The nesting behaviour of *Eutermes sp.* (Isoptera: Termitidae) in Amani Nature Reserve, Tanzania

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Abstract

Nests of the termite genus *Eutermes* were studied in Amani Nature Reserve, Tanzania. The termites tend to build nests approximately halfway up tree trunks, and do not discriminate between trees of different heights or different species. Density of trees only limits nest density where conditions are apparently favourable; elsewhere environmental or biotic factors are more important. Predation by ants is not a significant influence on nest density, but it may influence the ratio of soldiers to workers present in the tunnels. Temperature does not affect activity of termites, and the effect of humidity on activity is only small. Nest size is linked to the ratio of soldiers to workers. Choice of food substrate was not determined satisfactorily.

Introduction

All species of termite (Insecta: Isoptera) are colonial. Nests may be excavated in several ways e.g. below the ground, or built as mounds above the ground (Gullan and Cranston, 1994) or take other forms. Nests serve numerous functions such as protecting the colony against predators, stabilising the microclimate e.g. temperature and humidity of the colony and providing storage for food (Choe and Crespi, 1997). Termite nests found on the trees of Amani Nature Reserve (East Usambara mountains, Tanzania) are those of the genus *Eutermes*. These termites nest in colonies excavated by the initial primary reproductive animals, usually in rotting wood. *Eutermes* is a central site nester, which means that the members of the colony spend their entire lifetime in one well-defined central nest (rather than many, as in multiple site nesters), which is separate from their food source. The food is brought back to the nest, rather than the food being in the same place as the nest (as in single site nesters). This type of nesting provides a relatively high level of stability of both nest and food resources, as the two types of resources come from separate places, and food stores in the nest can be continually replenished from sources further from the nest (Choe and Crespi, 1997).

The aim of this project was to study the nesting behaviour of the termites found around part of Amani Nature Reserve. Nests are built from soil and other particles, faeces and saliva on tree trunks or branches some distance above the ground. Linking the nest to both the ground and leaves and branches above the nest are tunnels, built out of similar material to the nests, running vertically up and down the trunk and along branches. Termite workers and soldiers can therefore move all over the tree and to the ground in an environment which is similar to that of the nest – tunnels protect against drying out (these termites have unsclerotised skins which allow water loss) and predation. Having noticed many arboreal nests in this area we became interested in whether factors such as predation, competition for food and climatic variables affected the distribution of the nests.

The following questions were posed:

1) Height
    a. Do termites nest at a particular height above the ground?
    b. Do they nest at a particular height relative to the height of the tree?
    c. Do they choose trees of a particular height in which to nest?
    d. If any of the above are true, is this due to predation levels or access to food?
2) Density
    a. What is the density of the nests?
    b. Do termites choose particular tree species on which to nest?
    c. Does the density of the nests depend on the density of trees or other factors (biotic or environmental) such as predation or competition for food and nesting resources?
3) Activity
    a. Does temperature or humidity affect the ability of termites to be active (activity = no. of termites moving past a certain point in a tunnel per minute) or the need to be active?
    b. Does a large nest require more activity in order to be maintained e.g. supplied with food or protected against predators?
    c. Is there any difference between the ratio of soldiers and workers?

4) Food preferences
    a. What type of food substrate does this type of termite forage on?

Methods

The overall study area was located in Amani Nature Reserve, in the East Usambara mountains in north-eastern Tanzania. The East Usambaras are a range of low mountains close to the coast of Tanzania. Within the study area, four main sites around the IUCN hostel were sampled (Fig. 1). The transect in each main site consisted of a road or path running through a montane rainforest type habitat, the main tree species being *Maesopsis eminii*. Thus each site was an forest edge type habitat, allowing us full physical access to the sampled trees and allowing us to control for edge effects which might otherwise occur if both dense forest and forest edge type habitats were compared. A subdivision of the “right road” site in some of the analyses also created a minor site (“lecture hall”), which was near one of the buildings of the hostel. Fig. 1 shows the study sites in details.

Height

A total of 30 nests on *Maesopsis eminii* trees were sampled over four sites (13 from “bird walk”, 10 from “right road”, 3 from “forest” and 4 from “plantation”). *Maesopsis eminii* trees were chosen since this is a very common species at all the sites and nests were very commonly found on them. We limited ourselves to collecting data about nests on one tree species in order to remove any possible effects of differences between tree species that might affect the heights of termite nests. Height of nest, height of tree and height of nearest tree (control tree) was measured, using a clinometer. Samples of termites were taken from the tunnel on every tree, then identified to genus level using Webb (1961).

Density

Areas of $300m^2$ (30m x 10m) were sampled, 100m apart, along a transect through each of four sites (16 from “bird walk”, 9 from “right road”, “ 8 from forest” and 3 from “plantation”). For each sample the total number of trees, the number of *Maesopsis eminii* trees, the total number of nests and the number of nests on *Maesopsis eminii* trees were counted.

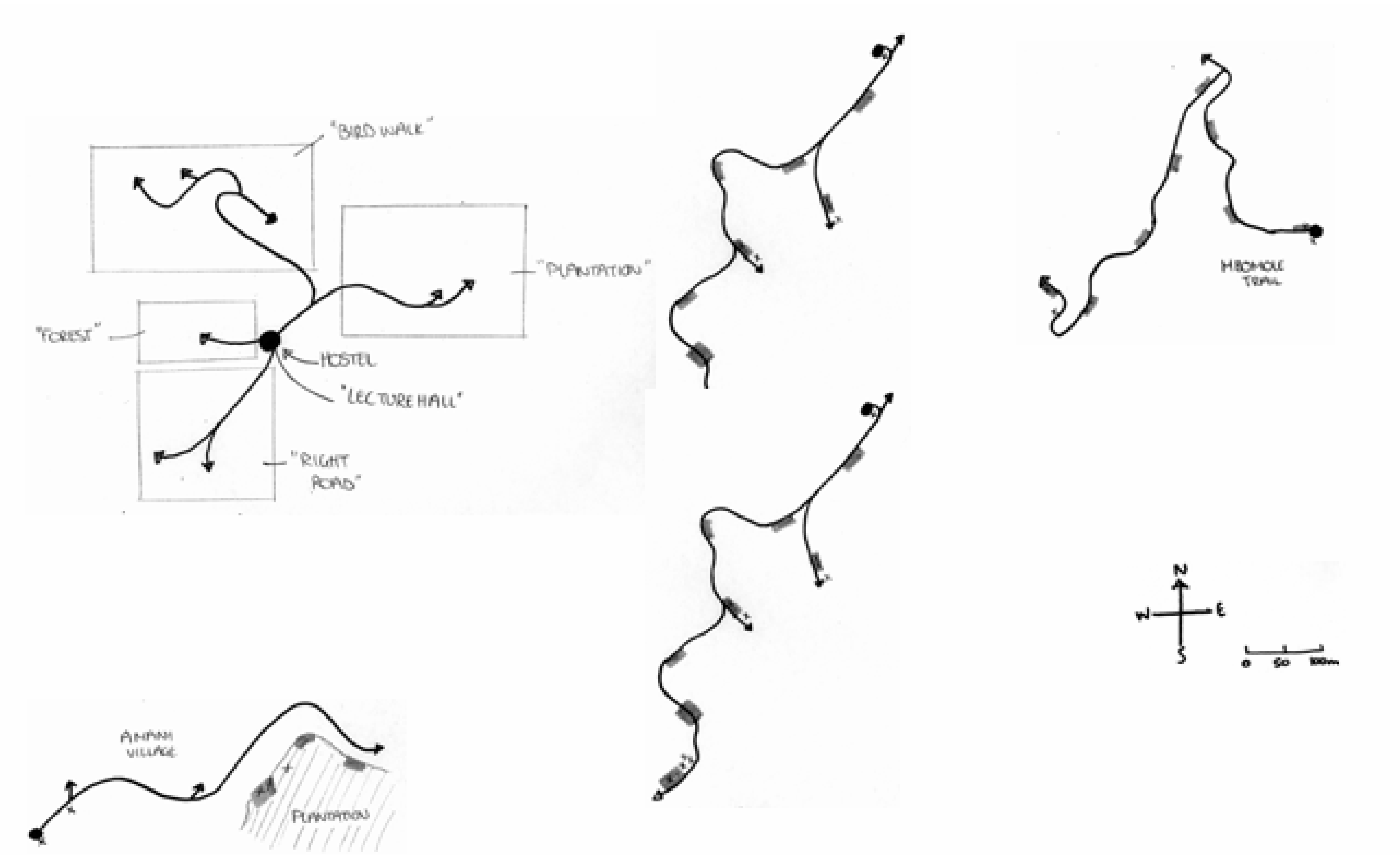

Figure 1. Map showing the location of the sites in relation to the hostel and each other (a), the forest site (c), plantation (d),

Activity

At 10.00hrs, 15.00hrs and 19.30hrs local time each day for 5 days the numbers of termite soldiers and workers moving per minute past a fixed point in the tunnel were counted in samples from each of three sites ("bird walk", "lecture hall" and "right road" – Fig.1). Temperature and relative humidity levels were measured using a thermometer and a humidity meter respectively. Any incidence of predation by ants that was directly observed was noted. The presence or absence of a large, obviously visible nest was also noted.

Food preferences

A feeding-choice apparatus was constructed from 5 weighing boats each with volumes of 112.5cm^3. Four feeding chambers were arranged around a central well and secured with adhesive tape; cutting the relevant corners off and constructing corridors between those corners with adhesive tape made passageways between the central well and each of the feeding chambers. A plastic bag was secured over the top of the apparatus to prevent the termites from escaping. The experiment was constructed inside a laboratory. Twenty termites and a portion of their nest were placed into the central well of the apparatus. In each of the four feeding chambers a different type of substrate was placed – soil, leaves, dead wood and living wood. The termites had free and equal access to each chamber from the central well, but could not get from one food chamber to another without coming back into the central well. The number of termites in each chamber was counted every 30 minutes for 2 hours. This experiment was carried out three times, each time under similar conditions with freshly caught termites from the same nest.

Results

Height

Fig. 2 shows the relationship between height of nest and height of tree on which it was located. Nests were, on average, located at about 44% of the height of the tree and the relationship was significant ($r^2 = 0.64$, $P < 0.001$).

There was no significant difference between the height of *Maesopsis eminii* trees with nests and the control trees (those without nests) (t-test: P = 0.34, d.f. = 57). *Eutermes* does not choose trees of particular heights in which to nest.

There was no significant difference between relative heights of nests at each of the four main sites (one way ANOVA: P = 0.8, d.f = 29).

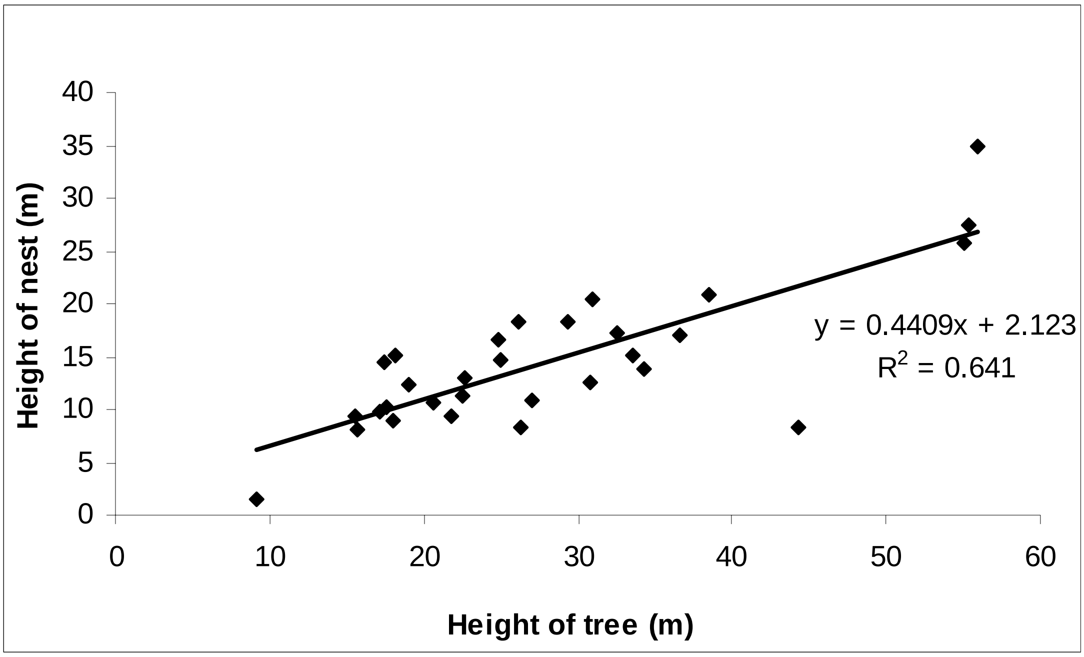

Figure 2. Relationship between heights of *Eutermes spp*. nests and tree height close to Amani.

Density

Fig. 3 shows that there was no significant difference between the density of nests on *Maesopsis eminii* and the density of nests on other tree species (Chi-squared test: ^{2} = 1.8, d.f. = 1). *Eutermes* does not choose to nest on *Maesopsis eminii* especially.

Density of trees was correlated with density of nests when data from all sites were considered (Fig. 3) (one way ANOVA: P < 0.001, d.f. = 1). There was a similar density of trees at each site (one way ANOVA: P = 0.06, d.f. = 27), but there was a significant difference between the density of nests between sites (one way ANOVA: P = 0.013, d.f. = 27).

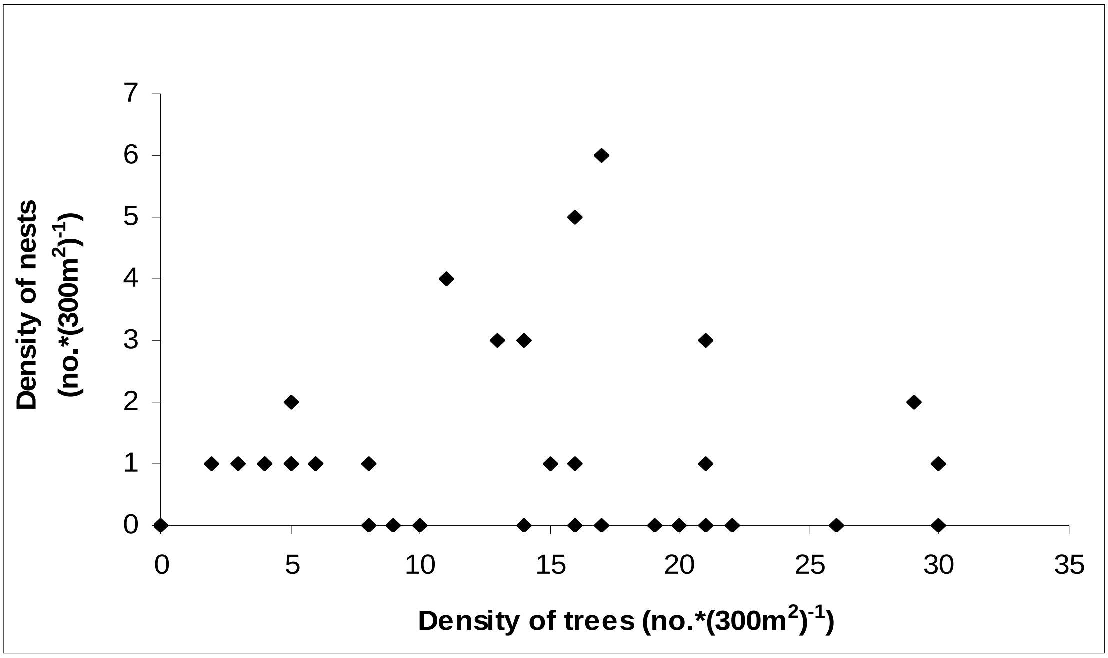

Figure 3. Relationship between the density of *Eutermes spp.* nests and the density of trees around Amani.

Fig. 4 shows that there was a positive correlation between the density of nests and density of trees at the "right road" site (r^2 = 0.64, P = 0.01). There was no significant correlation at any other site.

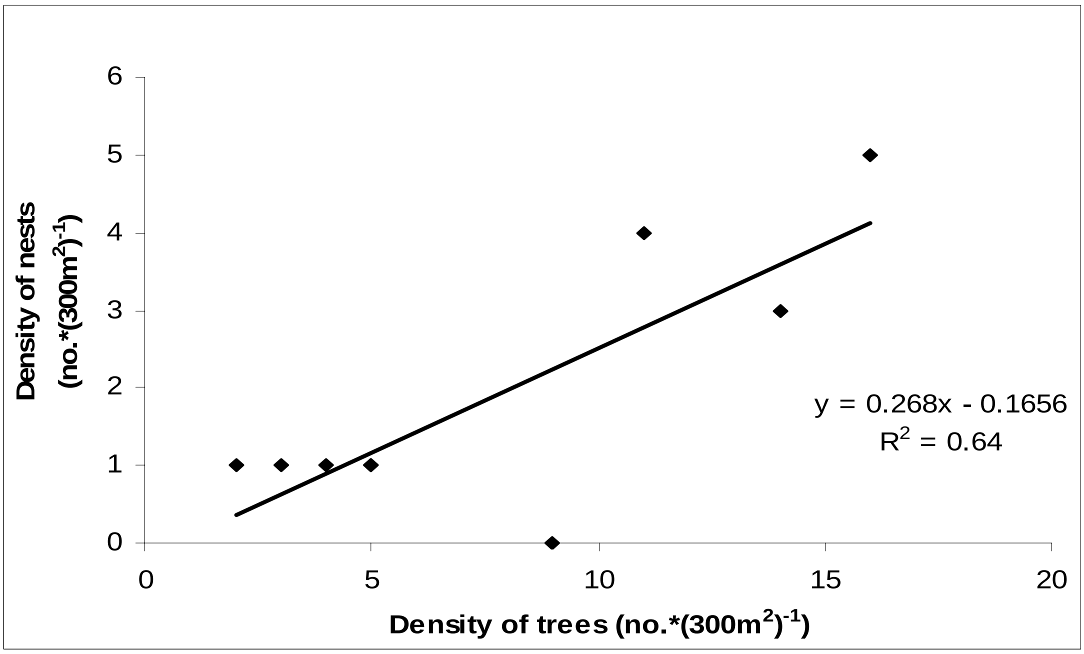

Figure 4. Relationship between the density of *Eutermes spp.* nests and the density of trees at the "right road" site in Amani.

Activity

Fig. 5 shows that there was a weak negative correlation between the activity of termites and humidity levels ($r^2 = 0.306$: $P = 0.04$) at all sites.

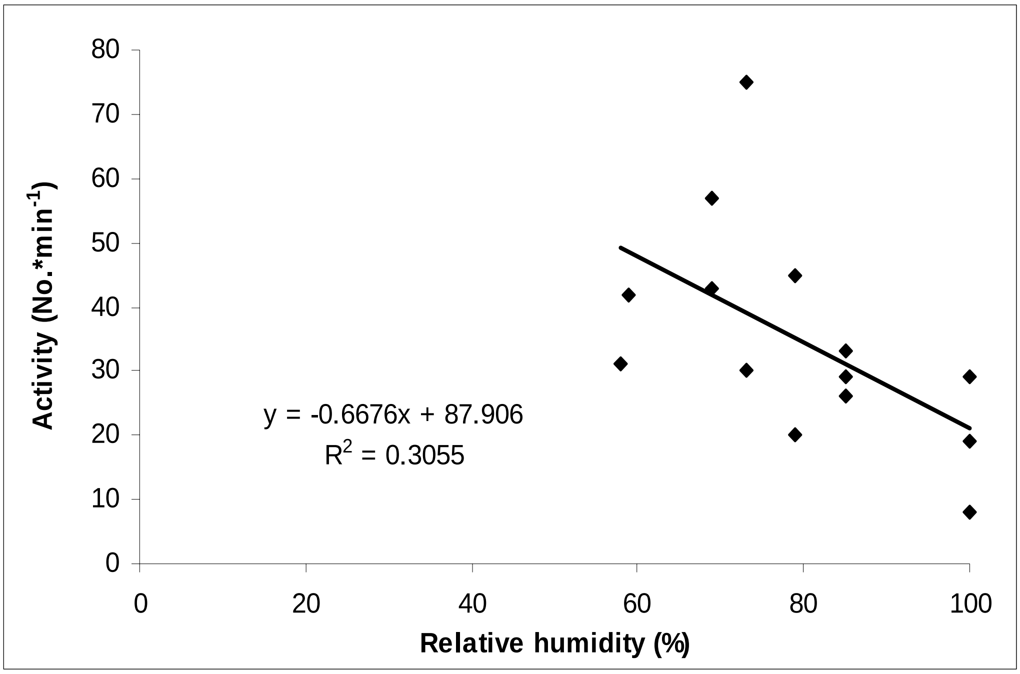

Figure 5. The effect of humidity on termites (*Eutermes spp.*) activity at sites near Amani. Each point is the total activity for a sample of ten trees (total activity refers to the sum number of both workers and soldiers moving past a certain point in a tunnel for a sample of 10 trees).

Fig. 6 shows that there was no significant correlation between the activity of termites and temperature ($r^2 = 0.114$, $P = 0.298$) at all sites.

Fig. 7 shows a comparison of the activity of workers and soldiers when large nests are present or absent. There were significantly more termites moving per minute on trees with large nests compared with those without large nests (one way ANOVA: P = 0.002, d.f. = 53). There were more soldiers on the trees with large nests than on those without. All sites had similar densities of large nests (one way ANOVA: P = 0.54, d.f. = 53).

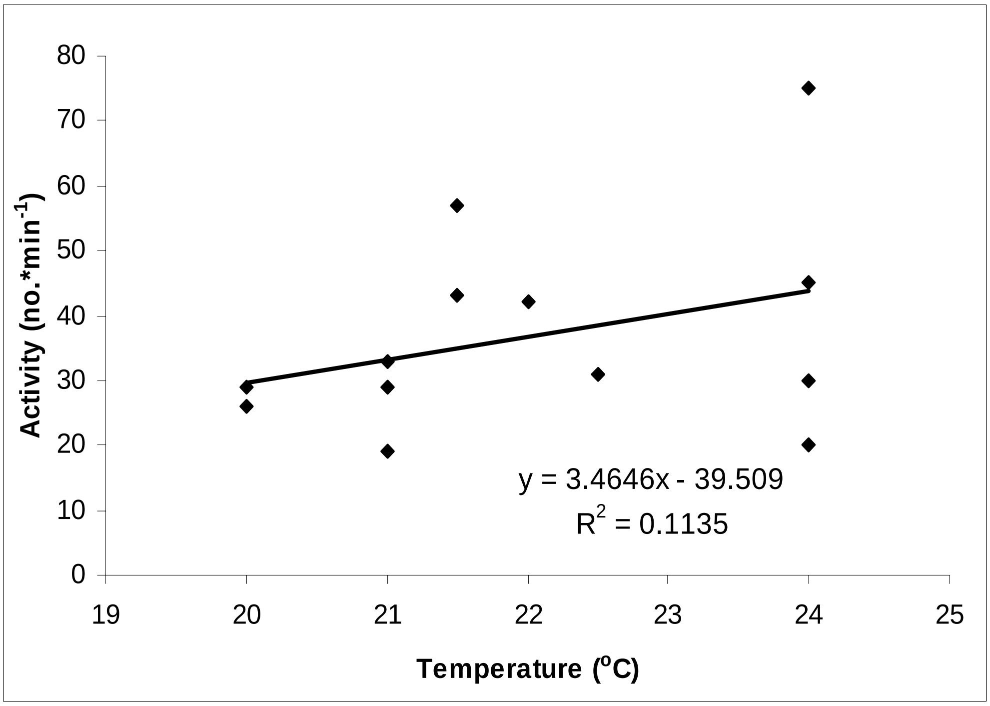

Figure 6. The effect of temperature on termite (*Eutermes spp*.) activity at sites near Amani. Each point is the total activity for a sample of ten trees (total activity refers to the sum number of both workers and soldiers moving past a certain point in a tunnel for a sample of 10 trees).

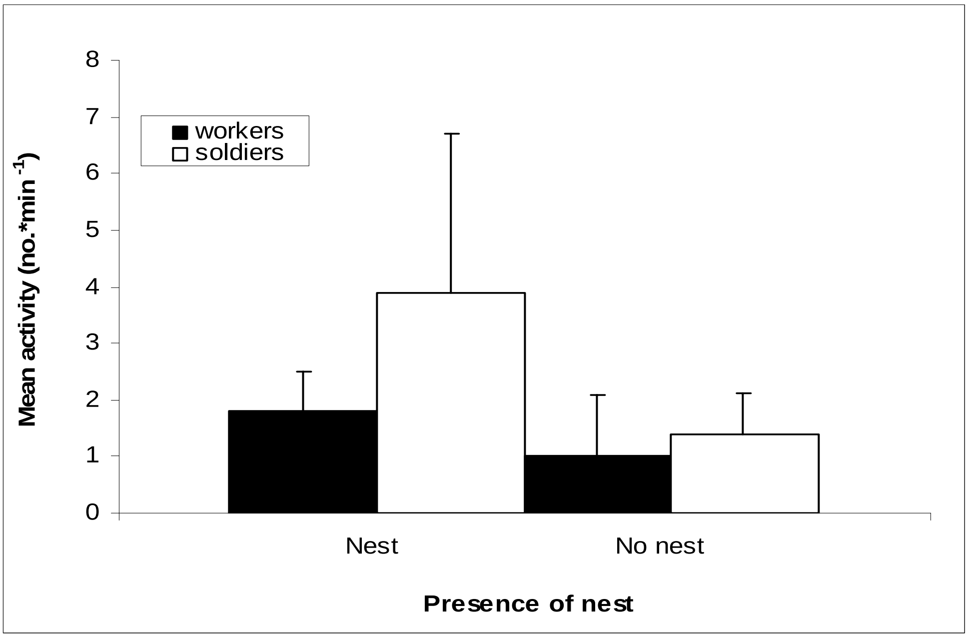

Figure 7. A comparison of the activity of workers and soldiers of *Eutermes spp*. near Amani when large nests are present or absent. Errors bars shown are equivalent to 1 standard deviation

Fig. 8 shows a comparison of the activity of workers and soldiers at different sites. There was no significant difference between the activity of workers at each site (one way ANOVA: P = 0.1, d.f. = 53), but there were significantly more soldiers moving at the "lecture hall" site than at the other two sites.

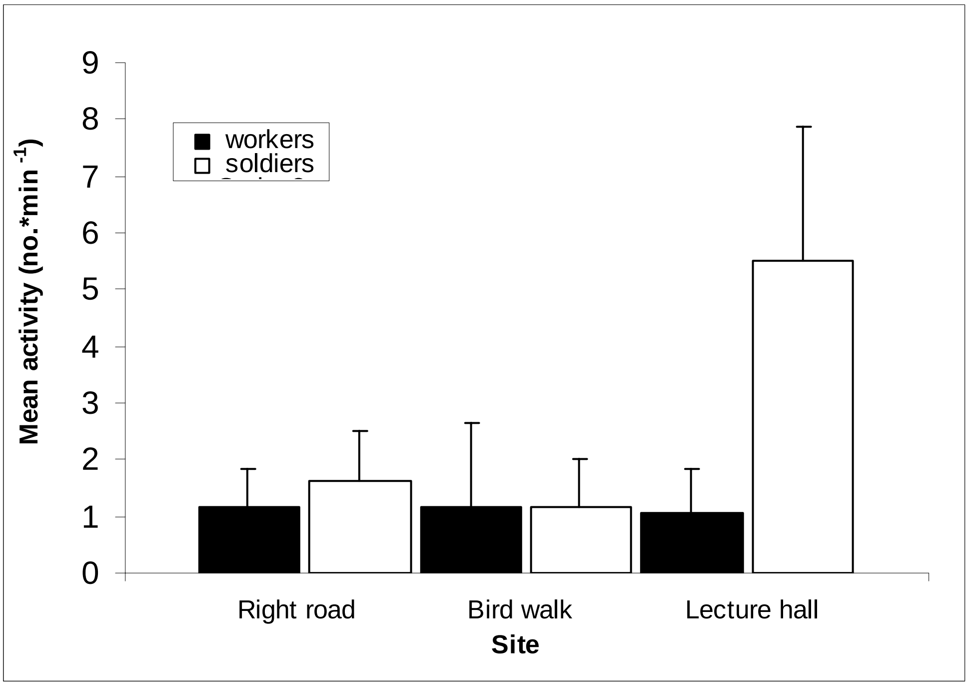

Figure 8. A comparison of the activity of soldiers and workers of *Eutermes spp*. at different sites near Amani. Errors bars shown are equivalent to 1 standard deviation.

Of 30 trees sampled, predation by ants was only consistently observed on two trees, both of them at the "lecture hall" site.

Food preferences

Fig. 9 shows the mean (of 3 replicates) percentage of termites in each feeding chamber after 2 hours. The termites chose their feeding chamber at random (Chi-squared test: X2 = 9.83, d.f. = 1).

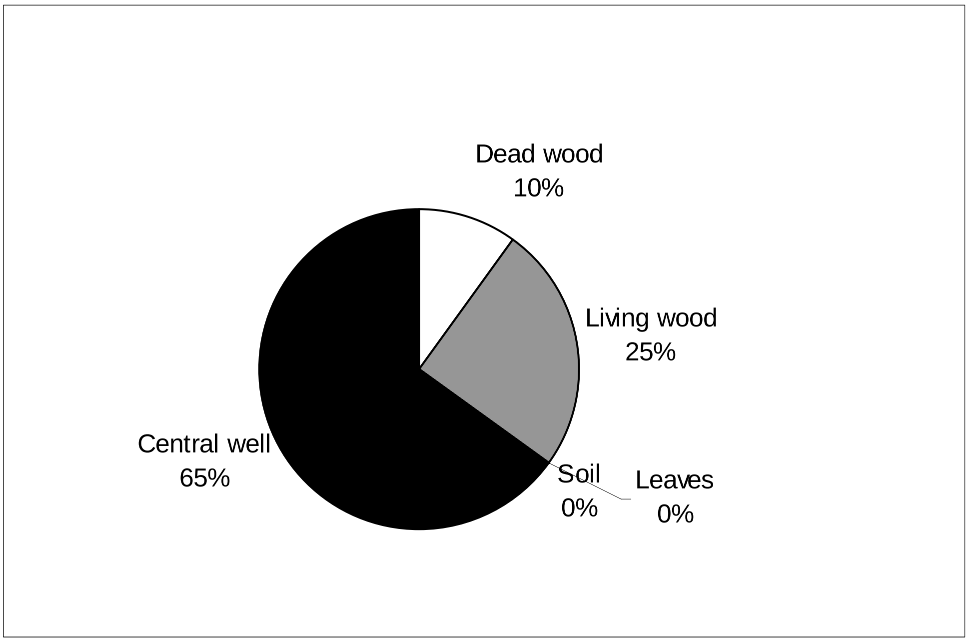

Figure 9. Shows the mean % of termites (*Eutermes spp.)* found in each feeding chamber after 2 hours, in an experiment to determine food preferences of this type of termite.

Discussion

Eutermes usually nest about halfway up each tree; they do not choose trees of particular heights or of a particular species in which to nest. A large variability in the data for both absolute height of nests and relative heights of nests suggests that height may not be such an important factor in the determination of where to build a nest – a more important influence may be the availability of knotholes or of suitably soft or damaged wood in which to excavate a hole (Darlington *et al*, 1995; Gullan and Cranston, 1994).

There was a similar density of trees at each site, yet the “right road” site had a higher density of nests than the other sites, and is the only site at which density of trees appears to limit the density of nests. We suggest that this is because the “right road” is particularly favourable for termites in some way compared with the other sites. At sites that are less favourable, biotic or environmental factors may limit the density of nests.

Predation by ants does not seem to be very significant in this area, and although the observation is anecdotal, it is backed up by Darlington (1985), who states that ants don’t usually attack mature, healthy termite nests (they only attack when nest is already damaged).

The availability of food does not seem to be limiting either. Since the termites chose their food substrate at random, they may not have a specific preferred food substrate. According to Gullan and Cranston (1994) the family that this genus of termite belong to, the Termitidae, comprises of fungus cultivators, ingesting a wide range of cellulose-based foods and cultivating the fungus *Termitomyces spp.* on their own faeces. The fungus makes the undigested material in the faeces more nutritious for the termites. If these termites do cultivate fungus (an investigation of a broken nest could not determine whether they do or not) then the identity of the food substrate is probably irrelevant to density of nests, because there is an abundance of cellulose-based food sources available in the forest. Even if there is little plant matter immediately nearby, in all sites there were plants within 35m of each nest, the termites' usual range of foraging (although they can forage up to 50m from the nest) (Darlington, 1982).

Temperature and humidity levels do not vary significantly between sites. This lead us to the hypothesis that there may be some other factor that influences nesting density at three of the sites but not the fourth. For example the "right road" may contain more trees that have suitable knotholes or rotting parts – at the other sites there may be enough trees but not enough that are rotting. However, this is speculative – we would need to do further studies on the state of the trees in order to determine whether this is a valid explanation.

The air temperature had no effect on the activity of termites. We assume that this is because the nests and tunnels are built from materials that are good insulators and so maintain a constant temperature within. Humidity outside the nests and tunnels only has a small effect, we assume this is because the materials are relatively non-porous, and so a near-constant humidity inside the nests and tunnels can be maintained. According to Gullan and Cranston (1994) a constant microclimate is necessary inside the nest in order to efficiently cultivate fungus. The weak negative correlation (Fig. 5) between humidity and activity could be due to tunnels having thinner walls than nests, and therefore being more subject to structural damage or wetting by the rain that was causing the high humidities. Termites may reduce their activity during rainy periods in order to avoid being washed away.

The absence of a large, obvious nest does not necessarily mean that there is no nest at all. Small nests may have been too small for us to see. Thus greater activity on trees with large nests than on trees with "no nests" may be linked to size of nests – smaller nests contain fewer termites so the number of termites observed per minute moving past a fixed point on the tree (our measurement of activity) may have been lower than for trees with large nests. Large nests need more soldiers in total than small nests (Fig. 7) because of a greater need for defence of the nest – if the nest is more visible it may attract more predators, and also a greater volume needs to be defended. However, a larger nest will have a smaller surface area per unit of volume than a small nest and so the number of soldiers per unit volume of nest may be smaller than the equivalent value for a smaller nest, as there is relatively less surface to defend. We would need to go back and measure the volumes of nests and calculate numbers of soldiers relative to nest volume in order to determine whether this pattern occurs.

The difference in the activity of soldiers at different sites may be explained by the differing risk of predation. The only site at which predation by ants was observed was the "lecture hall" site – the site with significantly more soldiers than the others.

None of the factors that we originally hypothesised might affect the location of nests was very influential. Food availability seems to be high if we assume that these termites are generalist foragers; predation risk appears low in most areas. Temperature and humidity do not affect activity very much; they probably do not affect where a colony is situated either. Nests can be built to provide a constant microclimate by use of insulating materials and by including passageways for the circulation of air (Gullan and Cranston, 1994), so the climate outside is probably not limiting. Location and availability of rotting wood may be more important for the termites in deciding where to start a new colony and how many colonies an area can support. It also seems that the ratio of the different castes depends on the need for each type – e.g. soldiers are more abundant when there is a greater need for defence, such as in large nests in areas of relatively high predation.

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References

Choe, J.C. and B.J. Crespi (1997) Social Behaviour in Insects and Arachnids. Cambridge University Press. Pgs 57, 65.

Darlington, J.P.E.C. (1982) The underground passages and storage pits used in foraging by a nest of the termite *Macrotermes michaelsoni* in Kajiado, Kenya. J. Zool. Lond 198: 237-247.

Darlington, J.P.E.C. (1985) Attacks by Doryline ants and termite nest defences (Hymenoptera; Formicidae; Isoptera; Termitidae). Sociobiology 11(2): 189-200.

Darlington, J.P.E.C., M. Leponce and W.O. Ogutu (1995) Termites in Kibale Forest National Park, Western Uganda. Unknown source.

Gullan, P.J. and P.S. Cranston (1994) The Insects: An Outline of Entomology. Chapman and Hall, London. Pg 360.

Webb, G.C. (1961) Keys to the genera of the African termites. Ibadan University Press.