

How do ants affect pine trees and their associated arthropods?

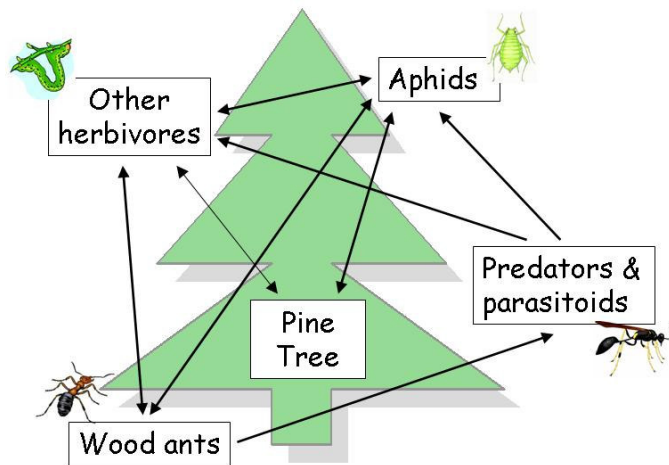
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Introduction

Wood ants (*Formica aquilonia* and *F. lugubris*) forage in pine trees (*Pinus sylvestris*) for arthropod prey and to collect honeydew from tended aphids. We investigated the balance of these ant feeding-modes which can influence the biodiversity and ecosystem function associated with each tree. Tending aphids for honeydew is hypothesised to cause negative impacts on the tree as aphids are costly for the tree to maintain, whilst the removal of arthropod herbivores is thought to be beneficial to the tree (James *et al.*, 1999; Rosengren & Sundström, 1991; Adlung, 1966; Barlett, 1961). The unique feeding habit of ants necessitates a range of mutualistic interactions (Figure 1). These trophic interactions may also be influenced via an effect on aphids or arthropod prey of the abundant conifer secondary metabolites, the monoterpenes, which vary between individual trees, and are genetically determined. Genetic variability has been suggested as having a possible effect on the foraging behaviour of wood ants (Rosengren & Sundström, 1991).

Figure 1. Trophic interactions in pine trees



The objective of this study was to determine: (1) the relative importance of the two feeding modes to wood ants; (2) whether the extent of foraging is influenced by the trees' monoterpene phenotype; (3) what effect any association between the tree's monoterpene phenotype and ant foraging has on the tree's vigour and seed production.

Methods

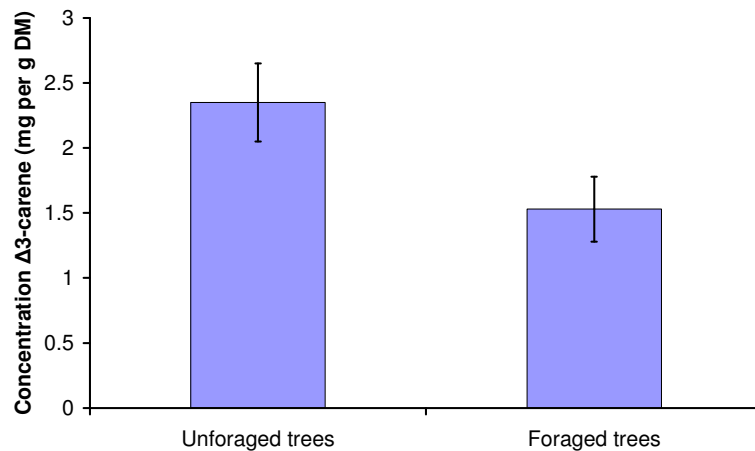
Our study site was a native Caledonian pine forest situated on Deeside, NE Scotland (56° 59' N, 03° 19' E). Forty-five trees were selected at random from within a population but stratified spatially, and to cover a broad range of monoterpene compositions. Monthly counts were made of ants descending these trees over a two year period. Laden ants were removed from the trail and their loads identified. A random sample of

ants provided an assessment of the proportion of honeydew carried. For the analysis trees were divided into foraged or unforaged categories.

Results and discussion

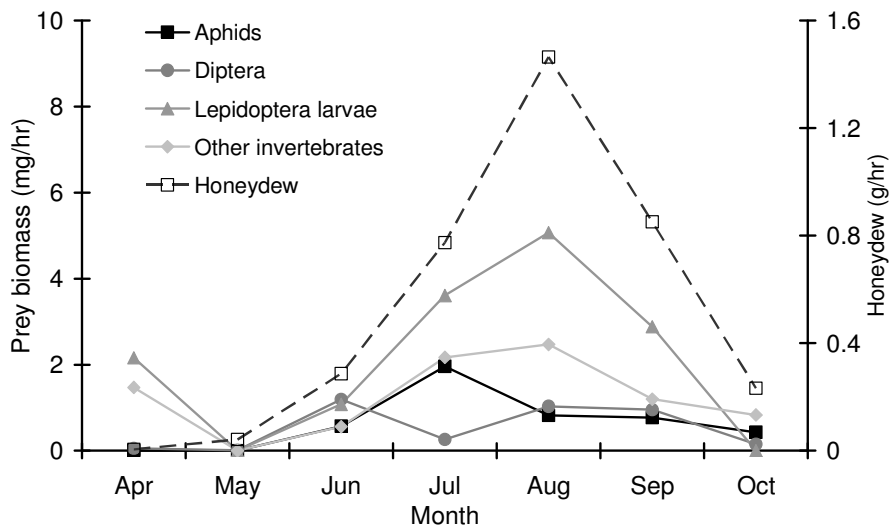
Twenty-five of the forty-five trees sampled were regularly used for ant foraging. The pattern of ant activity across the months was unimodal, peaking in August. Comparison of the trees' monoterpene concentrations revealed that trees foraged by ants contain lower levels of Δ^3 -carene (Figure 2). This monoterpene has previously been shown to affect the numbers of herbivorous insects in pine trees (Dennis *et al.*, in subm.) but this is the first evidence of an effect at the next trophic level.

Figure 2. Concentration of Δ^3 -carene (\pm standard error) in foraged and unforaged trees



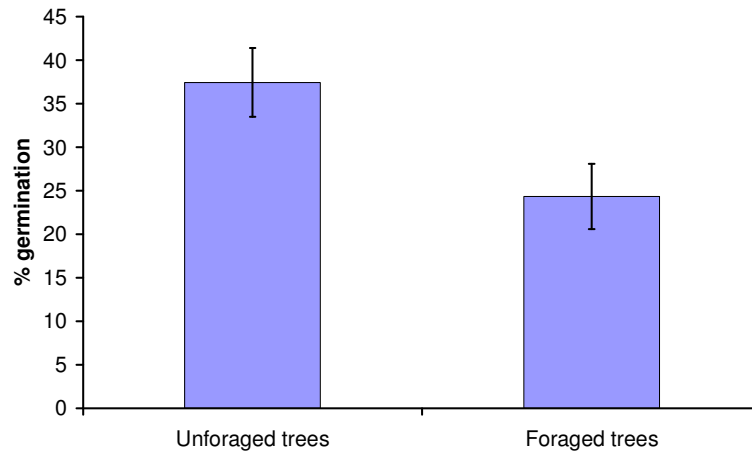
We also found the proportion of honeydew in the diet to be far higher than previously documented (*e.g.* Sudd & Lodhi, 1981) (Figure 3).

Figure 3. Diet composition in wood ants



Aphids were at least three times more abundant on foraged trees compared to unforaged trees. The consequences of this feeding activity could be costly to these trees as the disadvantage of maintaining a high resident population of tended aphids is offset against the benefits of limited herbivore removal by ants. Indeed, we found that ant-foraged trees showed a significant reduction in the proportion of germinating seeds produced (Figure 4). This may represent a cost to the tree of supporting large numbers of honeydew-producing aphids tended by ants.

Figure 4. Percentage (\pm standard error) of seeds germinating from foraged and unforaged trees



References

- Adlung, K.G. (1966) A critical evaluation of the European research on use of red wood ants (*Formica rufa* group) for the protection of forests against harmful insects. *Zeitschrift für angewandte Entomologie*, **57**, 167-189.
- Bartlett, B.R. (1961) The influence of ants upon parasites, predators and scale insects. *Annales of the Entomological Society of America*, **54**, 543-551.
- Dennis, P., Stockan, J., Thoss, V., Elston, D.A. & Iason, G. (2006) Evidence for effects of genotypic diversity via monoterpene composition on phytophagous insects of a native Scots pine forest. *In subm.*
- James, D.G., Stevens, M.M., O'Malley, K.J. & Faulder, R.J. (1999) Ant foraging reduces the abundance of beneficial and incidental arthropods in citrus canopies. *Biological Control*, **14**, 121-126.
- Rosengren, R. & Sundström, L. (1991) The interaction between red wood ants, *Cinara* aphids, and pines. A ghost of mutualism past? *in Ant-Plant Interactions* (eds. C.R. Huxley & D.F. Culter), pp. 80-91. Oxford University Press, Oxford.
- Sudd, J.H. & Lodhi, Q.K. (1981) The distribution of foraging workers of the red wood ant *Formica lugubris* Zetterstedt (Hymenoptera: Formicidae) and their effect on the numbers and diversity of other arthropods. *Biological Conservation*, **20**, 133-145.