a choice between garden soil or sand. Wilcoxon test; $P<0.01$.

That preference, however, was not related to the amount of soil present in the mixture (percentages varying from 14 to 100 %) ($P>0.05$).

When comparing dealation of the termites between the different percentages of soil, more termites lost their wings where there was more soil in the mixture soil-sand ($P=0.0119$, Fig. 2). The mean number of burrowed individuals did not vary within the different percentages of soil ($P=0.3738$). This indicates that the proportion of soil to sand in the ground has a significant effect on dealation, but has no influence in the number of burrowed individuals.

DISCUSSION

The number of dealated termites increased with the amount of soil present in the mixture (Fig.), which is in accordance with Nutting who suggested that soil properties play a role in termite dealation. In fact, dealation in termites

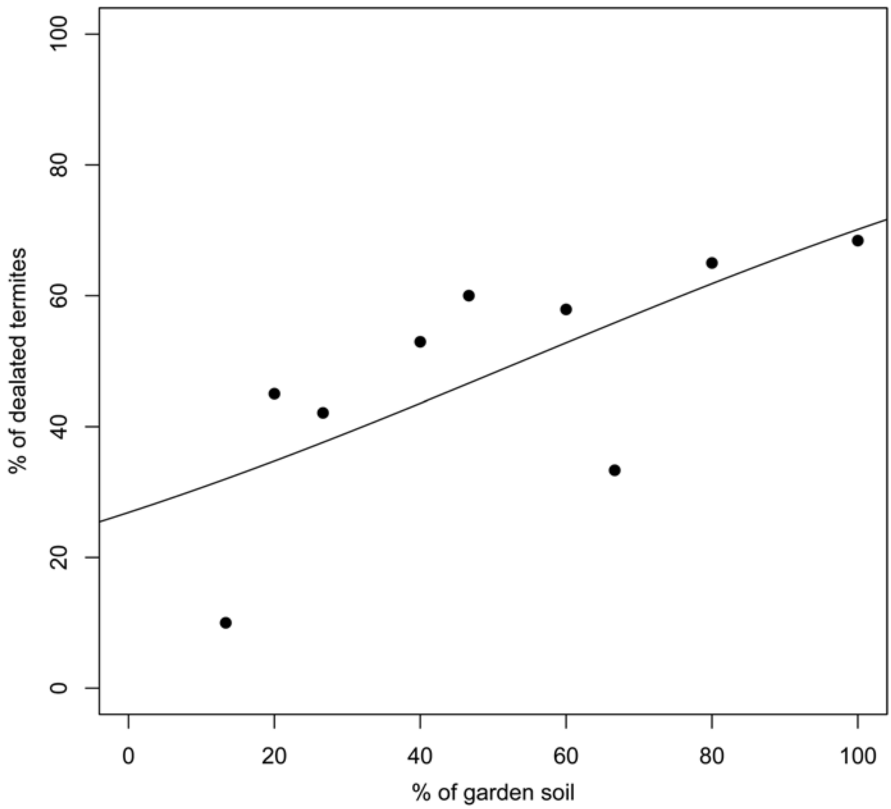

Fig. 2. Percentage of alates of *Coptotermes gestroi* Wasmann termites shedding their wings after being confined 136 hours in gerboxes with substrates containing sand plus increasing proportions of garden soil. Generalised Linear Modelling with binomial errors. $P<0.05$

is affected by factors closely related to nest founding, such as couple pairing and low densities of individuals (Matsuura & Nishida 2002). Couple pairing is a prime requisite for founding a successful colony, and so are low densities of individuals since this reduces competition, an important factor in nest location (Shellman-Reeve 1994). Dealation, therefore, may be thought as an indication that alates have chosen to stop their search for a nesting site once a substrate suitable for nesting was found. In other words, termites were able to access the quality of the substrate, using local cues related to the proportion of soil in it.

Preference for soil over sand is also confirmed by the fact that termites dug many more holes in soil than in sand (Fig. 1). Independently of the percentage of soil present, termites showed a clear preference for excavating the mixture of sand and soil, in detriment of pure sand, which suggests an ability to distinguish between pure sand and any soil percentage equal to or higher than 14%. Interestingly, no matter how much soil is present (from 14 to 100%), termites seem to not be able to distinguish among such proportions, or they prefer equally any of these amounts.

However, the number of individuals burrowed was not related to the amount of soil present in the treatments, which may be an evidence that termites, although making a choice to nest in the soil mixture, might not be satisfied when they start to dig, thus trying again. This indicates that termites search actively for a nesting site, and do not stay in the first hole dug if it is not suitable. The fact that termites try several times before choosing the nest site would be expected for places with obstacles such as cobbles and stones, or, as may be the case in our experiment when they are actively searching for something as a limited resource.

Finally, the fact that more termites made their initial nest, or "copularium", in the soil mixture side complements the hypothesis that termites effectively search for nesting sites and start their colonies in more favorable places, using local cues, rather than proceeding randomly as previously thought.

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