

Nesting Preferences of the Termite *Nasutitermes Walkeri* in a Dry Sclerophyll Forest

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1. Introduction

Termites are a prolific insect, being most diverse in warm, humid regions of every continent except—of course—Antarctica. The termite family *Termitidae* includes the highest number of genera, yet they are mostly restricted to only a few biogeographical regions. The genera *Termes*, *Amitermes*, *Macrocerotermes* and *Nasutitermes* however, span across all the equatorial regions (Miura et al., 2000) . They have filled numerous ecological niches with diverse phylogenetic mounds/nests and morphologies, yet there is little research on the relationship between their nesting preferences and local flora.

Nasutitermes species are the most widespread wood-feeding *Termitidae*, building large arboreal nests most commonly in neotropical regions and southeast Asia (Miura et al., 2000). The interactions that *Nasutitermes walkeri* display with surrounding tree species in Australia are especially of interest, with Australia being one of the only ecologically isolated continents. Despite having diverse floristic compositions, the subtropical and temperate regions of Australia are mostly dominated by sclerophyllous forests (*Forests Australia*, 2023). These forests are primarily occupied by eucalypts, which possess several unique factors that can influence termite selection preferences, including but not limited to bark characteristics, wood density and surrounding plant debris (Gazal et al., 2010; Gonçalves et al., 2005). Currently, comparable studies from adjacent biogeographical regions are the only resources available for inferences on the tendencies *N. walkeri* display in Australian habitats.

Buschini (1999) mentions in their study of spatial aggregation patterns for *Nasutitermes* species in Southeastern Brazil, that the most prominent causes for this species' regular distributions were intraspecific competition and tall grasses. As well as spatial differences,

arboreal termite species have been found to show preferences for certain heights on trees. In a paper by Roisin (2006), it was found that tall evergreen forests in neotropical regions host a diverse collection of wood/soil-feeding termites, showing distinct preferences for specific heights. Furthermore, the effect of ambient temperature was a focus in many studies, making confident conclusions that termites all display highly developed forms of thermoregulation (Fuller & Postava-Davignon, 2014; Hu & Appel, 2004; McManamy et al., 2008; Wiltz, 2012). The current literature provides many overviews and suggestions on the spatial and behavioural characteristics of termites; however, specific termite preferences cannot be generalised to broad concepts associated with general documentation. Therefore, it is necessary to research the unique relationships arboreal termite species such as *N. walkeri* share with surrounding flora.

This report will consider several relationships between Australian tree species and the nesting tendencies of the wood-feeding termite species *N. walkeri* through the investigation of five questions:

1. Do termite nests occur more frequently on certain tree species?
2. Do termite nests face certain orientations more frequently?
3. Is there a correlation between nest heights relative to tree heights?
4. Do termite nests occur more frequently with different levels of canopy cover?
5. Do termite nests occur more frequently on trees with different diameters?

2. Methodology

Fieldwork took place on the 26th of April 2024 at the Samford Ecological Research Facility (SERF), Southeast Queensland, Australia. Observations included nest heights, tree heights, nest orientation, diameter at breast height (DBH), tree species and canopy cover. Observations were made along two transect lines at a compass bearing of 40°, using a 60-metre measuring tape as a guide to travel along.

Nest and tree heights were measured using a Rangefinder with the user standing 10 metres from the tree, as calibrated. To standardize results, one individual was tasked with DBH recordings, using a diameter-specific tape measure. Canopy cover was recorded as a group estimation, using an estimation chart provided by the Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain, 2010). The orientation of each nest was recorded by aiming a compass parallel to the direction of the nest relative to the tree. Lastly, species were identified with the aid of a reference sheet containing the common tree species at SERF.

Observations were analysed through a series of statistical tests, which were completed using the statistics-specific programming language 'R'. The categorical features such as species, canopy cover, and orientation were tested against a theoretical expectation of frequencies using a Chi-squared test of goodness-of-fit, assuming the independence of observations. Tree species, DBH, and canopy cover pose extrinsic factors that could theoretically deviate from an expected ratio of 1:1 (null hypothesis) such as the distribution of each species. Thus, the species, DBH, and canopy cover of a control tree was recorded at the same time as recording a nest. A compass bearing (180°) from each nest was chosen for all control trees. Lastly, the relationship between

the two measurement variables nest height and tree height were analysed using Pearson's correlation test, assuming normal distributions and homoscedasticity.

3. Results

3.1 Summary

Five aspects of termite nesting preferences were analysed. The frequencies associated with the three categorical factors: tree Species, canopy cover and diameter at breast height, all showed an insignificant difference from the expected proportions gathered from the field. The correlation between the measurement variables nest height and tree height presented as insignificant. Nest frequencies associated with the orientation category displayed a significant difference from a null hypothesis of equal proportions.

3.2 Tree Species

The observed frequencies in Figure 1 showed a clear dominance in *Lophostemon suaveolens* and *Eucalyptus crebra* (10 and 14 respectively) and occurrences on *Corymbia intermedia* and *Melaleuca quinquenervia* were scarce (2 and 1 respectively). The expected frequencies for tree species were calculated from the most likely proportions due to species distributions, and they closely resembled the observations, thus showing no significant difference ($X^2 = 5.0543$, $DF = 3$, $p > 0.1$).

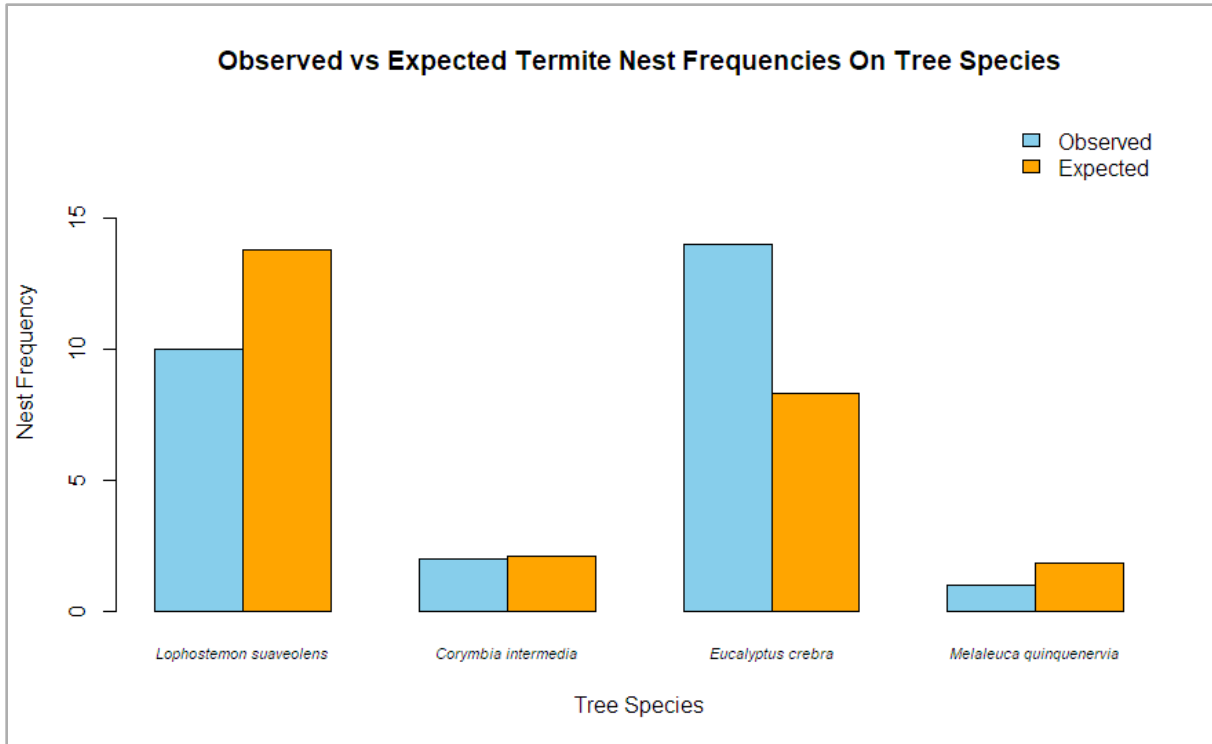


Figure 1. A comparison between observed and expected frequencies of termite nests on different tree species. Tested against an external null hypothesis determined by the inclusion of control observations.

3.3 Nest Orientation

Figure 2 surprisingly highlighted an almost exclusive preference for a northern orientation. Northeast, north, northwest, and west frequencies were recorded as 6, 8, 6 and 5 respectively and the only other instances recorded were once for south and once for east. The expected proportions for orientations remained equal which is not the trend that was observed on the field and therefore showed a significant difference from the null hypothesis ($X^2 = 21.296$, $DF = 7$, $p < 0.01$).

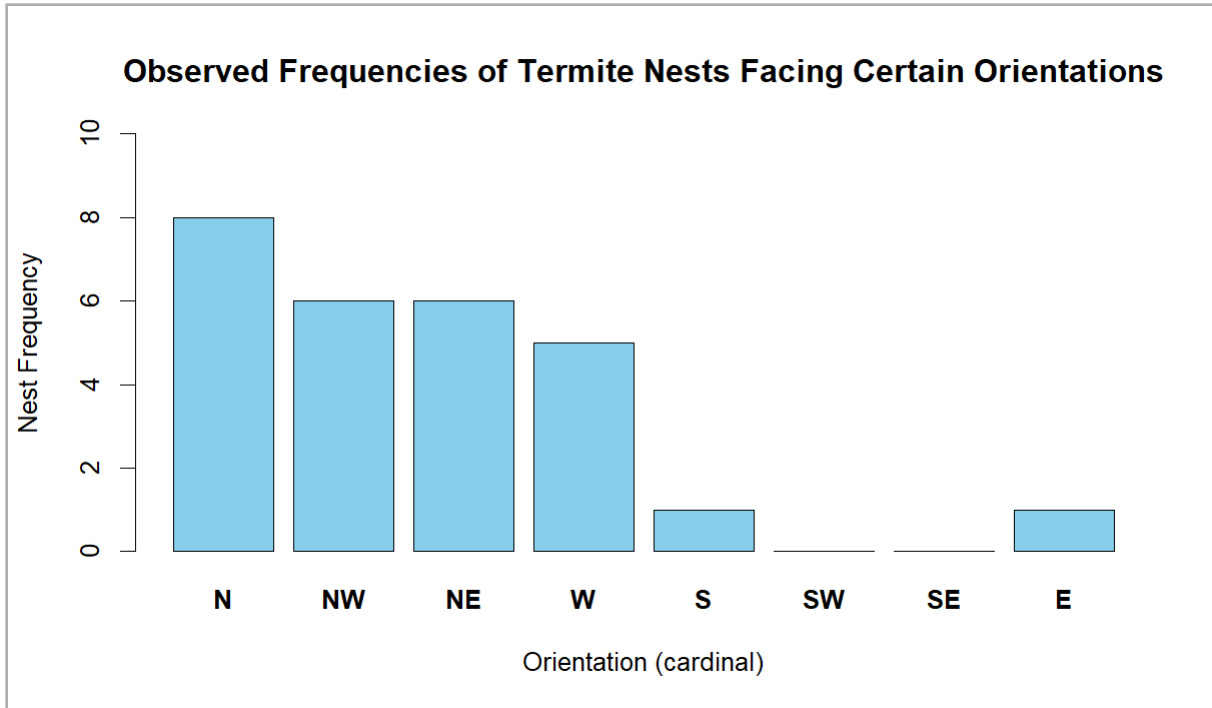


Figure 2. A visualisation of observed frequencies of termite nests facing certain cardinal directions.

Tested against a null hypothesis of equal proportions.

3.4 Nest Height and Tree Height

The points in Figure 3 displayed a dispersed correlation between nest heights and total tree heights. The trend line demonstrates a significant, yet moderate to weak positive relationship between the two measurement variables ($t = 2.1819$, $DF = 25$, $p < 0.05$, $r = 0.3999$).

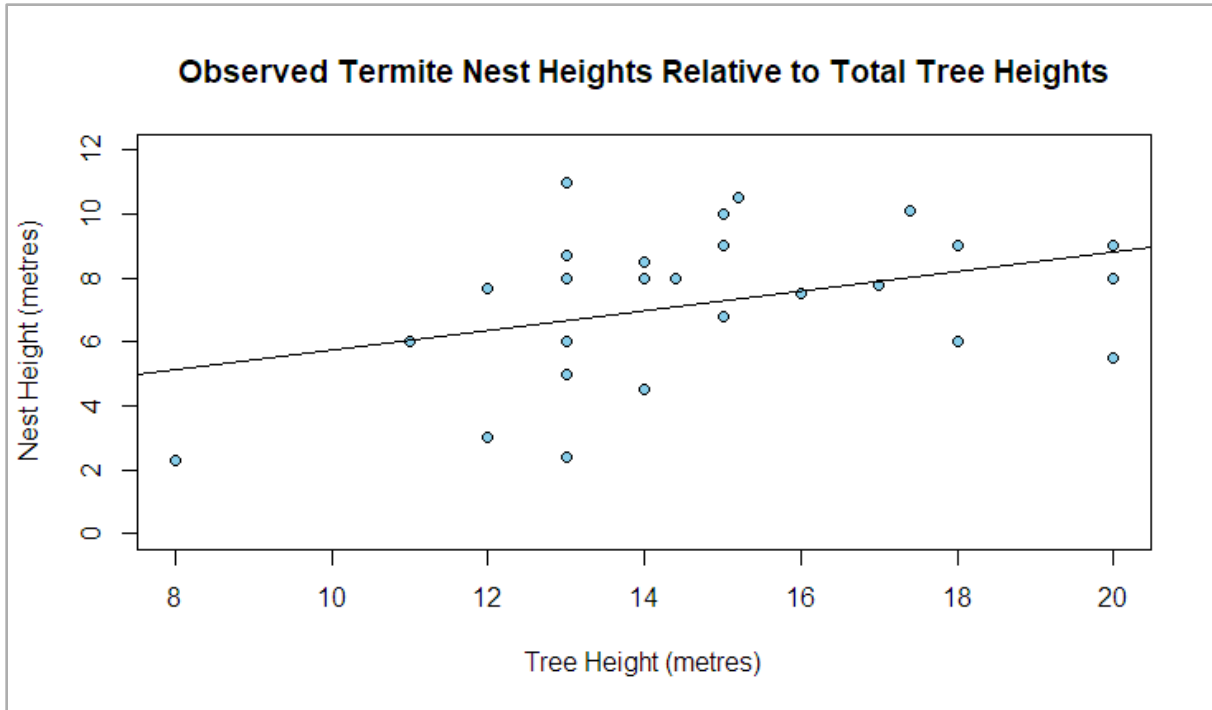


Figure 3. A visualisation of correlation between nest height measurements and tree height measurements with a linear regression.

3.5 Canopy Cover

Figure 4 marked a strong preference for 21 – 40% canopy cover (13), with an apparent left-skewed normal distribution. Adjacent canopy covers 0 – 20% and 41 – 60% showed less preference with similar frequencies of 6 and 7, respectively. The canopy cover 61 – 80% was only observed once. The expected proportions calculated from the total canopy cover observations seemed to produce a normal distribution and the observed nest frequencies matched the expected frequencies very closely, thus resulting in an insignificant difference from the null hypothesis.

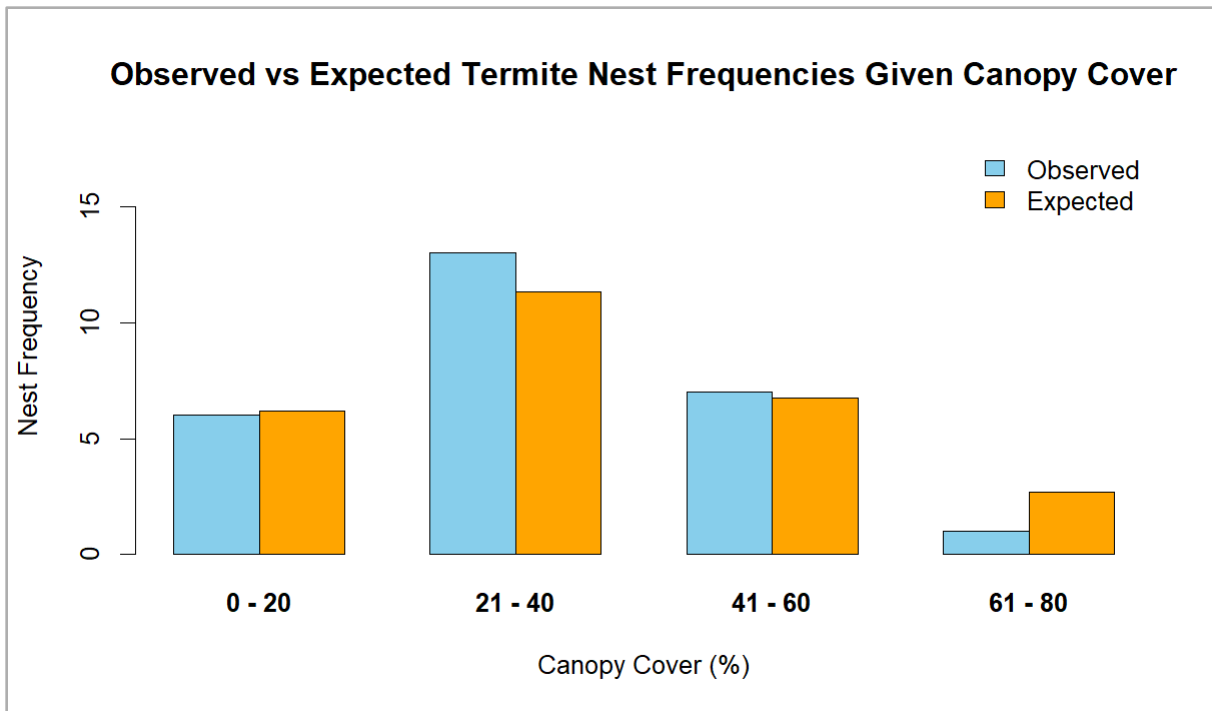


Figure 4. Observed vs expected frequencies of termite occurrences given different percentages of canopy cover.

3.6 Diameter at Breast Height

Of the diameters recorded in Figure 5, 61 – 100 cm was the tree size that was most heavily preferred (11). The ranges 101 – 140 cm and 141 – 180 cm were the next most frequent category, with both having a frequency of 7. Trees with a diameter from 20 – 60 cm were chosen the least (2). The calculated expected frequencies for DBH followed a normal distribution similar to canopy cover (Figure 4), which the observed frequencies moderately emulated resulting in an insignificant difference ($X^2 = 6.589$, $DF = 3$, $p > 0.05$).

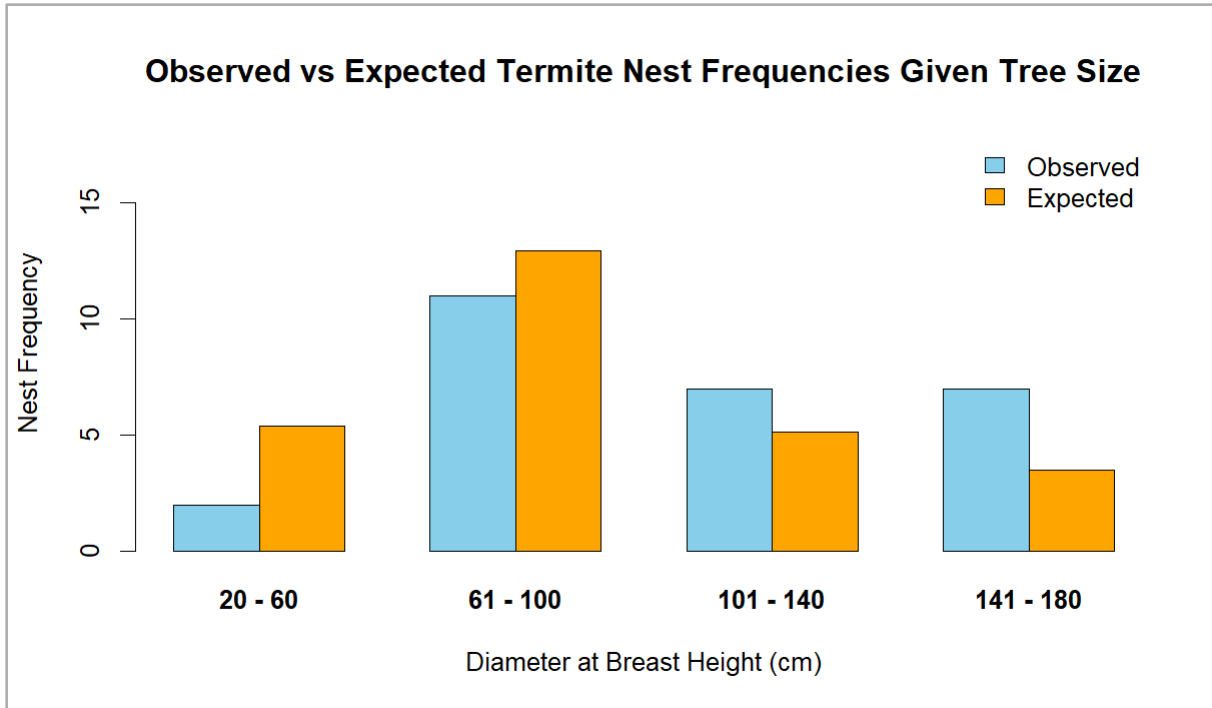


Figure 5. Histogram comparing the expected and observed frequencies for nest frequencies and tree diameters.

4. Discussion

It was the primary aim of this study to investigate the inherent relationships that have formed between the wood-feeding termite species *N. walkeri* and the common tree species found in SERF, Queensland, Australia. Every test provided valuable insights into the particular preferences *N. walkeri* have with the surrounding flora.

4.1 Tree Species Preferences

The possibility that *N. walkeri* showed a preference for tree species was first explored. It was found that they particularly favour *E. crebra*, despite *L. suaveolens* being the most abundant tree (Figure 1). Considering this, several insightful articles acknowledge the many factors that contribute to a colony's decision-making process. In two separate studies regarding termite

selection criteria, the first by Gazal et al. (2010) found that the density of the wood influences their selection. Whereas Benedito de Souza (2020) articulated that the thickness and roughness of the bark significantly contributes to colony frequencies, by measuring the speed termites travel on- and consume different barks. After considering these factors, both authors alluded to a similar conclusion, which is also predicted within this report's findings. Social insects cover great distances which require a great deal of energy, thus, to optimise the efficiency and survivability of the colony, termites will make a predictable compromise between resource richness (bark characteristics and wood density) and spatial proximity. Considering that *E. crebra* is widely known for its deeply fissured, dense skin and the bark of the *L. suaveolens* is not too dissimilar, *N. walkeri* would reasonably show a preference for those types of trees as they provide numerous structural benefits as well as proving to be an efficient resource. In addition to *E. crebra* displaying a more favourable surface, a study in 2005 made an exceedingly important suggestion for termite tree selection habits. Gonçalves et al. (2005) found that termites require cellulosic debris to consume as they travel to nearby nesting sites. Eucalypts are commonly known to drop their branches in times of drought as a means of survival, this would then give termites the necessary fuel to make the distance to trees that contain more preferable attributes. Applying the current knowledge that termites will opt for an energy-efficient approach to propagation, it is clear that tree species with thicker and rougher barks, medium wood density, and the coincidental property to offer proximal resources, will typically be favoured.

4.2 Nest Orientation Preferences

The preference for nest orientation was then considered. Surprisingly, there was an almost exclusive preference for the northeast to west orientation (Figure 2). A clear distinction in directional tendency provided substantial evidence to suggest that *N. walkeri* relies on external

factors, that are most likely abiotic. Studies have shown that it is common for arboreal and subterranean termites to build nests in such a way that the nest remains within strict thermal and moisture tolerances (Fuller & Postava-davignon, 2014; Hu & Appel, 2004; McManamy et al., 2008; Wiltz, 2012). Leite et al. (2011) concurred with the aforementioned studies and concluded in their article that wind direction explains the greater numbers of termites on the western side of the sampled trees, creating a use for the tree as a form of shelter. These studies all suggest that termites collectively respond to extrinsic variables for the entirety of the nest's construction period and subsequent lifespan. When we consider the geography of the study site, the most regular and abundant abiotic factors are sunlight and the prevailing winds. SERF is located closest to the eastern shores of Australia and would therefore experience primarily easterly winds with a variance of northeast to southeast depending on the surrounding topography. The combination of typical wind directions and the well-known east-to-west path of the sun, provides substantial evidence for termite nesting behaviours. Figure 2 highlights the exclusive preference for avoiding a direct collision with winds and the experience of the afternoon sunlight from the west as the local temperature begins to drop. The observations gathered in this study heavily support Liete's statements and the overwhelming evidence toward preferred construction habits of termites. It is important however, to mention the evolution of their tendency to choose specific orientations. It is still poorly understood whether they are genetically predisposed to construct their nests to a specific orientation through magnetoreception, or if they react to sunlight and prevailing winds through physiological means.

4.3 Nest Height and Tree Height Correlation

N. Walkeri nest heights and the height of the trees that accommodated them were tested for a possible correlation. Ultimately, the results obtained were unremarkable. A correlation did exist to some degree within the standard confidence interval $p < 0.05$ (Figure 3), however there seemed to be a multitude of other confounding factors that disrupted the relationship investigated. Nests varied greatly on similar tree heights; however, that is not to say that the findings in this report should be disregarded, Roisin et al. (2006) found in a neotropical rainforest in Panama that termite nests were discovered to have a significant taxonomic composition from the ground to canopy. From this, it could be surmised that the singular species observed at SERF constructs nests at a general height range. Further research into tropical regions containing a higher variation of tree heights and greater biodiversity would be highly recommended.

4.4 Canopy Cover Preferences

Termite are known to build excellent thermoregulatory homes, choosing among their real estate options cautiously. Most tree species at SERF are sclerophyllous and typically offer little shade with a mostly open canopy. Figure 4 revealed an interesting synchronicity with the expected proportions derived from random sampling, implying the observations are statistically insignificant. The termite frequencies are thus seemingly unaffected by canopy cover. On the other hand, a study in West Africa argued that shade management had a significant effect on pest- and non-pest termite species richness, to support cocoa agroforestry systems (Felicitas et al., 2018). This paper brought attention to an important consideration, especially as per Felicitas' findings, where approaching 20% canopy coverage drastically reduced species richness. As well as this, during fieldwork at SERF, ground nests from other termite species (most likely

Microcerotermes turneri) were spotted; however, they were not recorded. There is a possibility that the species richness was affected by shade cover and interspecific competition among the arboreal and subterranean termites. A separate study conducted with the specific aim to quantify species richness in Queensland's Moreton Bay Region would be required to confirm whether the species that were recorded had out-competed other species, and if different termite species display preferences for certain canopy coverage.

4.5 Diameter at Breast Height Preferences

The last question in this study sought to determine the significance of termite frequencies regarding tree diameters. It came as no surprise that termite nest observations matched the expected normal distribution (Figure 5). It is well known that arboreal termites like *N. walkeri* will predictably build a nest on a larger tree as it is a richer resource and is typically surrounded by cellulosic debris and other larger trees. An important aspect of larger trees stated by Gonçalves et al. (2005) is the structure of the tree itself. As termites travel to form a new colony, drywood and debris are necessary as fuel and temporary sites to travel to the next tree for colonisation. As previously stated, Eucalypts commonly drop their branches as a survival tactic which makes it reasonable to assume that larger trees will have more appendices for releasing, as to regulate its own moisture content. This then provides a large enough area of detritus for surrounding nests to take advantage of. In conjunction with proximal resources, larger trees will also bear larger and more branches as structural supports for termite nests.

5. Conclusion

The specific relationships *N. walkeri* shares with surrounding flora is poorly documented and only inferable through adjacent studies. In this report, it was found that *N. walkeri* shows predictable tendencies when regarding preferable tree characteristics and abiotic influences. These findings strongly support current literature in almost every aspect and offer suggestions for future research. Major recommendations for further studies should include investigation into the distribution of species richness across southeast Queensland for collation with existing research. This will create a highly specified knowledgebases for either further studies or effective management strategies. Research should also aim to analyse the energy limitations of different termite species to possibly highlight more effective physical management tools.

6. References

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