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Nesting ecology of *Formica cunicularia*

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1. Introduction

The UK does not have a very rich ant fauna. The likely ecological reason for this is that the climate in Britain is too cool for many highly thermophilic species of ants. Consequently, several species of ants are rare or scarce in Britain. Indeed, nine species appear on the UK Biodiversity Action Plan (BAP) (www.ukbap.org.uk) list representing over 20% of the mainland ant fauna. Species in the genus *Formica* are particularly fond of hot conditions and form a good proportion of the rare species in Britain. Seven *Formica* species find their way onto the BAP list, over 60% of all *Formica* species found in the country (although one of these BAP species, *F. pratensis* is now thought to be extinct in Britain).

One of the most endangered species of ant in Britain is *F. rufibarbis* Fabricius, the red-barbed ant. *F. rufibarbis* is locally common throughout much of continental Europe from Portugal to Western Siberia and is not considered under threat. However, in Britain, the species has probably always been scarce and not recently recorded beyond the Surrey Heaths (Chobham Common and Bisley), the Scilly Isles and one recent record from Kent (Pontin 2000). Even in Surrey though, the species is maintaining a tenuous grip and in 2003 there was only one active nest at Chobham Common with a further two at Bisley.

In order to breed, *F. rufibarbis* needs temperatures in excess of 25^{o}C over a sufficiently long period of time (Pontin 1998). To achieve this target, *F. rufibarbis*, along with many other species from the genus, build solaria above ground and exposed to direct sunlight. At Chobham, the solarium is constructed within a grass tussock. The nests are very delicate and easily damaged. As a result, they are very susceptible to trampling by livestock and humans and to destruction by green woodpeckers *Picus viridis*. A further natural threat to *F. rufibarbis* comes through the presence of *F. sanguinea* . *F. sanguinea* is a slave-making species that can take over and destroy another colony. With so few *F. rufibarbis* present in Britain, this threat needs to be considered seriously.

The most significant factor implicated in the decline of the species in Britain are land management changes. A wide variety of species have suffered through changes in the management of grazing stock, in particular the cessation of grazing on poor, infertile soil. Some areas have been improved whilst others, such as many heathlands, have simply had livestock removed due to economic pressures. More often than not, the cessation of grazing allows vegetation to grow taller and to fill bare patches of soil resulting in a lowering of the ground temperature. The onus has fallen more and more on volunteer conservation bodies to maintain the open structure of heathland to encourage species diversity. Livestock is sometimes a viable option (depending on the variety of animal deployed), but usually requires measures to ensure that the animals remain within a well-defined area, measures that are often too costly to enforce. Burning to knock back invasive vegetation also used to be carried out more frequently than at present, and is now not usually seen as an option in the south of England for safety and aesthetic reasons. Finally, plowing and scarification to remove vegetation that has grown up too much is also undesirable because these operations could easily destroy the fragile nests of *F. rufibarbis*.

It is likely that the continued persistence of *F. rufibarbis* in Britain will require active management. The seeding of new and suitable areas with *F. rufibarbis* queens has been considered, but is exceptionally difficult and unlikely to succeed. The most likely approach that needs to be taken is to actively manage those areas in the vicinity of nests to encourage natural spreading and the formation of new nests. It is well known that the ants require warm conditions, but it is not known whether *F. rufibarbis* (or any closely related species) seek out a precise vegetation structure for nesting. This type of information would be particularly valuable when deciding how to manage the vegetation on a very local scale. The aim of the current study was threefold:

1) to establish how large an area around a nest is used by foraging *Formica* ants;

2) to determine whether the behaviour of the ants can be affected by changing local vegetation structure; and

3) to establish whether the vegetation in the immediate vicinity of the nest has a particular structure.

Whilst the species of conservation concern was *F. rufibarbis*, it was clear that for the purposes of this exercise we were unable to work on *F. rufibarbis* for two reasons. The work was carried out on Chobham Common during the summers of 2001 and 2002. In 2001, there were two active nests reducing to one such nest in 2002. We needed to include several replicates in the study to be confident of any outcome. Furthermore, one of the nests was the focus of another behavioural study in 2001. Consequently, we decided to concentrate our efforts on another thermophilic species, *F. cunicularia*. *F. cunicularia* is a species closely related to *F. rufibarbis* which can also be found in heathland (and dry open calcareous) habitats. Whilst it requires warm conditions to breed, it is able to operate under slightly cooler conditions than *F. rufibarbis*.

2. Methods

2.1 Study site

The work was carried out on Chobham Common National Nature Reserve, Surrey UK. Chobham Common consists of lowland heath designated as a Site of Special Scientific Interest and has an area of 517ha. It is situated in the London Basin with an elevation above area level ranging from 30-75m. Habitats within the area include wet and dry heath, marsh grassland and bogs, interspersed amongst patches of woodland. The Common has approximately 300,000 visitors per year. The study site was located on a south-facing slope near the Monument Car Park (Chobham Road, B383, grid ref: SU 965655).

2.2 Foraging distance around nest and response to vegetation manipulation

The study was carried out during the months of August and September. Two nests were studied in 2001 and a further three nests in 2002. A grid consisting of 100 quadrats was established over each nest. Each quadrat measured 1.2m x 1.2m and each nest was located in the centre of a grid. The grid covered a linear distance of at least 6m from the nest in each direction. The vegetation type within each quadrat varied so that sometimes quadrats contained thick, tussocky vegetation whilst others contained large areas of bare ground. Consequently, the ease with which ants could be observed varied enormously among quadrats. To compensate for this, 5cm wide strips were cut into the vegetation as close to ground level as possible, orientated with respect to the nest as shown in Figure 1.

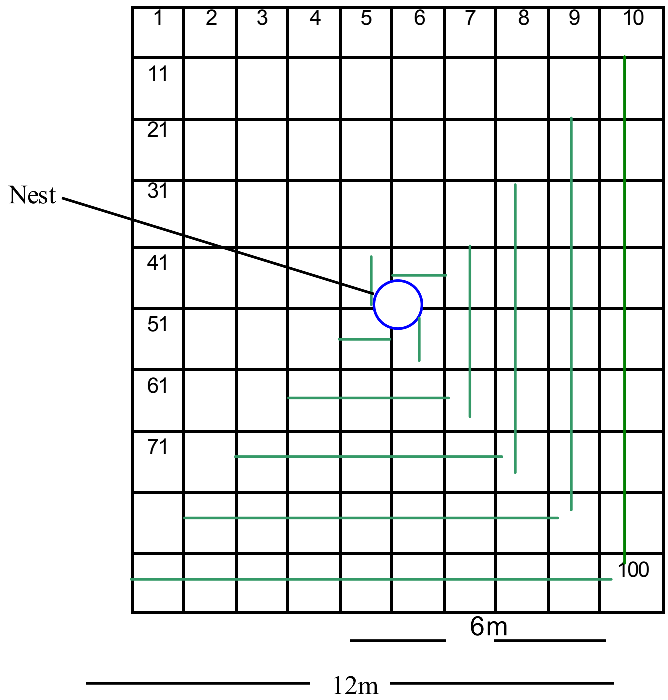


Figure 1. Layout of grid around each control and experimental nest. Quadrat 1 is in the top left-hand corner. The orientations of the 5cm wide strips of cut vegetation relative to the nest are indicated (NB each quadrat had a strip cut through it).

Ant activity was quantified within each quadrat by counting only the number of ants that crossed the strip during a set period of time irrespective of whether individuals could be seen within other parts of the quadrat. During 2001 one of the nests was randomly assigned as a control whilst the other was the experimental nest. 50 quadrats were selected at random from within each grid and assessed for ant activity during the first of two days. The order in which the quadrats were observed was randomized and each quadrat was observed for 2 minutes. Observations were carried out between 11.00 and 17.00 hours, in other words during the warmest parts of the day when the ants were most likely to be active. Observations were not made during the rain, but no other climatic condition was allowed to interfere with the study. Between 12.00 and 13.00, the maximum temperature in the shade within the ground flora 5cm above the ground was recorded. During the second of the pair of days the remaining 50 quadrats within each grid were assessed for ant activity using the same procedure described above. The two days were usually consecutive, unless rain intervened, but were never separated by more than one day. The observation preceded in this way during the first half of the study until each grid had been assessed for ant activity 10 times. The complete randomization of the order in which the grids were visited ensured that the effects of climatic variables were averaged out across the study.

Once the above data had been collected, 10 of the quadrats within the grid over the experimental nest were selected at random and the vegetation within these quadrats was cut by hand as close to the ground as possible. Observations continued within the experimental and control grids as described above until a further 10 observations had been made for each quadrat. The entire experiment was repeated in 2002 using three more nests of *F. cunicularia*, one of which was designated as the control nest and the other two as experimental nests.

2.3 Vegetation structure around nests

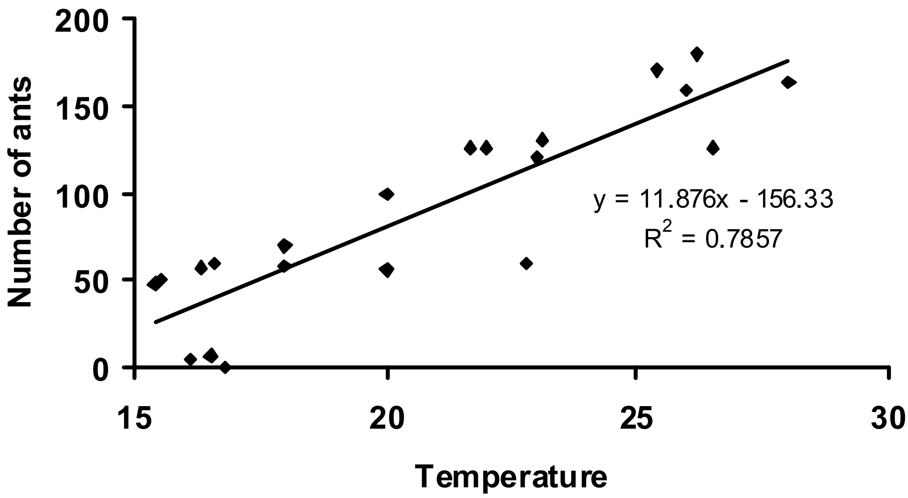
In 2002, a search of the study site revealed 12 nests of *F. cunicularia*. Four transects were set up radiating out from each nest pointing north, south, east and west. Each transect was 3m long. Five vegetation height categories were devised with ranges 0-2cm, 2-5cm, 5-15cm, 15-30cm and greater than 30cm. The percentage of each vegetation classification was recorded at 1m intervals along each of the transects in order to assess the vegetation structure around the nests. In addition, 25 random points were selected from within the study site using a grid laid over a map of the area. The vegetation analysis described for the nests was repeated around each of the 25 random points to allow comparisons to be made.

3. Results

3.1 Ant activity and ambient temperature

Figure 2 shows the relationship between numbers of ants recorded and air temperature. In both years, the method of temperature measurement used here predicted a significant amount of the variation in ant numbers recorded through time (2001: $r^2 = 78.6\%$, $p<0.001$; 2002: $r^2 = 70.8\%$, $p<0.001$). The 2001 data predicted that ant activity should cease when the above ground temperature fell to 13.1^{0}C, whilst the 2002 data predicted a cessation of activity at 15.4^{0}C.

a) 2001



b) 2002

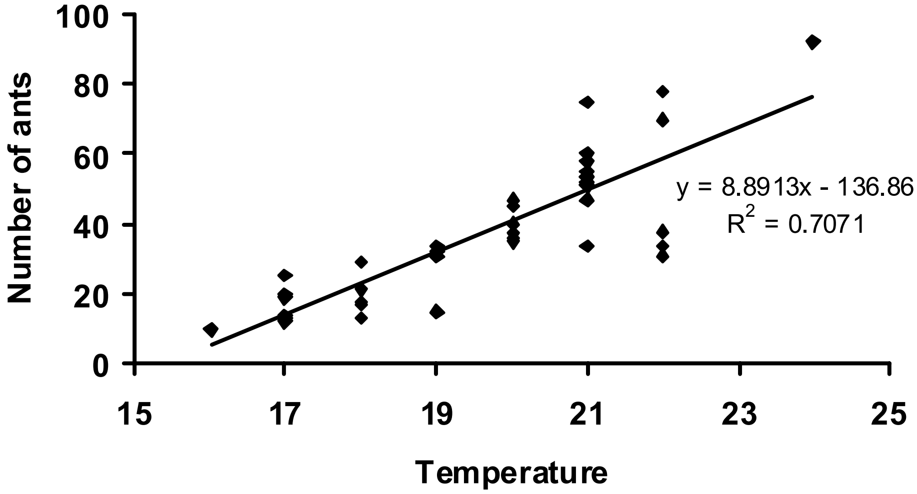


Figure 2. Relationship between number of ants recorded and above ground temperature (see text) for a) the 2001 season and b) the 2002 season.

3.2 Foraging distance around nest

Table 1 summarizes the distribution of ants around each nest for the two years of the study. The data are split into mean values for quadrats falling at different distances from the nest. For example, there are 4 quadrats covering ground between 0m and

Table 1. Mean proportions of total numbers of ants seen around each nest seen in quadrats at different distances from nest

Year	Nest	Distance from nest				
		0-1.2m	1.2-2.4m	2.4-3.6m	3.6-4.8m	4.8-6.0m
2001	Control 1	45.3	18.8	13.5	14.0	8.4
	Exp. 1	53.1	16.1	12.0	9.0	9.8
2002	Control 2	44.6	23.1	14.2	10.2	7.9
	Exp. 2	41.0	22.6	16.2	12.2	8.0
	Exp. 3	17.0	20.0	18.0	23.0	22.0

1.2m from nests (numbers 45, 46, 55 and 56 in Figure 1), then 12 quadrats covering ground between 1.2m and 2.4m from the nest (numbers 34-37, 44, 47, 54, 57 and 64-67 in Figure 2), and so on. The mean proportions of ants observed at the different distances from the nest did not differ significantly between control nest 1 and experimental nest 1 (2001 data), and between control nest 2 and experimental nest 2 (2002 data) (after Bonferroni correction for multiple tests). The data from experimental nest 3 was omitted from the analysis since a satellite nest was found just beyond the edge of the grid, hence the values of number of ants present includes individuals from two nests. Figure 3 shows plots of the proportions of the total seen at different distances from all four of the nests. Various models were fitted to describe the decrease in numbers with distance away from the nest. The model that fitted the data best had the form:

Number of ants = $a(1/\text{distance}^2) + b$ ……………………………………………..1

Where a is the regression coefficient and b the intercept.

Figure 4 shows plots of the transformed data according to model. 1. Linear regression lines through the transformed data sets explained over 98% ($p<0.001$) of the variation in all cases.

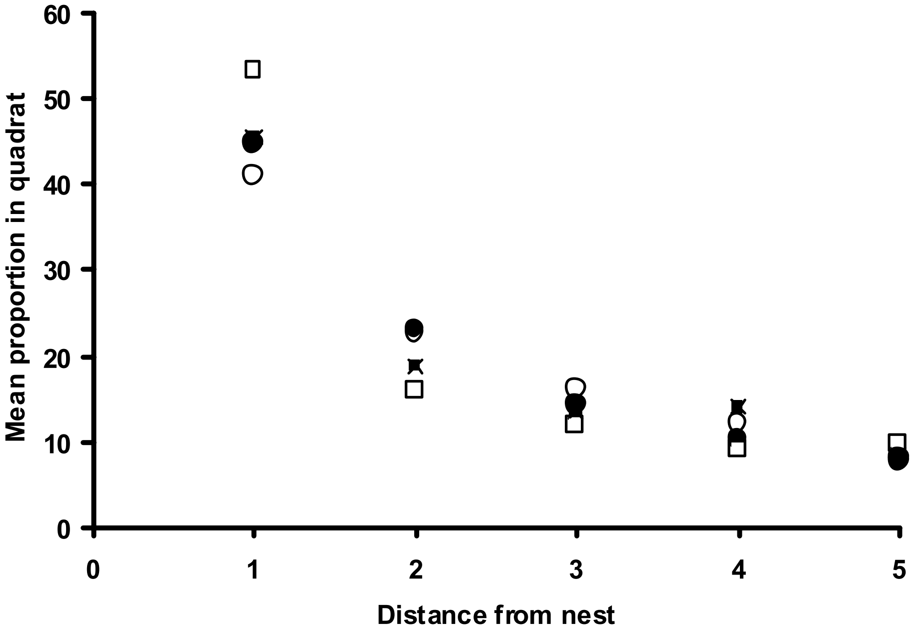


Figure 3. Proportion of individuals of *Formica cunicularia* found at different distances from the nest (1=0-1.2m; 2=1.2-2.4m; 3=2.4-3.6m; 4=3.6-4.8m; 5=4.8-6.0m) for control and experimental nests (see text). ■: control nest 1, ●: control nest 2, □: experimental nest 1, ○: experimental nest 2.

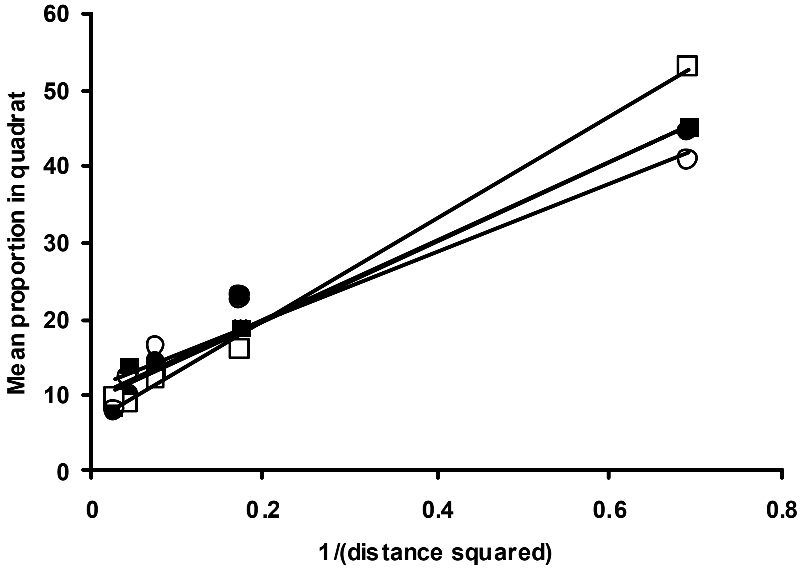


Figure 4. Proportion of individuals of *Formica cunicularia* found at transformed distances from the nest according to model 1 (see text) for control and experimental nests (see text). ■: control nest 1, ●: control nest 2, □: experimental nest 1,○: experimental nest 2.

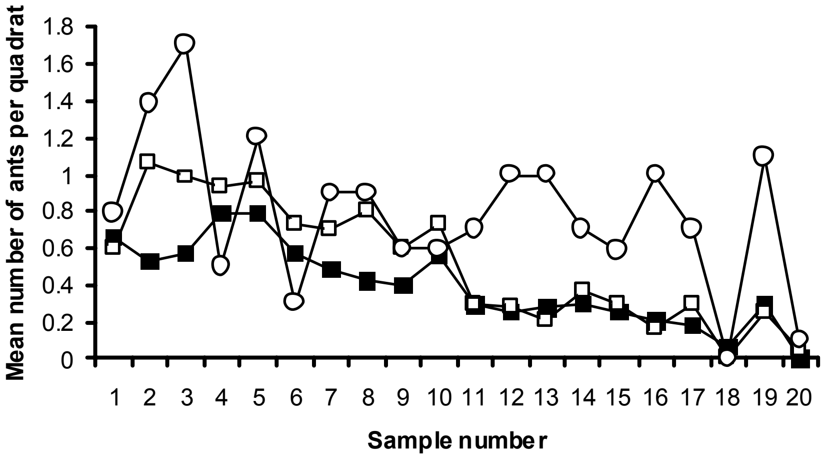
3.3 Effect of manipulating vegetation structure on ant activity

Figure 5 shows the effect of manipulating vegetation structure (cutting) on ant activity. The data from each experimental versus control nest comparison are shown separately since among year variation due to climatic differences and differences in the sizes of the nests would reduce clarity. During the first 10 samples prior to manipulation there was no difference between the 90 uncut quadrats and the 10 quadrats selected for manipulation in both 2001 (t=0.12, ns) and for both experimental nests in 2002 (t=0.39 and t=0.8, ns in both cases). After cutting, the number of ants active within the manipulated quadrats increased dramatically relative to the number observed in the unmanipulated quadrats in both 2001 (t=4.76, p<0.001) and for both experimental nests in 2002 (t=6.73 and t=11.08, p<0.001 in both cases).

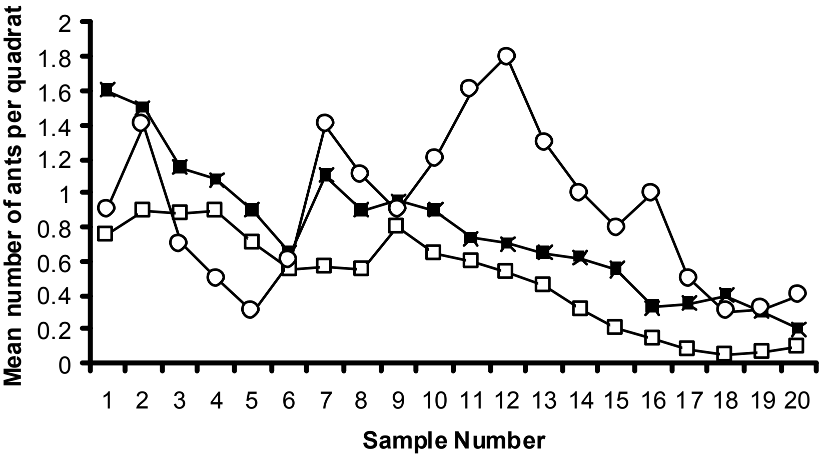
3.4 Vegetation structure around nests

Figure 6 shows the area around nests (n=12) occupied by different height vegetation relative to random points (n=25). Difference in vegetation structure between nest and random sites was indicated by an interaction between site (nest or random) and height classification in analysis of variance tables. Up to 1 m away from the nest, there was a very significant difference between the mean vegetation structure around nests and random points (Figure 5a) ($F_{4,27}$ = 109.84, p<0.001), with a much larger area of short sward in the vicinity of the nest.. From 1 m to 2 m from the nest the average sward height increased but still deviated significantly from the sward structure surrounding the random points (Figure 5b) ($F_{4,27}$ = 11.66, p<0.001). Between 2 m and 3 m from the nests, the mean height of the vegetation increased still further so that there was no longer a difference in the sward structures surrounding nest and random sites (Figure 5c) ($F_{4,27}$ = 2.31, ns).

a) 2001 season



b) 2002 season experimental nest 1



c) 2002 season experimental nest 2

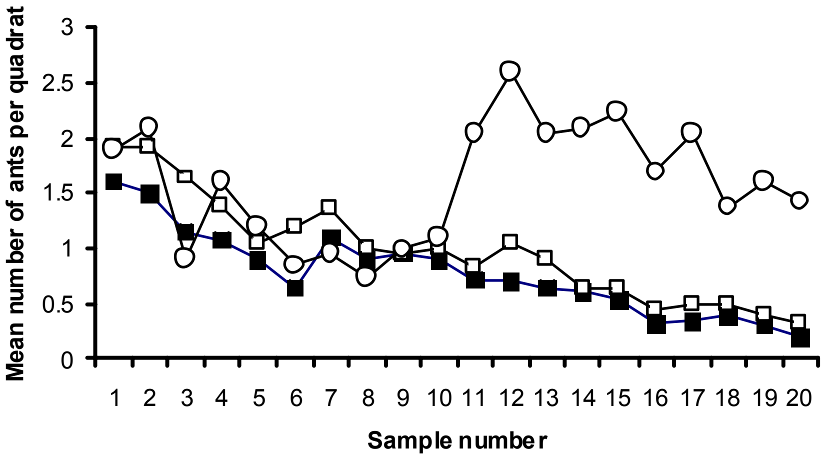
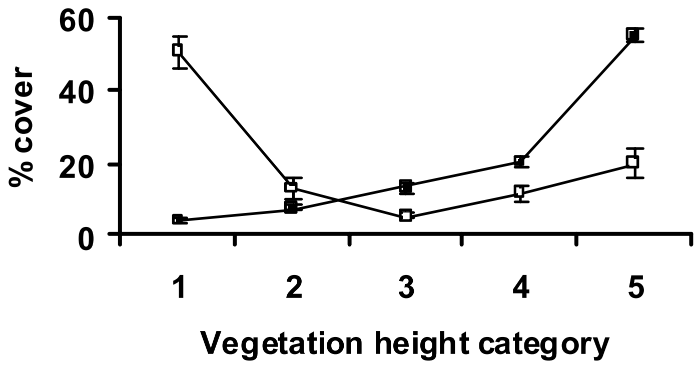
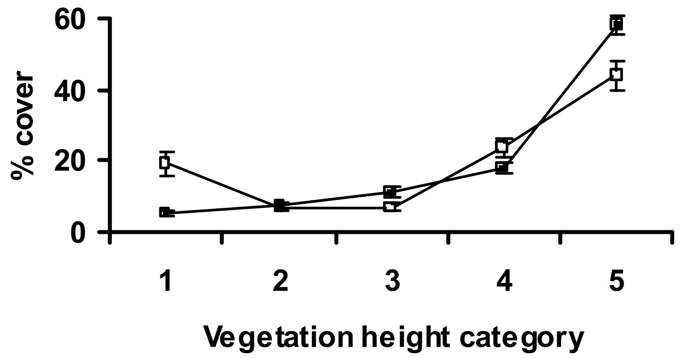


Figure 5. Mean numbers of ants through time per quadrat in grids around control nests (■: n=100 quadrats), per unmanipulated quadrat in grids around experimental nests (□: n=90 quadrats), and per manipulated quadrat in grids around experimental nests (○: n=10 quadrats) during a) 2001, b) 2002 experimental nest 1, and c) 2002 experimental nest 2.

a) 0 – 1m from nest (or random point)



b) 1 – 2m from nest (or random point)



c) 2 – 3m from nest (or random point)

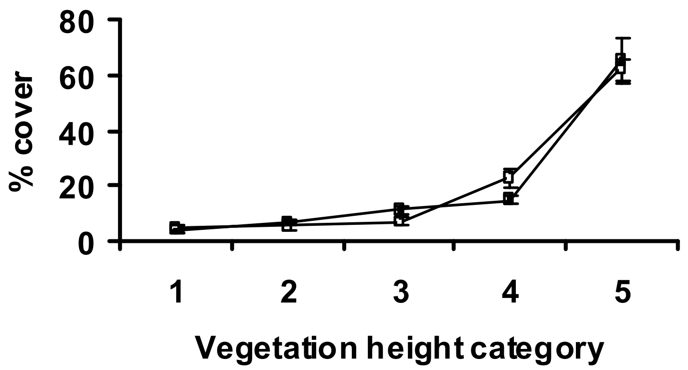


Figure 6. The percentage of ground (± standard error) covered by vegetation of different heights (1 = 1-2cm, 2 = 2-5cm, 3 = 5-15cm, 4 = 15-30cm, 5 = 30+cm) surrounding nest sites (□) and random points (■) from a) 0m to 1m, b) 1m to 2m, and 2m to 3m.

4. Discussion

Heathlands are relatively rare habitats globally. In the UK, heathlands are classified as threatened habitats (NCC 1984; Thompson *et al.* 1995). During the last 50 years, the area of heathland in the UK has decreased substantially (Chambers *et al* 1999), largely as a result of urbanization and conversion to farmland. Despite the increase in awareness of the importance of heathlands, the area of open heathland, particularly lowland heath, is still decreasing. Between 1987 and 1996, the area of lowland heath in Dorset declined by 7% (Rose *et al.* 2000). Most of this loss occurred through the encroachment of scrub and woody vegetation despite active conservation measures.

Over time, open heath is usually invaded by silver birch and pine (depending on past usage) and it is these species that conservation workers endeavour to remove by hand to maintain the early successional state of the landscape. Fire used to be a very important management tool in this process, but it has become less so, particularly on heathland in the vicinity of urban areas. Where sufficient funds are available, openness can be maintained or created through the use of grazing regimes or heavy machinery. Whichever method is used to manage the vegetation, the goal tends to be to produce an open sward across large patches of heath. For larger species, such as birds, this may produce a varied habitat, but for insects large patches may be quite homogeneous. Nevertheless, working to maintain an open sward is very important for the persistence of many thermophilic species in the UK, such as *Formica rufibarbis* (Pinchen 2001) and *F. cunicularia* However, as Pontin (1996) pointed out, the nests of these *Formica* species are very fragile and susceptible to trampling by people and animals. Furthermore, the current study demonstrated the importance of structural variation to these species at a very local scale. Consequently, 'blanket' approaches the heath vegetation management, such as grazing or the use of machinery may not be appropriate to enhance the prospects of some rare ant species, at least without employing other tactics.

It is possible that the main factor restricting the distribution of *F. cunicularia* and *F. rufibarbis* is the paucity of really warm patches within the vegetation that offer a structure suitable for nesting. On the study site, *F. cunicularia* selects tussocks within more open, presumably hotter, sections of vegetation for nesting. These nesting sites are quite small though and have a radius in the order of only 1 m. To increase the number of appropriate patches a much more focussed approach to vegetation management may by required. The minimum distance required between patches would be influenced by the way ants from different nests interact, and this would be determined by the species in question. For *F. cunicularia*, the present study demonstrated that ants do not wander far from their nest and that very few probably forage as far as 10m from the nest.

F. rufibarbis is very rare in the UK and present on only a small number of scattered sites. It is possible that the management approach suggested here may help to increase the number of nests at a very local level, which must be considered a priority. Expansion of the species beyond its current sites may take a long time since the dispersal capability of some *Formica* species, such as *F. exsecta* (Liautard & Keller 2001), is very limited. The *F. rufibarbis* colonies in Surrey are separated from each other by 9 km (Pontin 1996). It is likely that there is no exchange of individuals between these sites and quite possible than in the long run isolation will lead to problems associated with loss of genetic variation.

It is quite easy to modify the behaviour of *F. cunicularia* by altering vegetation structure. To produce a local vegetation structure that may be suitable for the establishment of a nest will almost certainly attract the attention of ants. It has been known for a long time that *Formica* ants preferentially move towards patches that have been relieved of vegetation. This may be a reaction of the ants to an increase in ground temperature and reflect the thermophilic nature of *F. cunicularia*. Figure 2 shows how ant activity relates to air temperature and suggests that activity ceases when the air temperature falls to around 14^0C. Pontin (1999) suggested that an air temperature of at least 18^0C is required to facilitate activity in *F. rufibarbis*. No extensive study has been made of the food items brought to the nest over a long period of time by either *F. rufibarbis* or *F. cunicularia*. Foraging activity is difficult to observe (Pontin 1998), although it is known that some *Formica* species, including *F. rufibarbis*, gather dead insects (Baur *et al.* 1998; Pontin 1998). Two factors interact to determine the number of food items returned from a patch to the nest: the density of food items in the patch and the ease with which they are found. Removing ground vegetation certainly attracts ants into an area, but it is not known whether it also results in a net increase in the number of food items found. More work needs to be carried out to elucidate this point.

The current study has demonstrated that it is quite easy to adjust the behaviour of ants by changing local vegetation structure. In areas where rare or scarce *Formica* spp. nest, it may be appropriate to carry out 'gardening' at a very local level to increase the number of suitable nesting sites to consolidate the population. Pontin (1996) suggested that grazing by horses and cows is inappropriate for *F. rufibarbis* due to the fragility of the nests and proposed that the cutting of vegetation by hand could be a suitable alternative. The vegetation structure in patches used to construct nests differed quite markedly from the vegetation structure generally found in the area. It is therefore possible that a paucity of suitable nesting sites was limiting the number of *F. cunicularia*. *F. rufibarbis* is very closely related to *F. cunicularia* and it is quite likely that *F. rufibarbis* reacts in a similar way to vegetation structure for nesting purposes. It would be quite straightforward to apply the procedure developed for *F. cunicularia* to test this hypothesis in *F. rufibarbis*. Should it transpire that *F. rufibarbis* also nests in the more open patches of vegetation, an obvious next step would be to produce small patches with appropriately open structure in an attempt to increase the number of nests in the area.

5. Acknowledgements

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6. References

BAUR, M.E., KAYA, H.K., & STRONG, D.R. 1998. Foraging ants as scavengers on entomopathogenic nematode killed insects. *Biological Control,* 12, 231-236.

CHAMBERS, F.M., MAUQUOY, D., & TODD, P.A. 1999. Recent rise to dominance of *Molinea caerulea* in environmentally sensitive areas: new perspectives from palaeoecological data. *Journal of Applied Ecology,* 36, 719-733.

LIAUTARD, C., & KELLER, L. 2001. Restricted effective queen dispersal at a microgeographic scale in polygynous populations of the ant *Formica exsecta*. *Evolution,* 55, 2484-2492.

NCC. 1984. *Nature Conservation in Great Britain*. Peterborough: Nature Conservancy Council.

PINCHEN, B.J. 2001. Species Recovery Programme 2000: Action for Biodiversity, BAP Aculeates. *English Nature Research Reports*, No. 402.

PONTIN, A.J. 1996. Species recovery programme report on the ant *Formica rufibarbis* F. *English Nature Report*. Peterborough: English Nature.

PONTIN, A.J. 1998. Ecological requirements and reproductive biology of *Formica rufibarbis* F. – an ant species of extreme rarity. *English Nature Report*. Peterborough: English Nature.

PONTIN, A.J. 1999. The reproductive biology and establishment of captive nests of *Formica rufibarbis* F. and some long-term observations of other rare heathland ants. *English Nature Report*. Peterborough: English Nature.

ROSE, R.J., and others. 2000. Changes on the heathlands in Dorset, England, between 1987 and 1996. *Biological Conservation,* 93, 117-125.

THOMPSON, D.B.A. 1995. Upland heather moorland in Great Britain: a review of international importance, vegetation changes and some objectives for nature conservation. *Biological Conservation,* 71, 163-178.

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Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
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