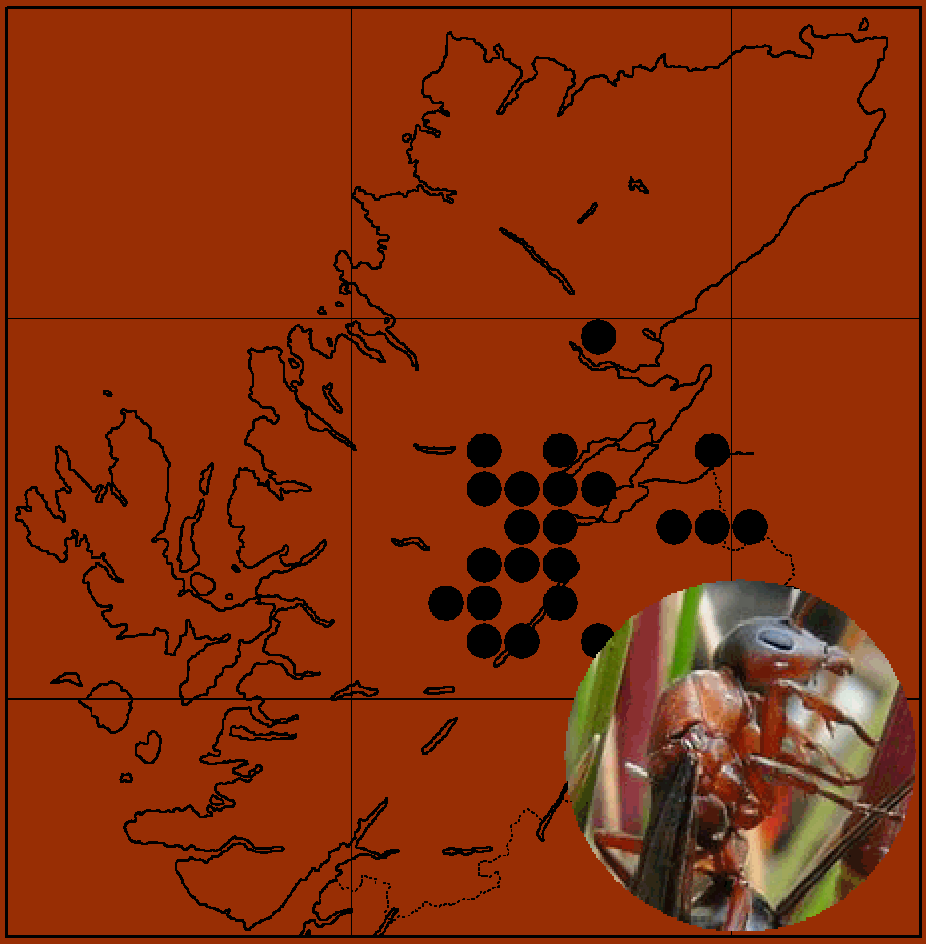
Highland Ants

Distribution, Ecology and Conservation



Murdo Macdonald

Highland Biological Recording Group

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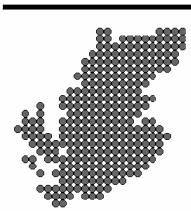


Dedicated to the memory of

Gill Nisbet
(1951-2006)

with whom this project was begun.

Published as a .pdf file by the Highland Biological Recording Group, Inverness .
Available from www.hbrg.org.uk.

ISBN 978-0-9552211-4-9

Front cover illustration: Slaver Ant *Formica sanguinea.* © Jane Bowman.
Back cover illustration: Shining Guest-ant *Formicoxenus nitidulus* with its wood-ant host *Formica lugubris*. © Stewart Taylor.

Contents

Introduction

Everyone is familiar with ants as a group, though these insects are not always regarded with affection. World-wide, there are around 11700 described species of ant (Bolton, 2013), with possibly as many yet to be recognized. The 24 native species of ants in Scotland demonstrate ecology and habits as fascinating as can be found among any invertebrate group. Much of this derives from their highly social habit, living in complex organized communities.

Reflecting the fact that ants thrive in warm places, Scotland has 24 of the 58 native ant species in the United Kingdom (41%). Scotland is nevertheless important for the conservation of some ants, either because they are scarce elsewhere in the UK, or because they are confined in the UK to Scotland. No fewer than 19 (79%) of the Scottish ants are established in Highland (Table 1), including the four species which are or were listed in the UK Biodiversity Action Plan. Highland holds significant populations of all four, as well as the only *Myrmica lonae* known in Britain, and most of the known Scottish *Formica fusca* and *Lasius platythorax*. It is true, however, that ants (like their relatives the bees and wasps) have not been well studied in Scotland even to the extent of having basic information on distribution. While this project has described distribution in Highland, there are undoubtedly new and exciting discoveries to be made elsewhere in the country.

The taxonomy of British ants has undergone some significant changes recently, particularly after detailed work by Bernhard Seifert in Germany. His efforts have established that many ants considered previously to be a single species are in fact two very similar species with distinct morphology and ecology. Splitting of one 'species' into two means that all previous records must be reassessed, and, in the absence of museum specimens to examine, the only option is to find and identify from scratch. In Highland, we have so far been affected by just two of these revisions: the splitting of *Lasius niger* and *L. platythorax*; and the separation of *Myrmica lonae* from *M. sabuleti*. Both developments raise some doubt about the identity of older records. It is possible that other changes will emerge. Already the wood-ants found over much of England and Wales have been recognised as not one species *Formica rufa*, but a complex of *rufa*, *polyctena* and their hybrids (Seifert *et al*., 2010). Current research using chemical and behavioural tests in progress in central Europe makes clear that our knowledge of the wood-ant species there is far from complete (Bernaskoni *et al*., 2011).

The aims of this work are several. As an atlas, it provides up-to-date information of the species we have and where they are found. Perhaps even more important, though, is its role in raising awareness of the diversity of species and their fascinating ways of life, and in informing land managers of the importance of retaining suitable ant habitats in the north of Scotland. With luck, this will lead others to cultivate an interest in the group, and fill in the gaps in our knowledge that undoubtedly remain. Anyone taking up that challenge will find an excellent introduction to the study of British ants in the classic works of Donisthorpe (1927a, b) and Brian (1977).

Scientific name	**English name**	**Page**
Myrmica lobicornis	A red ant	16
Myrmica lonae	A red ant	18
Myrmica rubra	Red Ant	22
Myrmica ruginodis	A red ant	24
Myrmica sabuleti	A red ant	26
Myrmica scabrinodis	A red ant	28
Myrmica sulcinodis	A red ant	20
Formicoxenus nitidulus	Shining Guest-ant	32
Leptothorax acervorum	Slender Ant	30
[*Tetramorium caespitum*]	Turf Ant	54
Lasius flavus	Yellow Meadow-ant	34
[*Lasius fuliginosus*]	A black ant	54
Lasius mixtus	A yellow ant	40
Lasius niger	Small Black Ant	36
Lasius platythorax	A black ant	38
Formica aquilonia	Scottish Wood-ant	42
Formica exsecta	Narrow-headed Ant	46
Formica fusca	A black ant	50
Formica lemani	A black ant	52
Formica lugubris	Hairy Wood-ant, Northern Wood-ant	44
Formica sanguinea	Slaver Ant	48

Table 1. The Highland species of ants. Tetramorium caespitum *and* Lasius fuliginosus *were recorded in Highland before 1980, but their continued presence is unconfirmed. Other species recorded from Scotland are* Lasius alienus*,* L. umbratus*,* L. psammophilus*, and a number of greenhouse aliens (tramp ants). No tramp species have been reported from Highland.*

Biology of ants

Ants are related to wasps and bees, and included with them as 'aculeates' (stinging insects) in the order Hymenoptera. These share many features, notably long elbowed antennae, two pairs of wings (in most males and queens, but never workers), a narrow waist, and a peculiar system of sex determination (females arise from fertilised eggs, males from unfertilised eggs).

Above all, though, ants are recognised by the public less by their physical structure than by their highly social behaviour and organisation. No-one coming upon a wood-ant mound covered in frenetically active insects, or lifting a stone to discover a mass of workers tending larvae and pupae, will be in any doubt that they are looking at ants. The same person meeting a single foraging worker may be much less certain. Some parasitoid wasps lack wings, and can look very ant-like, but they never occur in colonies and never have an ant-like waist.

Annual cycle

Although different species have very different details to their biology, there are many common features. In a generalised description, a colony is founded by a fertilised queen ant who drops her wings and is destined for an earthbound life of egg-laying. She protects her eggs until they hatch into worker ants (non-breeding females). These workers will spend their lives foraging for the nest, caring for eggs and pupae, and defending the nest against intruders. Ants can recognise individuals from another nest by the chemical signature of hydrocarbons on the cuticle (Martin *et al*., 2008). Each colony has a different chemical fingerprint, and strangers with a different 'smell' will be attacked vigorously. The workers may lay unfertilised eggs which do not hatch and are used only as food by the larvae (trophic eggs), and in some circumstances may lay eggs that develop into males.

At some point in the year, the queen will lay unfertilised eggs which develop into males. These emerge in synchrony, in most Highland species between June and September, as 'flying ants'. They search out young winged queens which emerge at the same time, and mate. The males then die, while the fertilised queens shed their wings and either found new nests or establish in an existing nest. Unlike social wasps and bees, many ants have several or many queens in each nest (polygyny), or form colonies consisting of several nests within a few metres (polydomy). Queens in polygynous nests compete to lay the greatest number of successful eggs. While males are produced from unfertilised eggs, the decision of whether a female larva becomes a worker (sterile) or queen (reproductive) is a complex interaction of nutrition, behaviour and hormones, the precise mechanism probably differing between species.

Also in contrast to social wasps and bumblebees, ant colonies are perennial. Instead of dying, queen ants and their workers remain alive over winter, moving deep into the earth below the mound, stump or stone where they are so easily found during the summer. They remain inactive and shielded from the worst of the cold until the ground warms up again in spring.

Nests

Most of our ants nest in the ground. Even nests in obvious mounds extend far into the earth below. Ants need warmth, normally from the sun. Mounds (solaria) of wood-ants and *Lasius flavus* absorb heat, and workers will move brood within the mound according to conditions. *Formica lemani* and *Myrmica* spp. often nest under stones that warm up by absorbing heat and light. The thatched mounds of the wood-ants are good insulators, and very effective at maintaining suitable temperatures. Rosengren *et. al*. (1987) found that the temperature inside a large mound remained close to 30°C while the external temperature fell sometimes below freezing. The heating mechanism may depend on colony size, but it seems that both heat from the sun and the generation of metabolic heat by the ants are involved.

Food

While *Lasius flavus* is unusual in that it rarely forages above ground, relying on root aphids for food, most ants forage widely for any food they may find. Honeydew from aphids is a very important source of sugars, and *Formica* species will travel high into the canopy of trees to search for it. Larvae require protein from anything the foragers may find - plant material (seeds and pollen), dead invertebrates, or live ones that can be overpowered by weight of numbers. A group of Slaver Ants *F. sanguinea* was once seen carrying a still-twitching and well-grown larva of the Small Elephant Hawk-moth *Deilephila porcellus* (see also Plate 14). Whatever is taken as food, ants can only ingest liquid, so solid food is chewed into a pulp.

Stings, acid sprays and bites

Myrmicine ants have stings. *Lasius* and *Formica* spray acid from a pore on the tip of the abdomen, often for several centimetres, turning the abdomen forward through the legs to ensure a good aim. These, and the powerful mandibles, are effective at subduing prey and in defence. Some *Myrmica* will sting humans - *M. rubra* has a reputation as a painful stinger - but the wood-ants are perhaps a greater danger as they spray acid into any eyes placed too close to a mound. Waving a strip of litmus or pH paper close to an occupied mound will stimulate frenzied spraying, and an immediate colour-change. Only females sting or spray. Slaver Ants tend to rely on bites, painful but non-toxic, to discourage interference.

Longevity and numbers

The longevity of queen ants is astonishing. Those of many species will live for over 10 years, and several over 20 years in the wild, laying eggs all this time as a consequence of a single initial mating. They may be accompanied in the nest by many tens or hundreds of thousands of workers, which are much shorter-lived. It was estimated that a colony of the Yellow Meadow Ant *Lasius flavus* contained 23,000 workers, with 17,000 root aphids in the nest satisfying the energy needs of the ants by releasing 6ml of honeydew every day (Seifert, 2007). That nest was small in comparison with some *L. flavus* nests holding 100,000 individuals. The ecological effect of Yellow Meadow Ants can be imagined given a fresh biomass up to 150kg/ha, and moving up to 7t of soil per hectare per annum (Seifert, 2007).

Relationships of ants with other organisms

Ants enjoy a wide range of symbiotic relationships with other organisms - some casual, some optional, others obligatory - and many more than are mentioned here. Symbiosis, meaning 'living together', is a formal relationship between two species, and comes in three main forms: mutualism, where both species benefit; commensalism, where one gains and one neither gains nor loses; and parasitism where one (the parasite) gains while the other (the host) loses.

Ants and aphids

Aphids, and especially the honeydew they produce, are very important to ants as food. The relationship is complex, involving aphid, ant, fungi, and the tree on which the aphids feed. Ants will tend aphid colonies of certain species, perhaps enhancing the food supply for the ant, and giving protection to the aphids. Removal of honeydew, a potential growth medium, by the ants may discourage establishment of moulds that might otherwise affect adversely the aphids or the host plant. While the aphids and plant may benefit from the absence of fungi, that must be set against the potential transfer of fungi by the ants, and an increased population of aphids. See Skinner and Allen (1996) and Nielsen *et al*. (2010) for more detail and references.

Ants and butterflies

The attempts to re-establish the Large Blue Butterfly *Phengaris arion* in England brought the symbiotic relationship between it and the red ant *Myrmica sabuleti* to public attention. Other butterflies in the Lycaenidae have evolved similar, though less advanced symbiosis, including three Highland species: Common Blue *Polyommatus icarus*, Small Blue *Cupido minimus*, and Northern Brown Argus *Aricia artaxerxes* (Fiedler, 1989). These form symbioses with, respectively, *Lasius flavus*, *L. niger* and *M. sabuleti*; *M. rubra* and *Formica fusca*; and *Lasius* species. The butterfly larvae have special glands which secrete a nutritious liquid which the ants drink, while the presence of the ants deters parasites and predators. The attentions of the ants are encouraged by chemical signals from the larvae. In at least some species the larvae also mimic sounds made by their queen hosts, further ensuring care (Barbero *et al*., 2009).

Ants and plants

Unlike many other insects, ants are generally not welcomed to flowers. They frequently take nectar, but are not good pollinators, and may chew and damage the essential flower parts. Several plants have evolved decoy organs to divert ants from the nectar source in the flowers. These extra-floral nectaries are found on the bracts of some vetches *Vicia*, and at the base of the leaves of cherry and related trees *Prunus*. Conversely, the sugar-secreting glands at the base of the fronds of Bracken *Pteridium aquilinum*, a fern that lacks flowers, may actually attract ants which discourage other potentially harmful insects. The balance of cost and benefit in these relationships is not always clear, and debate continues about their exact nature (Wagner and Kay, 2002; Punttila *et al*., 2004).

Ants aid the dispersal of some seeds like violets *Viola*, Gorse *Ulex europaeus*, and the Small

Cow-wheat *Melampyrum sylvaticum*. This last is a very rare and declining plant in Scotland. Its seed has an oil-rich appendage (elaiosome) which ants eat. They collect the shed seeds, and in the transfer of the seed to the nest some are 'sown'. This behaviour has not been directly observed in Britain and lack of seed dispersal by ants may be contributing to the poor health of the plant population (Dalrymple, 2007).

We have in Britain no plants that develop ant shelters (domatia) like those found in East African Whistling Thorn *Acacia drepanolobium*, and other tropical plants.

'Guests' of ants

Many beetles in the rove-beetle family Staphylinidae are life-long commensals in ant nests feeding on debris. Most are very small, like *Oxypoda haemorrhoa* and *Nototheca flavipes*. Some larger beetles like the green chafer *Protaetia metallica* and the ladybird look-alike *Clytra quadripunctata* (Plate 4) live in ant nests as larvae, as do some hoverflies (*Chrysotoxum*, *Microdon*). Woodlice are frequently found on the fringes of wood-ant nests, but have no particular relationship with ants. However, one small white blind species, the Ant Woodlouse *Platyarthrus hoffmannseggii,* has taken to permanent and obligatory residence in ant nests. We do not know of it in Highland, but it is found around the Firth of Forth. A sciarid midge, *Bradysia chandleri*, was described from the nests of *Formica rufa* in Cumbria (Smith and Menzel, 2007), and has been taken from a nest of *F. lugubris* in mid-Ross. It is not clear if this is a formal or casual association. For more, see the classic work by Donisthorpe (1927b).

Ants and other ants

Several Highland ants show special symbiotic relationships with other ants. At one end of the spectrum is the casual and purely optional association between the Slender Ant *Leptothorax acervorum* and various *Formica* ants (see p. 30). The other relationships are more formal.

In a category of its own is the Slaver Ant *Formica sanguinea* which raids the nests of *F. lemani* and adopts the workers as 'slaves'. While usually the Slavers have their smaller congeners to help, they always have their own workers and will sometimes establish single-species nests.

We have no permanent social parasites, where one species exploits the workers of another, among our Highland ants (there are some elsewhere in Britain), but several species are temporary social parasites as a normal part of nest-founding. Thus the Narrow-headed Ant *Formica exsecta* establishes new nests when a fresh mated queen invades the nest of *F. lemani* or *F. fusca*. The true wood-ants behave similarly, and *Lasius mixtus* does the same using *L. flavus* or *L. niger* as hosts. In each case the host workers eventually die out, by which time the invading queen has produced workers of her own to carry on the colony.

At the other extreme is the Shining Guest-ant *Formicoxenus nitidulus*, an obligate parasite in *Formica* mounds (see p. 32).

Habitats

In general, our Highland ants are not too fussy about the habitat they frequent, as long as the temperature and humidity are suitable and there is an adequate food supply. Differences in habitat are generally explained by these factors. Most ants will not be found in cool shaded sites (under canopy, for example), but a few metres away on a forest ride or edge, where the sunlight raises the ground temperature, several species may nest. Apart from the Shining Guest Ant *Formicoxenus nitidulus*, which is only found in the nests of wood-ants, the species occupy a wide range of sites and habitats, subject only to the temperature and humidity envelope. Intensively farmed land holds few ants, and our acid moors and grasslands usually have only two species - *Formica lemani* and *Myrmica ruginodis* - in significant numbers. Perhaps related to temperature, the number of ant species diminishes quite rapidly with altitude (Fig. 1). We have no records of workers above 620m.

Finding ants

Usually, finding ants calls for deliberate searching. The mound-builders are often easy to spot from the nests, and occasionally stray crumbs at a picnic will attract foragers, but most species require effort. An easy way to start is to turn over stones lying on soil in open situations. Suitable stones covering nests are in the 'Goldilocks zone', neither too big (taking too long to heat up), nor too small (losing heat too readily). Experience will soon teach the right stones to examine. Stones must be in contact with the soil. Those lying on vegetation do not serve. Any material that absorbs heat will attract nesting ants - corrugated metal, wooden boards, the refugia used for monitoring amphibians and reptiles, even lumps of discarded road tar.

Other places to search are under moss mats covering rocks, soil or wood; under the peeling bark of dead wood; and in decaying wood at all stages from when it becomes soft right through to the stage of brown powder.

It is useful to get one's eye in for tell-tale heaps of fine soil, no more than a few cm high and often a lot less (Plate 1), that can betray the presence of *Lasius* and *Myrmica* species. Similarly, accumulations of wood fragments at the base of a tree-stump should be investigated in case they mark a Slaver Ant nest. The much larger mounds of *Lasius flavus* are often heavily vegetated (Plate 2), and the beginner may be unaware that they are ant nests, especially as workers are rarely visible until the surface of the nest is disturbed slightly.

Although wood-ants have conspicuous nests, they may be hidden in ground-layer vegetation and invisible from just a few paces away, or in the case of *Formica aquilonia* heavily vegetated (Plate 3). These ants are often first detected as foragers, streaming along track-sides or up and down the trunks of aphid-rich trees.

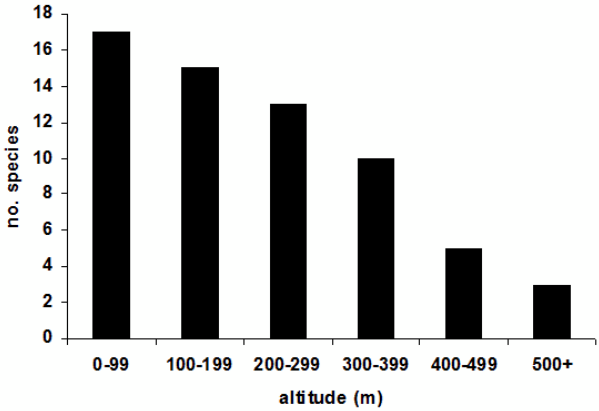


Figure 1. Number of ant species recorded in Highland related to altitude.

Plates 1-3. Nests of Lasius niger *(1) and other species may be revealed by small piles of fine soil. Nests of* Lasius flavus *(2) and* Formica aquilonia *(3) may be heavily vegetated. 1 and 3 © Murdo Macdonald ; 2 © Jane Bowman .*

Conservation of ants

Several Highland ants are of conservation significance because they are nationally threatened, because Highland holds significant stocks of species which may be declining elsewhere, or because they are scarce or restricted in Highland (Table 2). Most ants, being generalists, do not require specific habitats. Conservation action should be targeted at providing an areas open to the sun; suitable nest sites in the form of stony ground, dead wood, moss carpets; and appropriate food supply in the form of aphids and other plant-sucking bugs. The result may not always be attractive to the human eye. That should not, however, be a reason for neglecting the needs of ants.

The most pressing conservation concern relates to the mound-building *Formica* wood-ants and their relatives. Wood-ants are widespread in Highland, but familiarity with the forests of Strathspey or Culbin, where they are common, may mask their vulnerability. Over most of our area they occur in small numbers in forest blocks, often with several km between groups (Fig. 2). They seem to find establishing in new areas very difficult. In the native birch woodland of the west, fragmentation, not only of the ant populations but of the woodland patches, is especially obvious, and they are susceptible to loss from senescence of the largely unmanaged woodland, and from fires. On Skye, there is just one known nest of *F. lugubris* and one isolated birch wood with *F. aquilonia*. Additional importance comes from their role as hosts for the UK BAP Shining Guest-ant *Formicoxenus nitidulus*.

Species	Designation	Status in Highland
Formica exsecta	UK BAP, SBL, IUCN (pre 1994) - Endangered.	Restricted to Strathspey.
Formicoxenus nitidulus	UK BAP, SBL.	Strathspey and S Skye only.
Formica aquilonia	SBL, IUCN (1994) - Lower risk - near threatened.	Widespread, but fragmented. Absent or rare in most woodland blocks.
Formica lugubris	SBL, IUCN (1994) - Lower risk - near threatened.	
Formica sanguinea	Nationally Notable B.	Frequent in E Highland.
Myrmica lonae	None.	Confined in UK to W of Highland.
Formica fusca *Lasius platythorax*	None.	Scarce in W of Highland, very rare in Scotland.

Table 2. Conservation status of the Highland ants. SBL = Scottish Biodiversity List.; UK BAP = UK Biodiversity Action Plan Priority Species. Formica aquilonia *and* F. lugubris *are former UK BAP species, removed in 2007.*

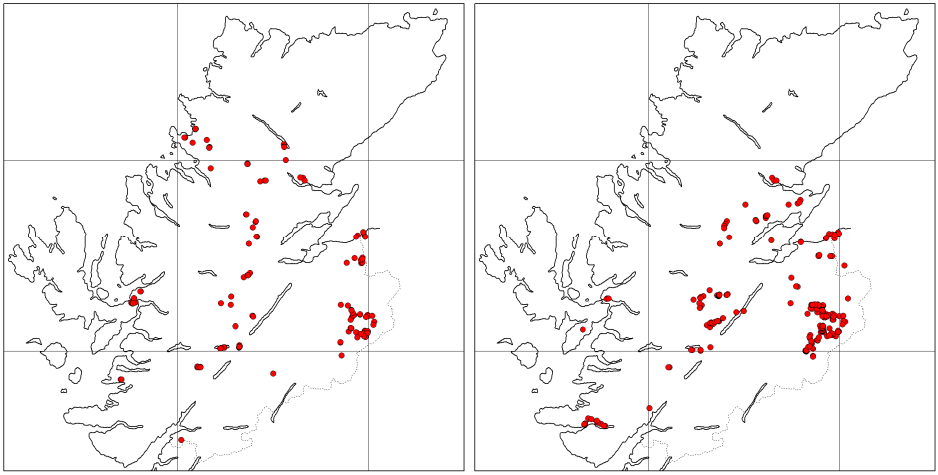


Figure 2. Nest sites of Formica aquilonia *(left) and* F. lugubris. *Dots are 3km diameter centred on the 100m grid position.*

Pressure for economic development has led to the loss of, or continuing threat to, wood-ants and other important species. Wood-ants and many other species of threatened invertebrates often count for little in the face of a projected 26% increase in human population in the Cairngorms National Park between 2010 and 2035 (Anon, 2012). Some land users do attempt to reduce damage to ants. In 2009, Scotland TranServ moved a number of nests of *F. lugubris* which would have been destroyed by the construction of a crawler lane on the A9 near Carrbridge, though with variable success. In 2010 an isolated nest near Moy was identified and protected during similar works, and in 2012 nests were moved during operations by Forestry Commission Scotland. Private estates in the Park have been proactive in identifying threats and mitigating damage to wood-ants in the course of their estate activities.

It is not always good news. In 2012 the most northerly nest of *Formicoxenus nitidulus* ever found in Britain was destroyed by unauthorised construction of a private forest road in the National Park. Proposed developments within the Park currently threaten hundreds of wood-ant mounds, and if permitted without conservation measures will cause further loss and fragmentation of the ant populations. Although FCS has guidance on conservation of wood-ants (Hughes and Broome, 2007) it is not always followed, and the ants are not always accorded the ecological value they deserve as natural control agents of forest pests and ecosystem engineers (Pisarski and Czechowski, 1990; Karhu, 2002; Punttila *et al*., 2004; Sorvari, 2009; Jilkova *et al.*, 2010; Finér *et al.*, 2012).

Unless the public and private bodies who are joint guardians of most wood-ants in Highland (through ownership, regulatory role or setting planning policy) take their conservation duties seriously, the future looks very bleak for these keystone species.

The area, data collection and maps

The area

The area covered is the current Highland Council local authority area. At 26,500 square km it occupies one third of the land area of Scotland. It is 25% larger than Wales, but has a population only one tenth as big at around 212,000. Much of it is remote mountain and island. It comprises vice-counties 96, 97, 104-109, with parts of 95 and 98, and the land area includes (in whole or part) 351 hectads (10km grid squares) excluding 3 with small skerries in the Minch. Eighteen of these contain little land within the recording area, either coastal in the west and north, or on the boundary with other authorities in the south and east.

Recording

Targeted recording of ants was begun in 2005 and continued until the end of 2012. All records were determined from specimens by a competent person. Reports not supported by specimens or determined by a non-specialist were not used.

Data

Along with the locality and date, additional data (sex, caste; nest situation; presence of alates; and the altitude) were recorded whenever possible. All data were stored digitally, and the maps were generated direct from that database. Every dot on the maps can be traced to a fully detailed record in the HBRG database, the quoted literature, or in a few cases the database of Bees, Wasps and Ants Recording Society. All except literature records should be accessible on the NBN Gateway http://data.nbn.org.uk.

Coverage and maps

Coverage for this Atlas extended to 299 (85%) of the 351 hectads (Fig. 3). Most of the 52 squares with no records are marginal to the area, often with very little land area within Highland, or are upland areas above the normal altitude limit for ants. Most hectads (69% of those with records) had 3 species or fewer recorded, and only 7.6% had more than 6 species (Fig. 4). A summary appears in Table 3.

The records plotted here are all from the period 1980 to 2012 inclusive, except in a few scarce species where older records are used and plotted as grey symbols. Because of the difficulty of finding ants, distribution should be interpreted at a fairly coarse scale. Many empty hectads on the maps within the overall large-scale distribution will have the species present.

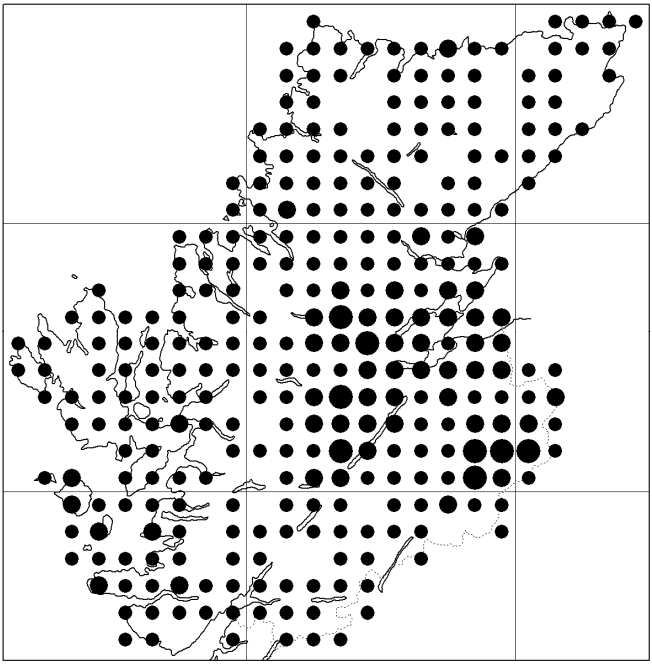


Figure 3. Survey coverage for the Atlas, 1980-2012 with a few older records as stated in the species accounts. Each dot represents the number of species recorded in each of the 351 10km grid squares in the area. From smallest to largest dots: 1-4 species, 5-9 species, 10-14 species.

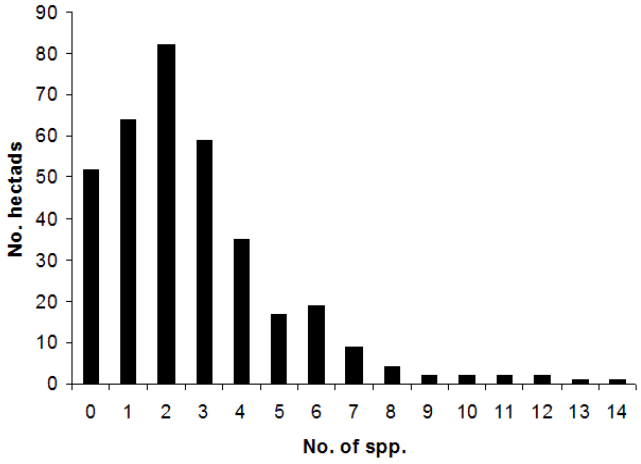


Figure 4. Number of ant species recorded per hectad in Highland. Mean 2.7 (all squares); 3.1 (surveyed squares).

Species	No. records	No. hectads
Myrmica ruginodis	638	248
Formica lemani	653	225
Leptothorax acervorum	178	84
Myrmica scabrinodis	141	83
Lasius niger	125	57
Formica lugubris	360	46
Formica aquilonia	271	43
Lasius flavus	69	31
Formica sanguinea	101	27
Myrmica lobicornis	30	24
Myrmica rubra	28	21
Myrmica sabuleti	25	15
Myrmica sulcinodis	39	12
Formica fusca	5 (6)	11 (6)
Formicoxenus nitidulus	20	6
Lasius platythorax	7 (1)	6 (1)
Formica exsecta	52 (1)	6 (1)
Myrmica lonae	5 (1)	3 (1)
Lasius mixtus	4 (3)	3 (2)
[Tetramorium caespitum]	2 (2)	(2)
[Lasius fuliginosus]	1 (1)	(1)
Totals	**2754 (15)**	**954 (14)**

Table 3. Records and hectads mapped for ants in the atlas. Numbers in brackets show how many pre-1980 records and hectads were included for the scarcer species. Tetramorium caespitum and Lasius fuliginosus *have accounts but no maps.*

The species accounts

Each species account contains the following information:

Latin name English name

Full Latin name and author. BRC number. NBN number (taxon version key). Conservation status: Any RDB, BAP or similar listing.

Recognition: A brief account of the main identification points, which should be read in conjunction with the keys.

Habitat: A brief note on the main habitats, with altitude ranges from the database.

Nest: Nature and location of nests.

Alates: Months in which males or alate queens have been found, indicating when sexuals are produced and when mating will occur. The number of records of these is given.

Distribution and abundance: A general statement of the distribution and abundance in Highland. A brief description of UK distribution and status.

The map: Only records considered reliable from the 351 hectads (10km squares) in Highland are plotted. Some records from boundary squares may strictly fall outside Highland. (All maps in this book were created with DMAP, www.dmap.co.uk.)

Comments: Any points of interest and relevance.

References: References for mapped records taken from the literature. Full details are in the References section on p. 62.

Plate 4. The beetle Clytra quadripunctata *which develops in the mounds of wood-ants. © Jane Bowman.*

Myrmica lobicornis A red ant

Myrmica lobicornis Nylander, 1846. BRC no. 4302. NHMSYS0000876365.

Recognition: Workers are often very dark, appearing almost black, though under a lens reddish tints will be apparent. The two-part waist will always distinguish it from the black *Lasius* and *Formica* species. The more-or-less vertical semicircular lobe on the bend of the antenna is diagnostic (Plate 5), and identification can be made with confidence on this character in the field with the aid of a lens. Consideration should be given to the possibility of *M. lonae* where the angle of the scape can be upswept, but does not form the vertical lobe of *lobicornis*. Queens are winged, with the same antennal character as workers. Males are winged, black, with a long scape (at least one-third the length of the entire antenna).

Habitat: It has been found most frequently on the coast and in flat river valleys. Usually sparsely distributed, the densest populations were found at Farr in Sutherland where nests are frequent under light cover of moss on sandy soil. Altitude range 2-370m (found at 406m on Cademuir Hill in the Borders near Peebles).

Nest: Most were found in moss on a variety of soils from sand to peat, but sometimes under stones.

Alates: August (1 record).

Distribution and abundance: This ant is present throughout the area, but is scarce. It is found throughout the UK, except for the Western Isles, Orkney, Shetland and N Ireland.

Comments: This is a widely-distributed ant which is rarely found, and often encountered as single workers. As nests are small and relatively scarce it is easily overlooked. The dark colour of the workers - typically almost black - can mislead at a casual glance into thinking it might be a *Lasius*. One worker was found being carried, presumably as prey, by a worker of *M. sulcinodis*. A record of *M. schencki* in Collingwood (1951) probably refers to the very similar *M. lobicornis*.

References: Dobson (1993).

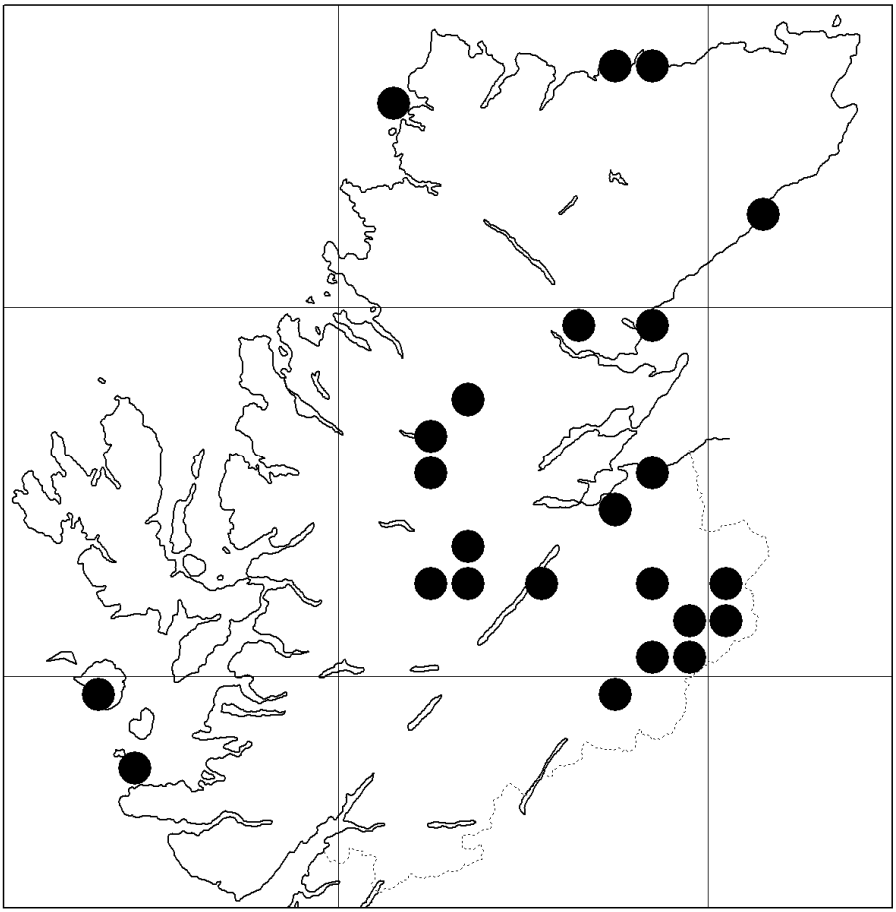


Plate 5. Head of Myrmica lobicornis *showing the vertical lobe at the base of the scape. © Erin Prado, www.antweb.org.*

Myrmica lonae A red ant

Myrmica lonae Finzi, 1926. NHMSYS0020545625.

Recognition: This ant was only recently separated from *M. sabuleti* (Seifert, 2000), and has been confused with that species. The scape of the antenna has a heavy lobe at the angle - much heavier and wider than in *sabuleti* - and which is also sufficiently upswept to cause some confusion with *M. lobicornis*. It is typically much darker in colour than *sabuleti*. The best distinction requires precise microscopic measurements, but after a little experience of *sabuleti* and *lobicornis* any *lonae* should be immediately and obviously different. Specimens of any suspected *lonae* should be retained for specialist confirmation.

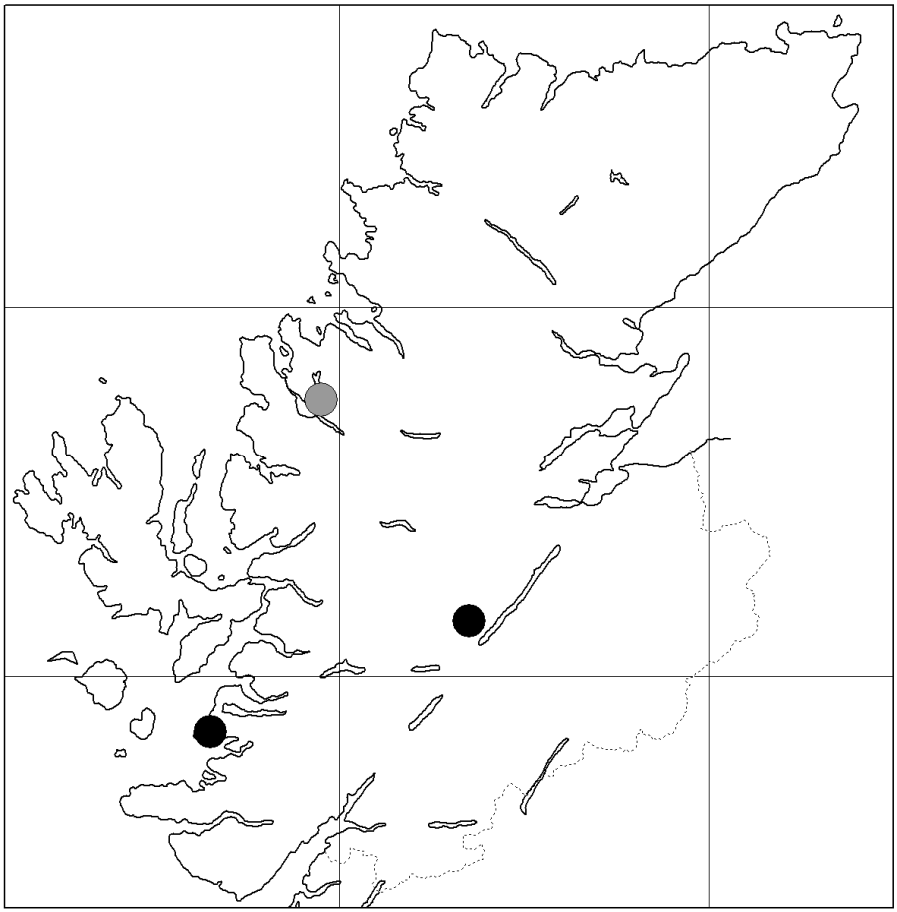
Habitat: There are few records, but it should be sought on south-facing open forest and forest edge, nesting under stones. Altitude range 5-120m.

Nest: The Arisaig nest was under a flat stone. A nest in NH31 was in a mound of *Lasius flavus* (A. Jarman pers. comm.).

Alates: No information.

Distribution and abundance: This seems to be a very rare ant, and so far is known in the UK only from the W Highlands at Loch Maree, Glen Moriston and Arisaig. It should be expected in suitable habitat more widely in W Ross, W Inverness and Argyll.

Comments: Seifert (2000) cites 'Loch Maree' as one of his localities but the specimen has no more precise information (Seifert, *in litt*., 2009). I have assumed that the record of *M. sabuleti* in Barrett (1979) in NG97 refers to *M. lonae*, and it has been mapped here in that hectad (the grey dot). A search was made in 2009 in the extensive woodland on the north side of Loch Maree, and on some of the islands, but *lonae* was not found.



Myrmica sulcinodis A red ant

Myrmica sulcinodis Nylander, 1846. BRC no. 4309. NHMSYS0000876377.

Recognition: Workers are noticeably larger and more robust than other *Myrmica*, more heavily sculptured, and very dark on the head and abdomen. The antenna is distinctive, with an almost right-angled curve on the scape, rather than the obtuse curve of *M. rubra* and *M. ruginodis*, and lacking the sharp angle of *M. sabuleti* and *M. scabrinodis*. A good character for confirmation is the heavy sculpturing on the sides of the petiole. Darker and more robust specimens of *M. ruginodis* have been identified as *sulcinodis*, but there is little excuse for this even with a lens in the field. The contrast between the right-angled curve of the scape in *sulcinodis* and the obtuse curve in *ruginodis* and *rubra* is easy to see. Queens are winged, with the same characters as workers. Males are winged, black, with a long scape (at least one-third the length of the entire antenna).

Habitat: This ant is associated with dry heathland and other well-drained places, including exposed gravely waste ground. Altitude range 10-560m.

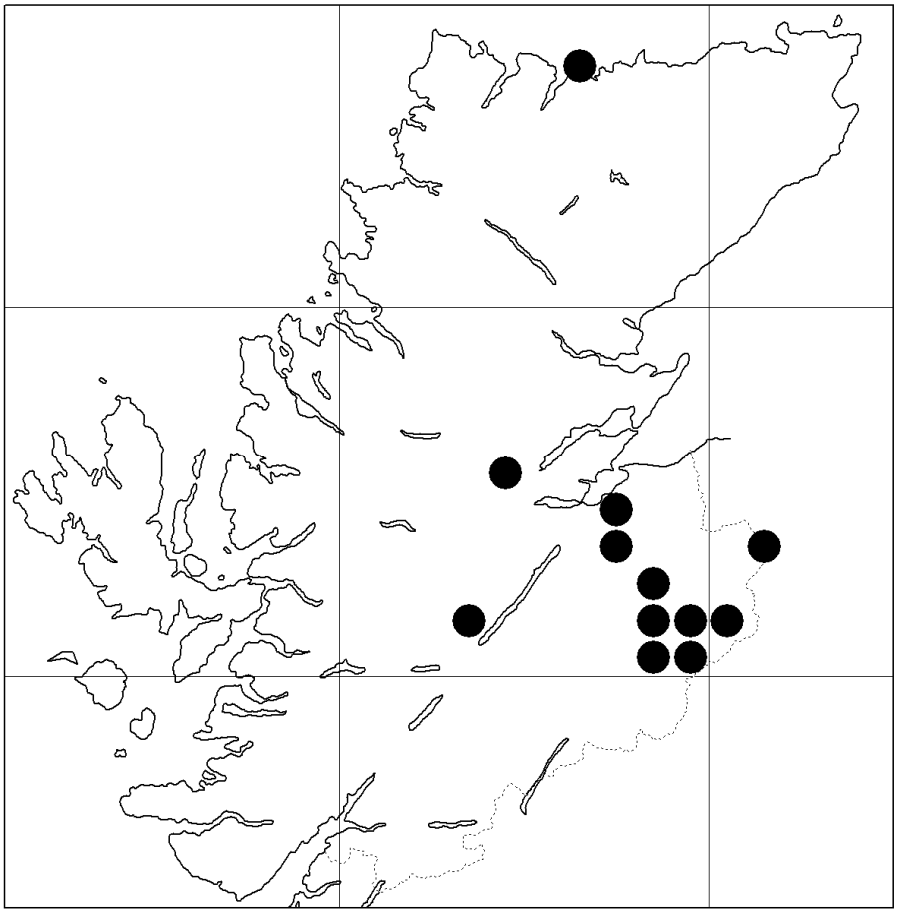
Nest: Typically nests are found in dry soil, and more often than in others in the genus with a small raised spoil heap that betrays its presence. It will nest under stones like other *Myrmica*.

Alates: July-August (3 records).

Distribution and abundance: It is found mainly in the east of the area, where it can be locally abundant. Generally, it is scarce. It is present throughout the UK except the Western Isles, Orkney, Shetland and N Ireland.

Comments: Most of the sites found in Highland are man-made. It is especially frequent on roadside banks on the A9 through Strathspey. Reports from the west have turned out to be *M. ruginodis*, but it should not be discounted there.

Some decades ago, the distinctions between the various *Myrmica* ants were not as well recognised as now, leading to names that clearly indicated confusion: *M. sulcinodoruginodi*s (now *sulcinodis*); *M. ruginodolaevinodis* (now *ruginodis* - *M. laevinodis* was the old name for *M. rubra*). *M. ruginodis* was combined under *M. rubra* by Collingwood (1951). Caution should therefore be applied when reading the older literature, and we should remember with gratitude that we can stand on the shoulders of giants and use the basic biological and taxonomic knowledge painstakingly worked out by the naturalists of the past.



Myrmica rubra A red ant

Myrmica rubra (Linnaeus, 1758). BRC no. 4303. NBNSYS0000009343.

Recognition: Workers are always noticeably reddish, though the exact shade varies considerably between nests. Yellowish workers can be distinguished from *Lasius flavus* by the two-part waist. The obtuse curve on the antennal scape is shared with the much more frequent *M. ruginodis*, which, however, has noticeably longer spines on the propodeum and a flat-topped (not pointed) petiole (Plates 6, 7). Queens are winged, with the same characters as workers. Males are winged, black, with a short scape (less than one-third the length of the entire antenna).

Habitat: It nests in many situations - from just above the shore to far up valleys. Altitude range 2-130m.

Nest: Few nests have been described from our area, but those have been under stones on both sandy and peaty soil.

Alates: August (1 record).

Distribution and abundance: This ant is present but scarce throughout the area. It may be more frequent in the west. It is found throughout the UK, except the Western Isles, Orkney and Shetland.

Comments: This ant has been introduced to parts of North America. In Maine, it has become a pest to humans and there is concern that it might affect native ant populations through its aggressive behaviour. It readily stings painfully, leading to the name there of European Fire Ant (Groden, 2004).

M. rubra queens occur in two forms, a large macrogynous form and a small microgynous form (Brian and Brian, 1949; 1955). It was once thought that the small form might be a social parasite ('*M. microrubra*'), but that is now not accepted (Seifert, 2007). An old name for the species is *M. laevinodis*.

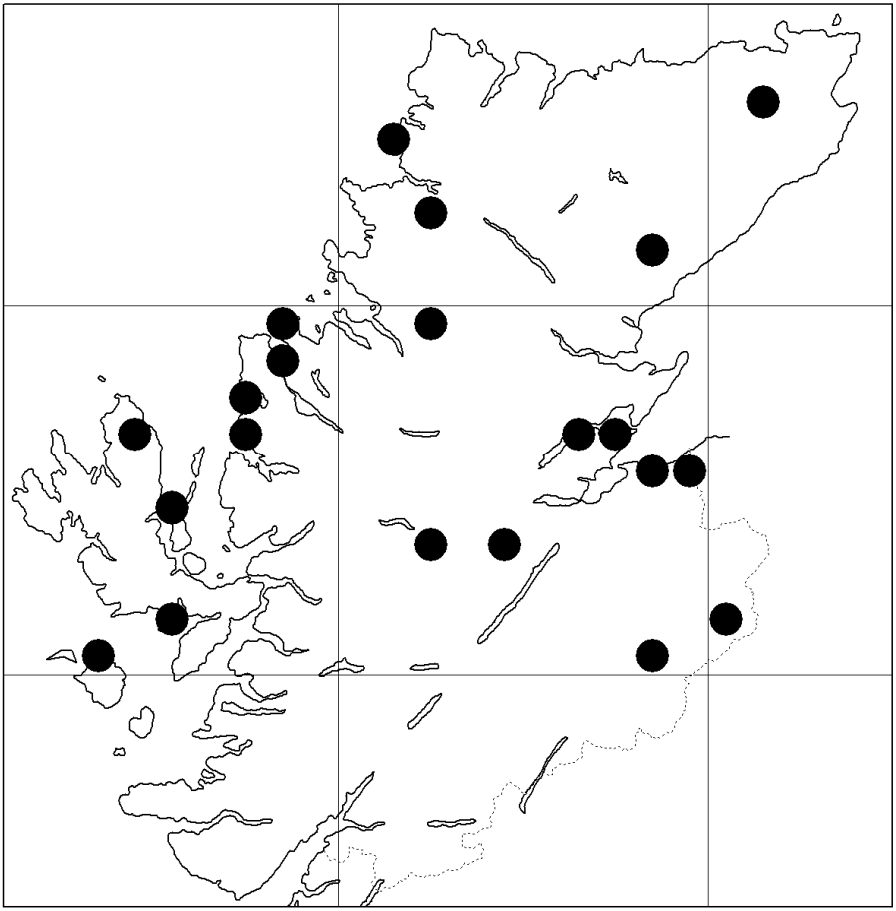


Plate 6. Waist of Myrmica rubra *showing the short spines and relatively smooth triangular petiole. © April Nobile, www.antweb.org.*

Myrmica ruginodis A red ant

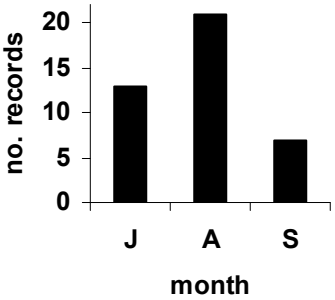
Myrmica ruginodis Nylander, 1846. BRC no. 4304. NHMSYS0000876371.

Recognition: Workers are usually noticeably reddish, though the exact shade varies considerably between nests. Yellowish workers can be distinguished from *Lasius flavus* by the two-part waist. The obtuse bend on the antennal scape is similar to the much scarcer *M. rubra*, which, however, has noticeably shorter spines on the propodeum and a petiole which is triangular in profile (Plates 6, 7). Queens are winged, with the same characters as workers. Males are winged, black, with a short scape (less than one-third the length of the entire antenna).

Habitat: This ant may be found in a huge range of habitats from the seashore to the mountains, and in grassland, heath, moor and forest. Altitude range 0-620m.

Nest: It nests in many situations - in soil, in moss, under stones, in decaying wood. Occasionally, a small mound of soil or vegetation fragments may be evident. Twice, nests were found under the same small stone as nests of *Formica lemani*, both species with brood.

Alates: July to September (41 records).



Distribution and abundance: This species is present and usually very common throughout the area and found throughout the UK, including the Western Isles, Orkney and Shetland. It is the most widespread British ant, being the only one recorded from Shetland and St Kilda (where it is not uncommon around Village Bay on Hirta).

Comments: Like *M. rubra*, this ant has two forms of queens, microgynes and macrogynes - the former establishing monogynous nests, the latter polygynous (Brian and Brian, 1949, 1955; Elmes, 1976; Seifert, 2007).

References: Wormell (2006).

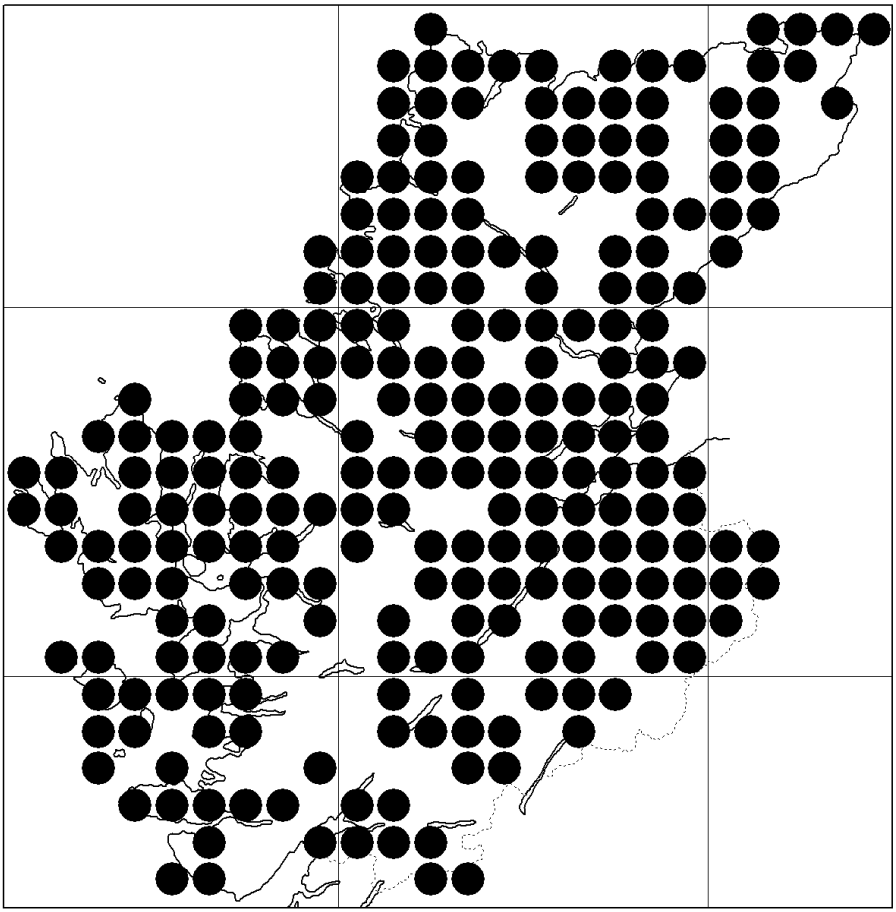


Plate 7. Waist of Myrmica ruginodis *showing the long spines and rough flat-topped petiole. © www.antweb.org.*

Myrmica sabuleti A red ant

Myrmica sabuleti Mynert, 1861. BRC no. 4305. NHMSYS0000876373.

Recognition: Workers are frequently yellowish, but can be distinguished from *Lasius flavus* by the two-part waist. The antenna in front view has a sharply angled bend like *M. scabrinodis*, with which it has often been confused. *M. sabuleti*, however, has an extended horizontal lobe on the bend of the scape, and the front and top surfaces of its petiole in profile meet with a clear curve (Plates 8, 9). The basal angle of the scape provides a very good method of separation, but it requires a bit of practice to perfect the technique (Attewell, 2006). It should also be compared with *M. lonae,* which is typically much darker and has a much heavier angle to the scape. Queens are winged, often very dark, with the same antennal characters as workers. Males are winged, black, with a short scape (less than one-third the length of the entire antenna).

Habitat: Nests in many situations. Altitude range 10-220m.

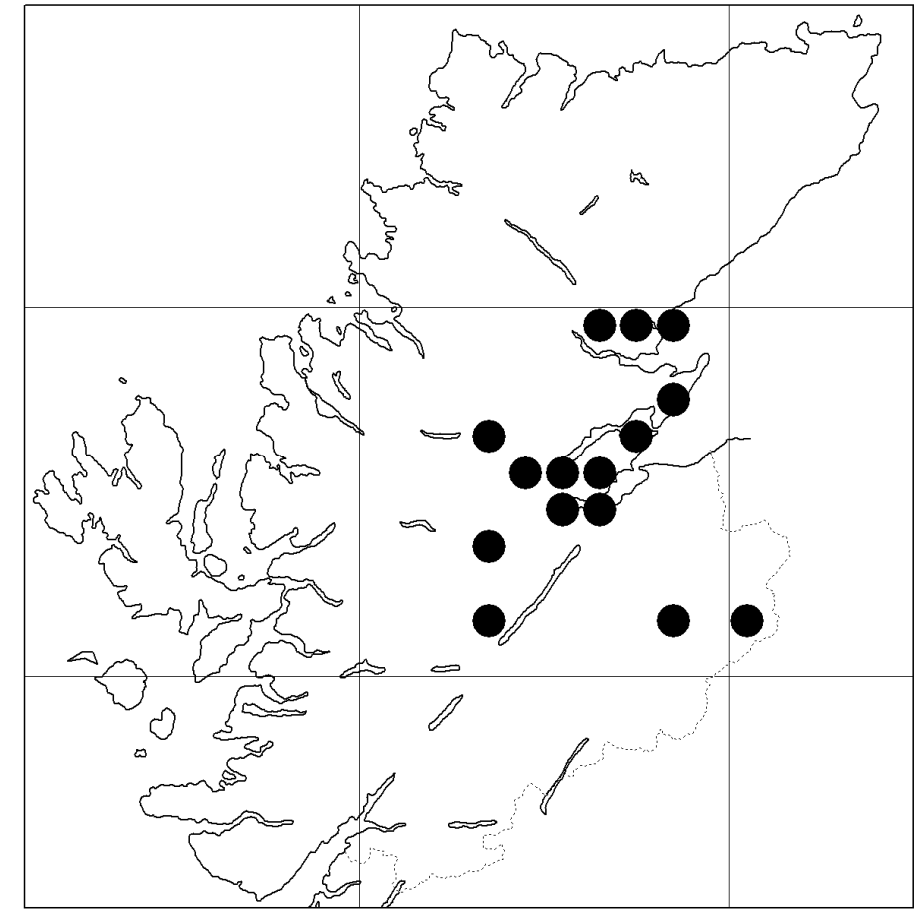
Nest: Like others of the genus, it nests in a variety of situations - in soil, in moss, under stones, under bark. Sometimes a small mound of soil or vegetation fragments is visible.

Alates: July (1 record).

Distribution and abundance: *M. sabuleti* is a scarce ant in Highland, mainly in the east. It occurs throughout the UK, except for far N and W Scotland, the Western Isles, Orkney and Shetland.

Comments: This species has been confused with the much commoner *M. scabrinodis*. Records of *sabuleti* from the Western Isles probably all refer to *scabrinodis*, and other reports from the west require confirmation. *M. sabuleti* is the required host of the Large Blue Butterfly *Phengaris arion* in England.

Myrmicine ants produce sounds for communication, using stridulation, rather like grasshoppers. By rubbing a thickened ridge on the underside of the postpetiole against an area of fine ridges on the segment behind, they generate a buzzing sound which the ants can detect through the substrate (see p. 6, and links to audio files under Barbero *et al.*, 2009).



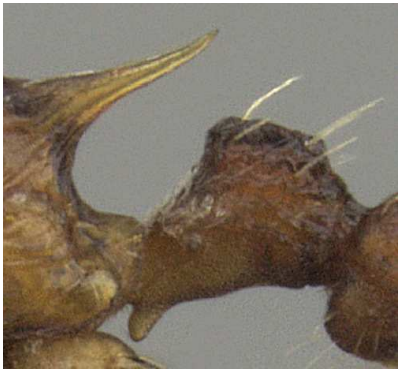


Plate 8. Profile of the petiole of Myrmica sabuleti *with the front and top surfaces meeting in a curve. Compare with Plate 9. © Noel Tawatao, www.antweb.org.*

Myrmica scabrinodis A red ant

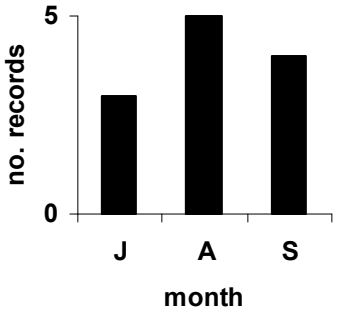
Myrmica scabrinodis Nylander, 1846. BRC no. 4306. NHMSYS0000876374.

Recognition: Workers are always noticeably reddish, though the exact shade varies between nests. The antenna is somewhat similar to *M. sabuleti*, which, however, has an extended horizontal lobe on the bend of the scape. The shape of the petiole can be used to support the identification, the front and top surfaces in profile in *scabrinodis* meeting in a sharp angle (Plates 8, 9). With practice, the basal angle of the scape provides a very good character for separation (Attewell, 2006). Queens are winged, often very dark, with the same antennal characters as workers. Males are winged, black, with a short scape (less than one-third the length of the entire antenna).

Habitat: It may be found in a wide range of habitats - grassland, moorland, forest edge and clearings. Altitude range 0-240m.

Nest: Nests are established in many situations - in soil, in moss, under stones, in decaying wood. Like others in the genus, a small mound of soil or vegetation fragments may rarely be raised. Perhaps more often than others in the genus it will nest in *Sphagnum* moss.

Alates: July to September (12 records).



Distribution and abundance: It is present throughout the area, generally frequent, and locally common, and throughout the UK, except Orkney and Shetland.

Comments: This is the commonest and most widespread of the red ants in Highland after *M. ruginodis*. It has frequently been misidentified as *M. sabuleti*, and care should be taken to check the distinguishing features with a microscope.

References: Dobson (1993), Wormell (2006).

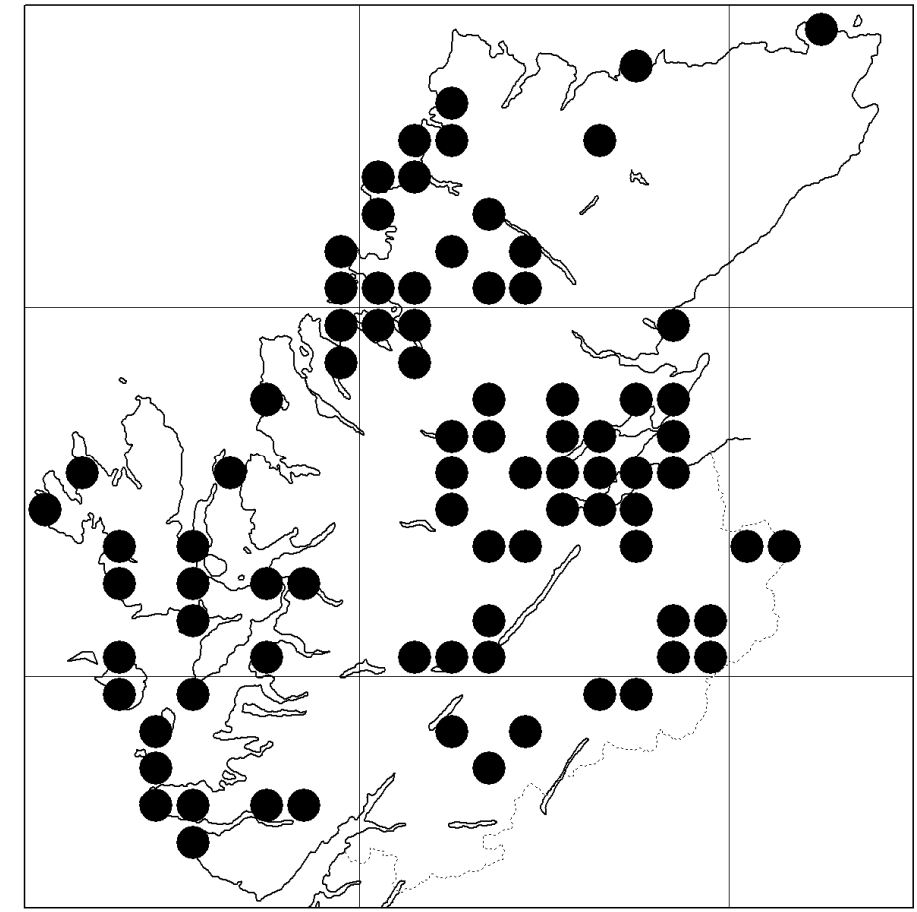


Plate 9. Profile of the petiole of Myrmica scabrinodis *with the front and top surfaces distinctly angled. Compare with Plate 8. © Erin Prado, www.antweb.org.*

Leptothorax acervorum Slender Ant

Leptothorax acervorum (Fabricius, 1793). BRC no. 4601. NHMSYS0000876230.

Recognition: The only representative of the genus in Scotland, this ant is immediately recognisable with experience by its small size (<4mm), slender build and black-and-red colouration (red thorax, black head and abdomen). Confusion is possible with the similarly-sized *Formicoxenus nitidulus* (p. 32) which is only found in wood-ant nests and has a smooth shiny head, and the all-black *Tetramorium caespitum* which has not been recorded from Highland since 1949. Queens are like large winged workers, while males are black and winged.

Habitat: It is probably most frequent in woodland, but also found in grassland and moorland. Altitude range 0-520m.

Nest: Nests are established in many situations, but are especially frequent in dead wood and dry peat. In N Sutherland it nests under stones on the stabilised sand. Colonies are typically small, with <200 workers, and with several queens which compete intensively by eating eggs other than their own (Seifert, 2007).

Alates: June to August (7 records).

Distribution and abundance: The Slender Ant is present throughout the area, but is distinctly less common in the west and far north. It is found throughout the UK, except Shetland. On Orkney it is only known from Hoy, and there is one record from the W Isles (S Uist, 2006).

Comments: Although it is an independent free-living ant, it is frequently associated with *Formica aquilonia*, *lugubris*, *exsecta*, *lemani* and *sanguinea*, and can often be seen walking about unmolested on wood-ant mounds. Care must therefore be exercised with tiny ants found on the surface of wood-ant mounds. Usually in Highland any such will be *Leptothorax*, not *Formicoxenus*, the two easily distinguished by the dark ridged head of the former and the pale smooth and shiny head of the latter. Like its close relative *Formicoxenus*, it has chemicals which make them distasteful to the larger ants with which they associate (Martin *et al*., 2007, see p. 32). It seems to represent an early stage in the evolution of the obligatory relationship shown by *Formicoxenus*.

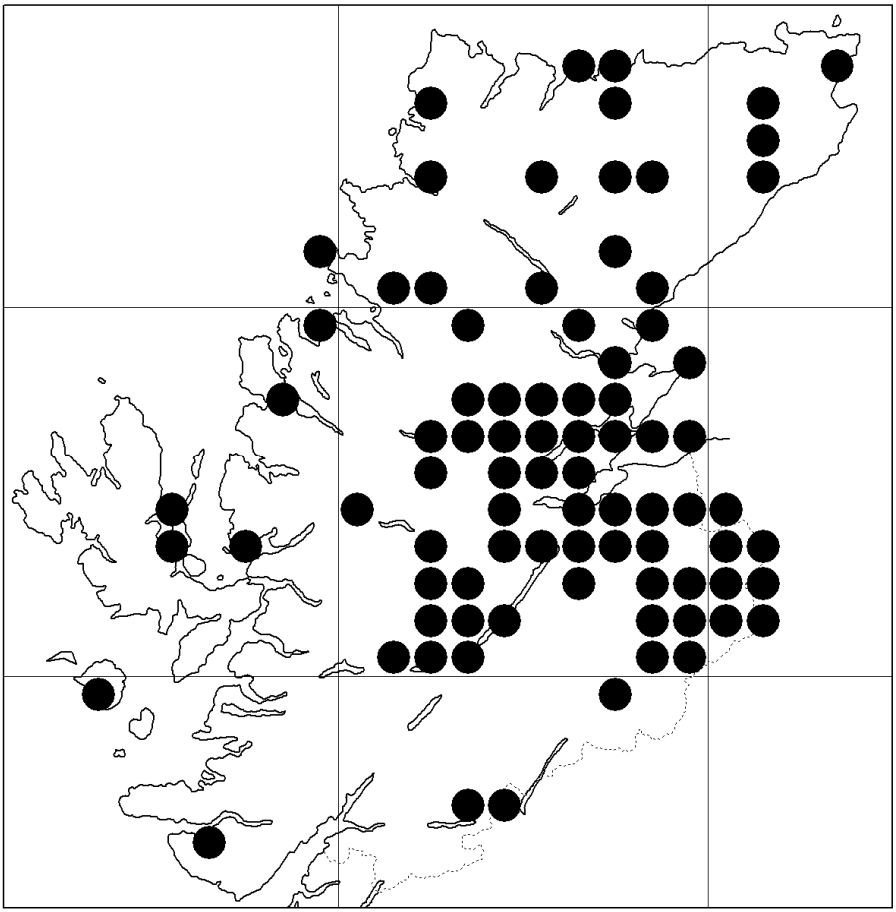


Plate 10. Short blunt spines of Leptothorax acervorum. *© Erin Prado, www.antweb.org.*

Formicoxenus nitidulus Shining Guest-ant

Formicoxenus nitidulus (Nylander, 1846). BRC no. 4501. NHMSYS0000875971. UKBAP Priority List, Scottish Biodiversity List.

Recognition: This tiny ant is best recognised by its association with mound-building *Formica* wood-ants. It may be found walking over the surface and in the vicinity of the mounds, especially when the males emerge in late summer. Confirmation must be provided by the exceptionally smooth and shining head, contrasting with the dull sculptured head of *Leptothorax acervorum* (p. 30 and Plate 11) which is also a frequent casual attendant on wood-ant mounds. Queens are winged, with the same characters as workers. Males lack wings (the only Highland ant to do so) and look very like workers.

Habitat: It is confined to the nests of its hosts. Altitude range 10-380m.

Nest: Nests are established in hollow twigs and stems embedded in the mounds of *Formica aquilonia* and *F. lugubris*. They are small, and there may be many in each mound.

Alates: We have no records of queens, but Orledge (2002a) states that alate females and wingless males may be found in July and August (exceptionally to November).

Distribution and abundance: In Highland this species is known only from the Mudalach birch wood in Skye (with *Formica aquilonia*), and Strathspey (with *F. lugubris*). In mainland Highland, only around 10 nests are known, and the densest site had *F. nitidulus* on 2 of 25 nests examined. It may always have been scarce in Highland, as it was first found in the area in 1912 by Horace Donisthorpe at Nethy Bridge 'after much search' (Collingwood, 1961). It is found throughout the mainland UK range of the hosts, except in N Scotland where the hosts extend nearly 100km farther north.

Comments: The nature of the relationship between Guest-ant and host is debated: some say it is commensal (living alongside, but not harming, the host); others regard it as a parasite (affecting the host adversely by using its food resources). It begs and steals food, sometimes standing on the (much larger) host's head as two wood-ants exchange food (trophallaxis). Chemicals on the cuticle make them distasteful to wood-ants. In close proximity to a wood-ant, the Guest-ant will become still, but if one is picked up by a larger ant it is immediately dropped (Martin *et al*., 2007). This explains how they can exist unmolested among the thousands of relatively enormous host workers. The ant is best detected on warm humid days when the tiny insects are surprisingly easy to spot as moving spots of reflected light.

References: Owen (1986).

Plate 11. Heads of Formicoxenus nitidulus *(left) and* Leptothorax acervorum *showing the difference in sculpture. © April Nobile, www.antweb.org.*

Lasius flavus Yellow Meadow-ant

Lasius flavus (Fabricius, 1782). BRC no. 6004. NHMSYS0000876223.

Recognition: Workers are pale yellow. They may be distinguished from pale *Myrmica* by the single leaf-shaped petiole. Our other yellow ant, *L. mixtus*, lacks long erect hairs on the top of the thorax, while these are an obvious feature of *flavus*. Males are winged and black.

Habitat: This ant is usually found in open habitats, and is most obvious in sandy soils where the characteristic mounds are most frequent. It may be common in crevices on coastal rocks. Altitude range 0-300m

Nest: In many parts of Britain *L. flavus* is famed for the large earth mounds, later vegetated, that mark its nests in meadows. In Highland, large mounds are rare (though locally, such as in parts of Strathfarrar, Glen Urquhart and Glen Moriston, they are the norm), and nests are frequently found under moss, under stones, or in loose soil with little or no spoil visible on the surface.

Alates: August - September (4 records).

Distribution and abundance: The Yellow Meadow-ant is present but local to the NW of the Great Glen. It is found throughout the UK except for parts of the E Highlands, Orkney and Shetland (there is one record from the Western Isles, S Uist in 1992).

Comments: The distribution of this ant in Highland is peculiar - apparently absent from the area SE of the Great Glen, unlike its close cousin *L. niger*. It appears to be most abundant in the western peninsulas of Morvern and Ardnamurchan, but even there it fails to achieve the prodigious densities shown on Lismore, just to the south of our boundary, where scratching almost any patch of warm dry soil is likely to reveal them. Except where soil mounds are built, their presence may never be suspected by the casual observer as the workers are almost wholly subterranean, feeding on root aphids, and do not habitually forage on the surface as our other ants do.

Pheasants when released in high densities have been known to cause severe damage to mounds, so in this or similar situations nests should be protected with wire netting.

References: Wormell (2006).

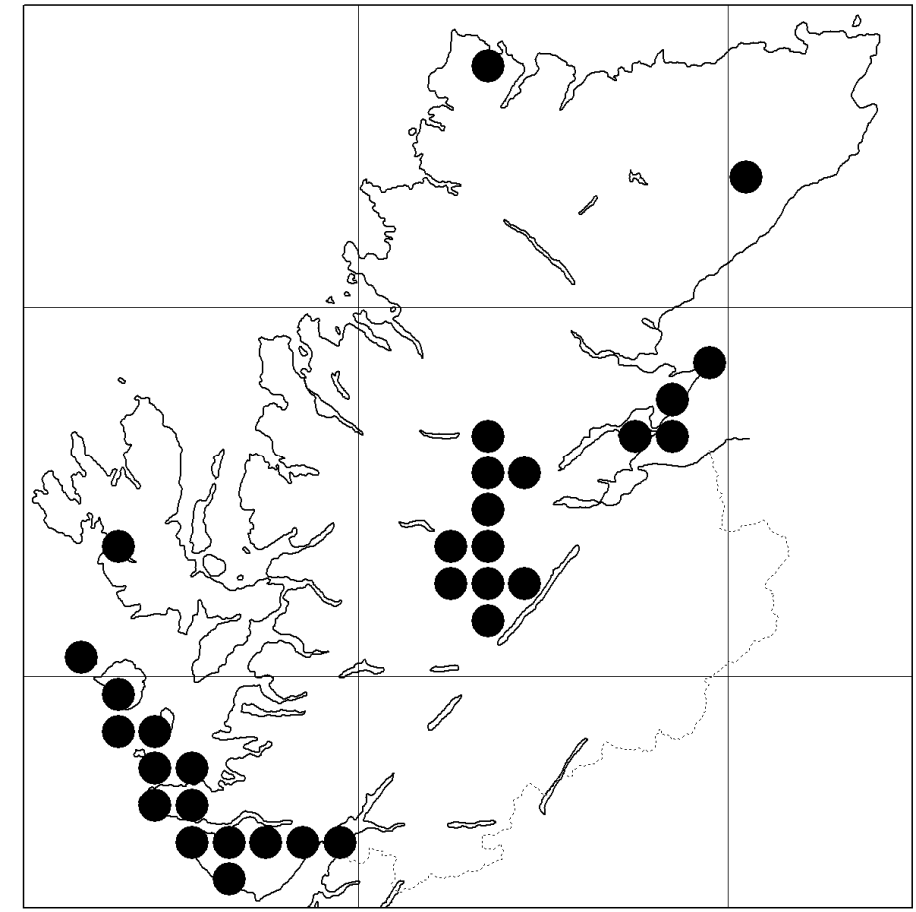


Plate 12. Thorax of Lasius flavus *showing the long hairs above (compare* L. mixtus *Plate 13). © April Nobile, www.antweb.org.*

Lasius niger Small Black Ant

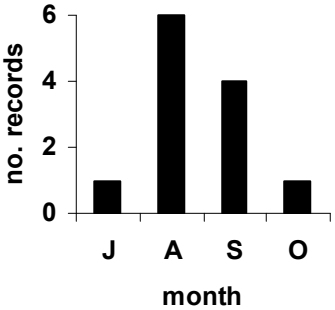
Lasius niger (Linnaeus, 1758). BRC no. 6013. NHMSYS0000873237.

Recognition: Workers can be confused with those of the abundant *Formica lemani*, which is usually larger and more intensely black (*L. niger* is dark brown). With a lens, the long erect hairs on top of the thorax of *Lasius* contrast with the very short hairs of *F. lemani*. *L. niger* must also be separated from *L. platythorax*, which has less hair on the flatter clypeus (Orledge, 2005). The possibility of *L. alienus* or *L. psammophilus* should also be considered, the former known from W Argyll just south of our area and the latter from SW Scotland. These both lack erect hairs on the scape and legs. Queens resemble winged workers, and males are winged and black.

Habitat: This ant is most numerous where the soil is fine and well-drained. Altitude range 0-181m.

Nest: Usually nests are established in fine dry soil with a small soil mound visible, but they may be under stones or in moss with no visible mound, or sometimes in mounds rivalling those of *L. flavus* in size.

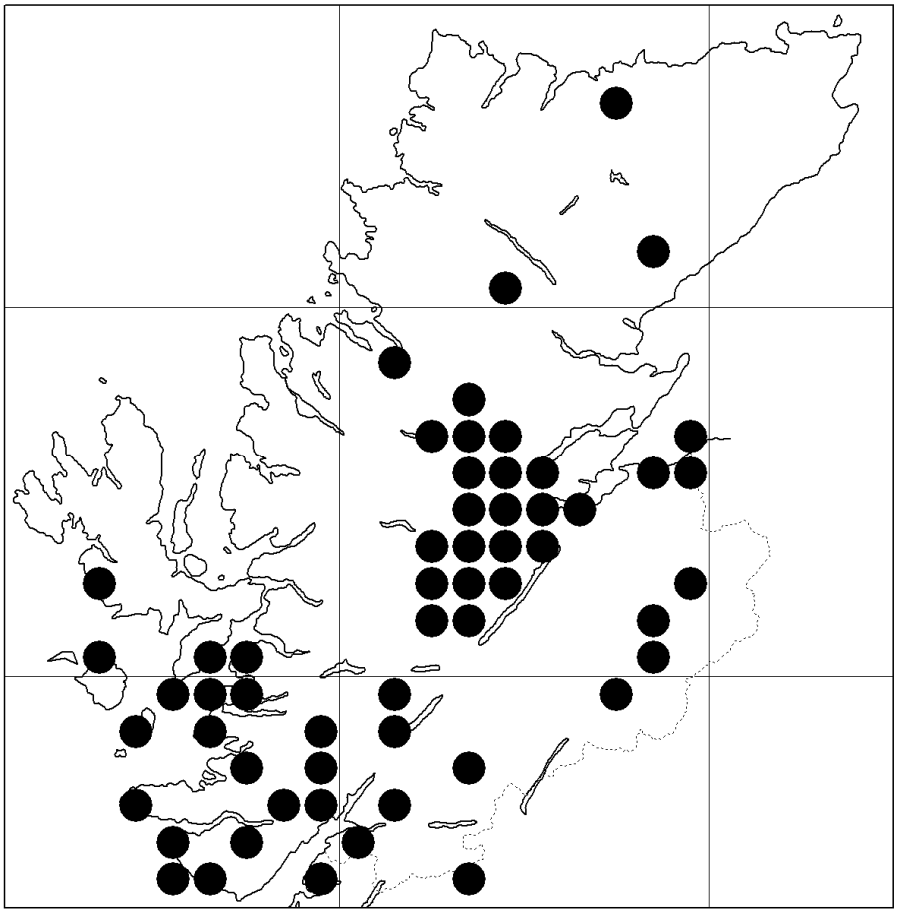
Alates: July to October (12 records).



Distribution and abundance: The distribution resembles generally that of *L. flavus*, but extending to the SE of the Great Glen. It is especially numerous to the NW of the Great Glen, in Lochaber and to the SW of Inverness, and much scarcer elsewhere in our area. It occurs throughout the UK, except the Western Isles, Orkney and Shetland.

Comments: This was recently (Seifert, 1991) separated from the rare *L. platythorax* (p. 38). If expert opinion is not available the *niger/platythorax* pair should be recorded as *L. niger* s.l. As with *Myrmica*, the names used in the past reflect the difficulty of classifying *Lasius* species - varietal names *alieno-niger* and *mixto-umbratus* tell the story clearly.

References: Wormell (2006).



Lasius platythorax A black ant

Lasius platythorax (Seifert, 1991). BRC no. 6010. NBNSYS0100003683.

Recognition: The long erect hairs on the top of the prothorax place this black ant in *Lasius* and prevent confusion with black *Formica.* It was separated from the much commoner and more widespread *L. niger* only in 1991 (Seifert, 1991), so earlier records will have been listed under *L. niger*. It is readily identified by the flat profile of the clypeus (conspicuously arched in *L. niger*), and the lack of fine pubescence on the clypeus. These characters can be used in the field with a lens and a little experience (Orledge, 2005).

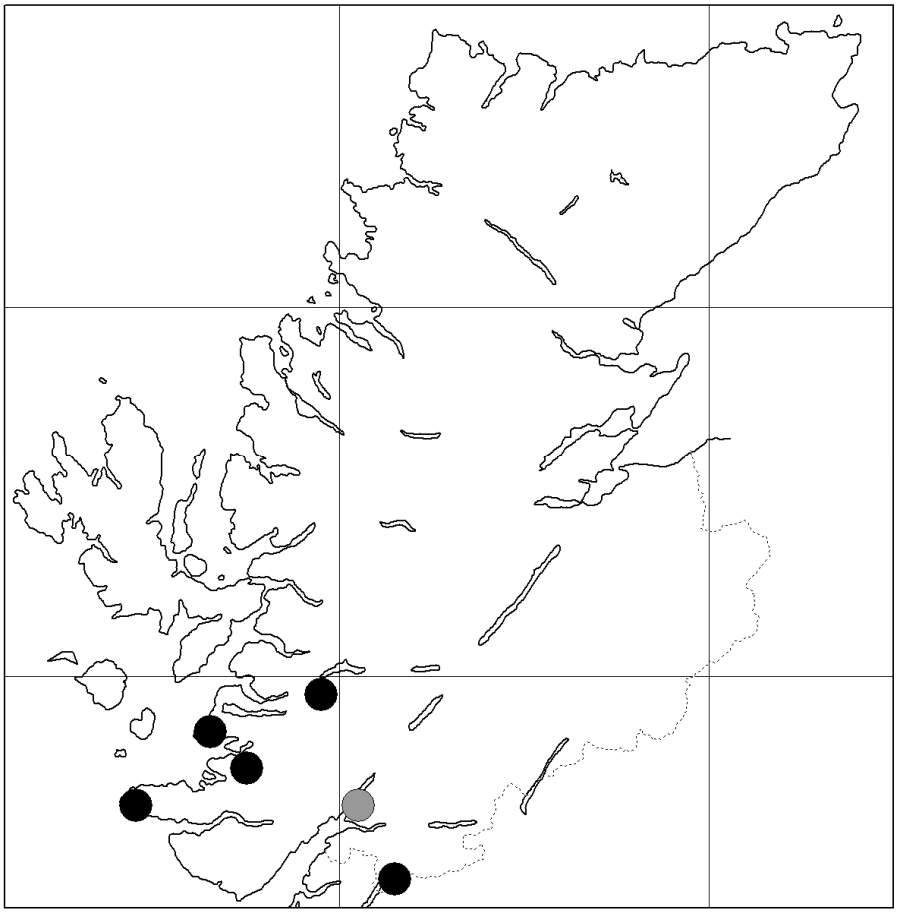
Habitat: It is found in the same situations as the other Highland *Lasius*, and often found in close proximity to them. In England it is particularly associated with dead wood for nesting in contrast to *L. niger* which occurs in drier soil, but that distinction is not evident so far in Highland. Altitude range 20-90m.

Nest: Nests are similar to those of *L. niger.*

Alates: No information.

Distribution and abundance: In Highland it is found only in the far west, where it is always scarcer than *L. niger*. This may reflect a requirement for higher humidity. It is known elsewhere in Scotland only from Tentsmuir in Fife (John Pontin, pers. comm.), but is probably generally under-recorded. In the rest of the UK, it occurs over much of England, Wales and N Ireland, and is not uncommon in the south.

Comments: One old record based on specimens from 1947 in the National Museum of Scotland (grey in the map) is included for this very scarce ant. In Highland it is clearly an insect of the west. Many tens of nests of black *Lasius* in the rest of the region have been examined and all have proved to be *L. niger*. All black *Lasius* of this pair should be regarded as *L. niger* sensu lato unless examined by a specialist.



Lasius mixtus A yellow ant

Lasius mixtus (Nylander, 1846). BRC no. 6007. NHMSYS0000876227.

Recognition: This is a yellow ant very similar to the much commoner *Lasius flavus*. It may be recognised by the absence of long erect hairs on the top of the thorax.

Habitat: It shares the same habitat as its hosts, the other *Lasius* ants. Altitude range: 50m.

Nest: This species is not a mound-builder, but it may be found in mounds of its hosts (see below).

Alates: No information.

Distribution and abundance: Only one recent nest is known in Highland, found in Glen Moriston in 2009. It is likely to be overlooked, but must be very scarce in the area. It is scarce in the south of Scotland, and widely distributed in England and Wales.

Comments: Two old records, grey in the map, from Collingwood (1961, and *in litt.* 2007) are included. This ant is a temporary social parasite of our other *Lasius* species, and mixed nests can be found. Any nests with both black and yellow workers should be checked carefully, though *L. flavus* and *L. niger* may be found in close proximity - sometimes even sharing a stone or nest mound though remaining as separate colonies. Collingwood (1957) used the name *L. umbratus* for *L. mixtus*, but true *umbratus* is not known from Highland and is very rare even in Scotland.

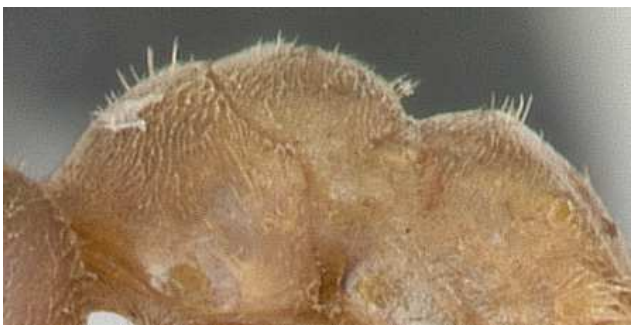


Plate 13. Thorax of Lasius mixtus *showing the short hairs above (compare* L. flavus *Plate 12). © April Nobile, www.antweb.org.*

Formica aquilonia Scottish Wood-ant

Formica aquilonia Yarrow, 1955. BRC no. 5901. NHMSYS0000875949. Former UKBAP priority species (removed 2007); IUCN Red List: Lower risk - near threatened.

Recognition: The two wood-ants are very similar, and have often been confused. Workers are on average noticeably smaller than those of *F. lugubris* - some as small as *Myrmica* workers. *F. lugubris* almost always has some conspicuously large and robust workers, though in both species they vary substantially in size in a single nest. Workers can, after practice, be recognised in the field with a x15 lens, the best character for *F. aquilonia* being the relatively few hairs on the mesothorax, propodeum and petiole scale (Fig. 7). Males are black.

Habitat: It lives in forest and on forest edge, both coniferous and deciduous. In the west, it occurs in old birch woodland. It will build in more shaded places than *F. lugubris*, but this is not a constant feature, and nests of the two species may be found close together in the same situations. Altitude range 10-360m.

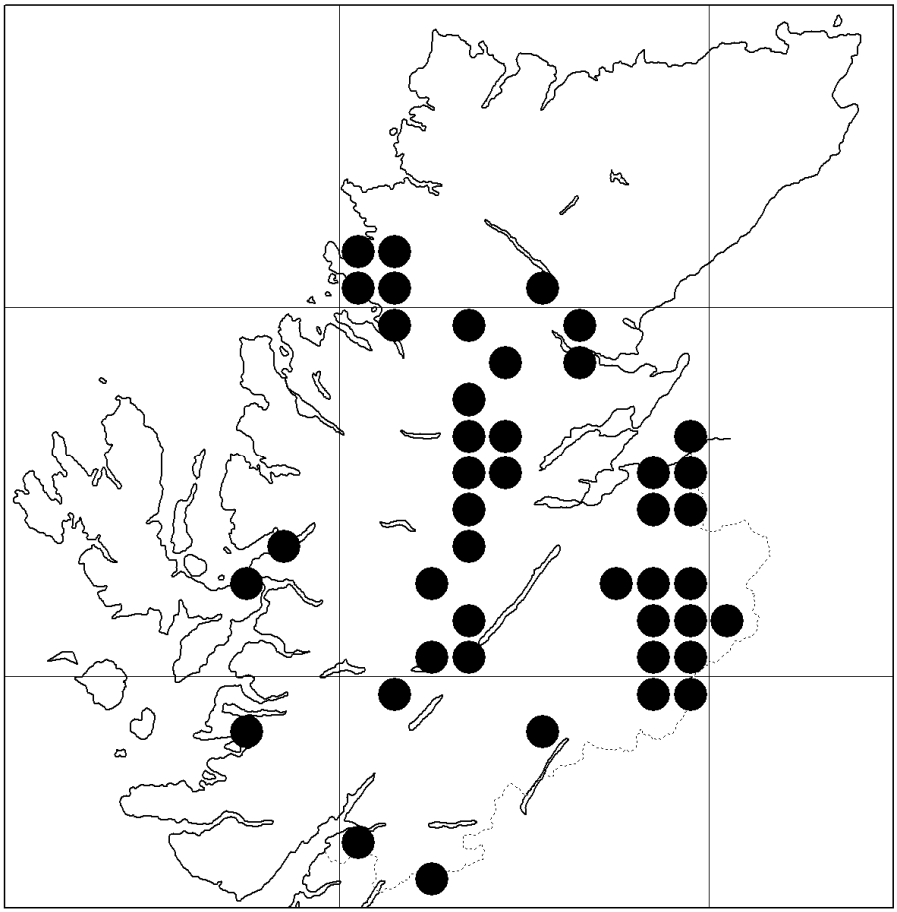
Nest: All the wood-ants build a thatched mound, in this species often more than 1m high and 2m diameter, though nests are frequently much smaller. At Mudalach in S Skye some nests are huge - 2m high and 4m base diameter. Differences are claimed between this and *F. lugubris*, but these are neither constant nor reliable for identification. The thatch is composed of whatever materials are available, normally conifer needles, twigs, dry buds and catkins, and (in pine forest) resin beads. In western birch woodland, nests have been found in and under fallen branches, no soil or thatch being visible.

Alates: May-June (2 records).

Distribution and abundance: The Scottish Wood-ant occurs throughout Highland to S Sutherland. It is usually less common than *F. lugubris* except in the west. In the UK it is found only in Scotland S to Argyll, except for an isolated population in Antrim.

Comments: Ever since Yarrow (1955) clarified the complex taxonomic and nomenclatural position of the *F. rufa* group of wood-ants, problems defining the best characters to separate the species have continued, and they are frequently misidentified even by experienced entomologists. Donisthorpe (1927a) records *F. rufa* and *F. pratensis* from Highland, but that pre-dates the current understanding of species limits. Neither has been found in Scotland.

The wood-ants, with their large size and conspicuous nests, would be expected to be well documented. However, despite national surveys (Hughes, 1997a; Phillips, 2000; Hughes, 2006), many new sites were found for both species during the atlas fieldwork. It is certain that more sites remain to be discovered.



References: Skidmore (1979), Owen (1986).

Formica lugubris Northern Wood-ant

Formica lugubris Zetterstedt, 1838. BRC no. 5906. NHMSYS0000875958. Former UKBAP species statement (removed 2007); IUCN Red List: Lower risk - near threatened.

Recognition: Confusion has been, and continues to be, common between this species and *Formica aquilonia*. *F. lugubris* workers can, with experience, be recognised in the field with a lens from the abundant long hairs on the thorax, propodeum and petiole scale (Fig. 7). They are darker than *aquilonia* on average. The largest workers are noticeably more robust than, and the smallest rarely as small as, those of *aquilonia*. Males are black and winged.

Habitat: *F. lugubris* is found in open areas in both coniferous and deciduous forests and woodland. It is less tolerant of shade than *F. aquilonia*, but this is not constant, and nests of the two species may be found close together in the same situations. Typically, nests are found strung along track edges and fence-lines on the edge of forest blocks, or scattered in open woodland or clearings. Just outside our area at Findhorn (NJ06) it occurs in coastal heath with scattered trees. Altitude range: 10-400m.

Nest: The thatched mounds are usually smaller than those of *aquilonia*, but the differences are neither constant nor reliable for identification. The thatch is composed of whatever is available, normally conifer needles, twigs, dry buds and catkins, and (in pine forest) resin beads. Some nests close to roadsides may be thatched entirely with small gravel particles. Apparently unmounded nests in soil or rotting wood have been suspected in Strathspey. New mounds are often formed by budding, while establishment of new nests by temporary social parasitism on *F. lemani* appears to be rare.

Alates: April to October, mostly June to August (11 records).

Distribution and abundance: While most abundant in the east of our area, it is the only wood-ant recorded in Ardnamurchan, and recently unsuspected sites were found in Skye (2012) and Lochalsh (2010). In the east, it is usually more frequent than *aquilonia*, though in some places it seems to be absent where *aquilonia* is abundant. In Scotland it is found south to Perthshire and Argyll (where its apparent scarcity may be the result of misidentification). It extends through N England and N Wales.

Comments: The resin beads that appear in wood-ant nests in conifer forests have been shown in the related *F. paralugubris* to give protection to adults against bacterial and to larvae against fungal infection (Chapuisat *et al*., 2007*).*

Plate 14. Formica lugubris *worker with a Goat Moth* Cossus cossus *larva. © Jane Bowman.*

Formica exsecta Narrow-headed Ant

Formica exsecta Nylander, 1846. BRC no. 5903. NHMSYS0000875953. UKBAP priority species, Scottish Biodiversity List, IUCN Endangered..

Recognition: Sharing the red-and-black coloration of the true wood-ants (*F. aquilonia* and *F. lugubris*), this species is smaller, brighter, more slender, and instantly recognisable by the heart-shaped head (Plate 15) and notched petiole scale. Queens are winged, with the same characters as workers. Males are winged and black, with the top of the head concave.

Habitat: This ant requires clearings and forest edges (including road verges) open to the sun. Altitude range 200-350m.

Nest: Like the true wood-ants, this species builds a thatched mound. Normally the mound is flatter and composed of finer materials (grass fragments) than nests of *F. aquilonia* or *F. lugubris*, but some nests of the latter can be similar. Founding is by temporary social parasitism, queens entering nests of *F. fusca* or *F. lemani*.

Alates: No information.

Distribution and abundance: This very scarce ant is confined in Highland to Strathspey around Carrbridge, Abernethy and Glen More, where they can be locally quite common. Elsewhere in Scotland there are small populations at Rannoch and Mar. The only others in the UK are in a small, threatened and highly disjunct population in Devon which has declined markedly in recent decades. It was reliably recorded at Amat (E Ross, NH49, grey on the map) in 1954, but the site was searched in 1996 and none was found (Hughes, 1997b).

Comments: A record from Glen Affric is frequently cited, but the report was never claimed as a positive identification, and there is no evidence that *Formica exsecta* has ever occurred there. The quote from Weatherill (1939) is: 'I saw what had every appearance of being a *Formica exsecta,* Nyl., nest. The colony was at the side of a dangerous bridge, and the opportunity to examine the ants was not good. Besides this, I had not seen the species before. From looking at specimens in the Museum since, I think it probable that this was *exsecta*.' The English population was once widely spread across the south from the New Forest to Cornwall, but is now restricted to a single site in Devon.

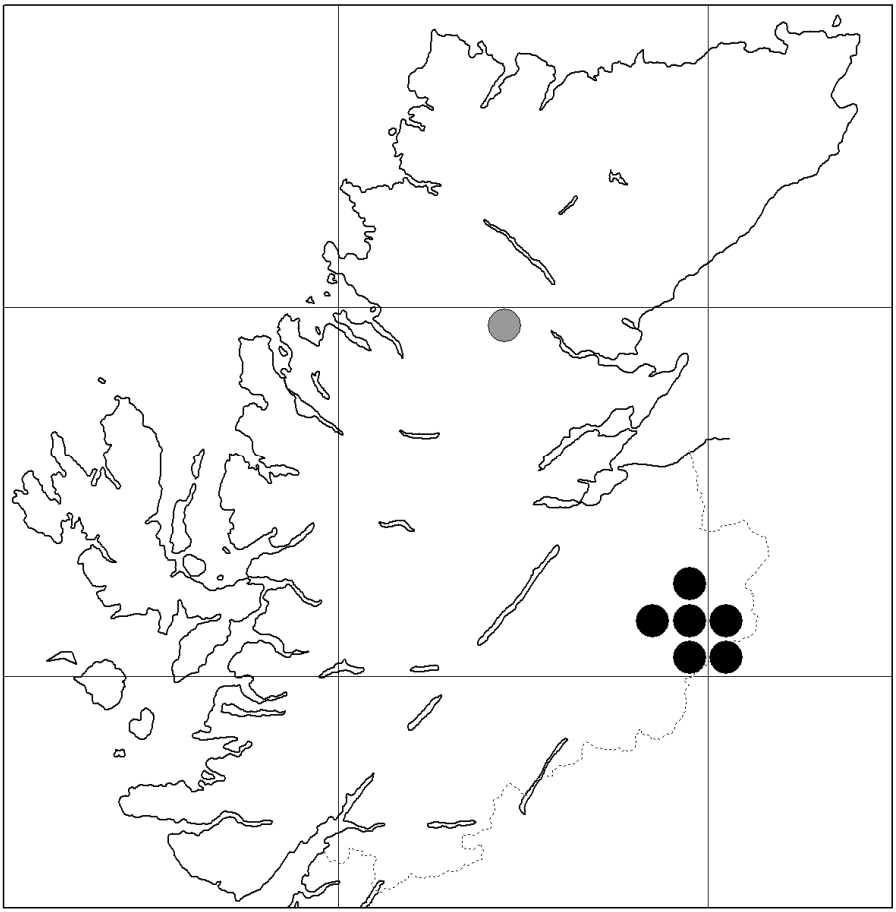


Plate 15. Head of Formica exsecta *showing the diagnostic notched head). © Noel Tawatao, www.antweb.org.*

Formica sanguinea Slaver Ant, Blood-red Ant

Formica sanguinea Latreille, 1798. BRC no. 5910. NHMSYS0000875966. RDB Nationally Notable B.

Recognition: This large red-and-black ant is very similar to the wood-ants, but does not build thatched mounds. It is easily distinguished from wood-ants by the notch in the clypeus (Plate 16), a feature that may be seen in the field with a lens. Workers at the nest can be frenetically active, running rapidly over the surface of the ground. They are very aggressive, biting strongly when irritated rather than spraying acid as the wood-ants do. Queens are winged, with the same characters as workers. Males are winged, black, with a notched clypeus.

Habitat: All sites seen have been on open sunny woodland edges, but in a variety of situations from mixed woodland to cleared plantation to grassy banks. The densest and most extensive populations are found in south-facing clear-fell on slopes. Altitude range 60-258m.

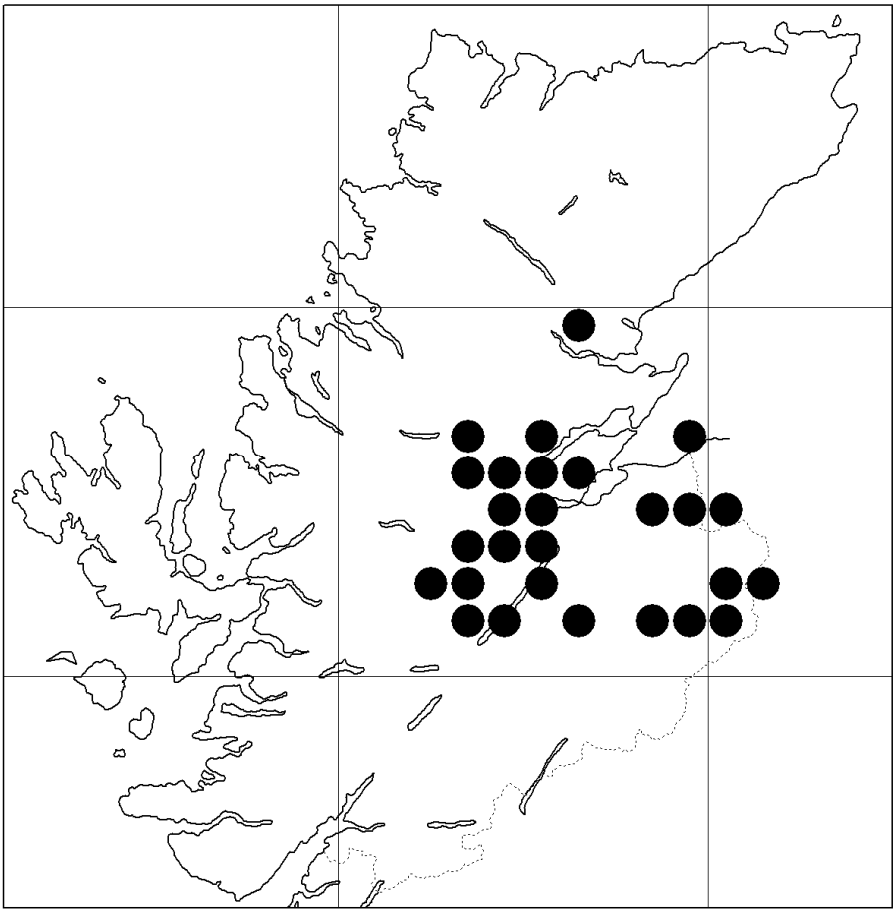
Nest: This ant is one of our most thermophilic (heat-loving) species (Seifert, 2007), and nests are always in situations open to the sun. Typically, nests are established at the base of a tree-stump or by fallen wood, and although they are never mounded, their position can be revealed by accumulated wood debris.

Alates: July (2 records).

Distribution and abundance: Slaver Ants are present widely in the east of the area, from Strathspey to SE Sutherland (Macdonald, 2009). They can be extremely abundant locally. The species has a disjunct distribution in UK, in N Scotland and in the southern half of England.

Comments: At first glance this ant can be taken for a wood-ant *F. aquilonia* or *F. lugubris*, even by the experienced. Any 'wood-ant' found where nest mounds are not evident should be given extra attention. Some workers can be very small, the size of the *F. lemani* slaves.

Slaver Ants are very effective colonisers of cleared forest. Strong populations can build up within a few years. Three sites in mid Ross, one with an astonishingly large and dense population of Slavers, were felled only seven years before the ants were found (Colin Leslie pers. comm.). Nests can quickly become extinct once regeneration on cleared sites cuts off the sunshine. They seem to have a strategy designed to make effective use of temporary habitats, with an ability to disperse and colonise new areas once conditions become unsuitable.



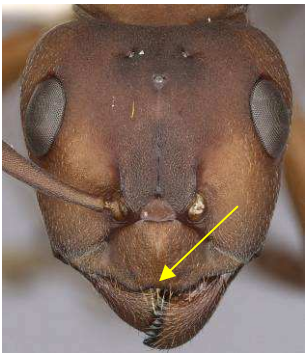


Plate 16. Head of Formica sanguinea *showing the diagnostic notched clypeus (arrowed). © Will Ericson, www.antweb.org.*

Formica fusca a black ant

Formica fusca Linnaeus, 1758. BRC no. 5904. NHMSYS0000875954. Scottish Biodiversity List.

Recognition: This scarce ant is very similar to the abundant *Formica lemani*, but workers have no more than 3 very short erect hairs on the top of the thorax (Plate 17), and no long hairs below the mid femur (Godden and Cosens, 1987). It is essential that specimens are taken if this species is suspected, to eliminate the possibility of abraded *lemani*. At least 5 workers should be examined with a stereo microscope. If all lack the hairs described, they can confidently be referred to *fusca* but if any have these hairs they will be *lemani*. Queens have the same features as workers, while males are like those of *F. lemani* but with a few short hairs on the petiole.

Habitat: This ant occurs in the same general habitat as its close relative *F. lemani*. Altitude range 20-70m.

Nest: Nests have been found under stones and in close proximity to those of *F. lemani*.

Alates: No information.

Distribution and abundance: A rare ant in Scotland, it is confined in Highland - as far as is known - to the west. It may turn up elsewhere as it is recorded from Argyll and Deeside. It is the commoner of the two in England, but largely replaced by *F. lemani* in Scotland. It has not been found in N Ireland.

Comments: Six hectads (grey in the map) show pre-1980 records of this rare species.

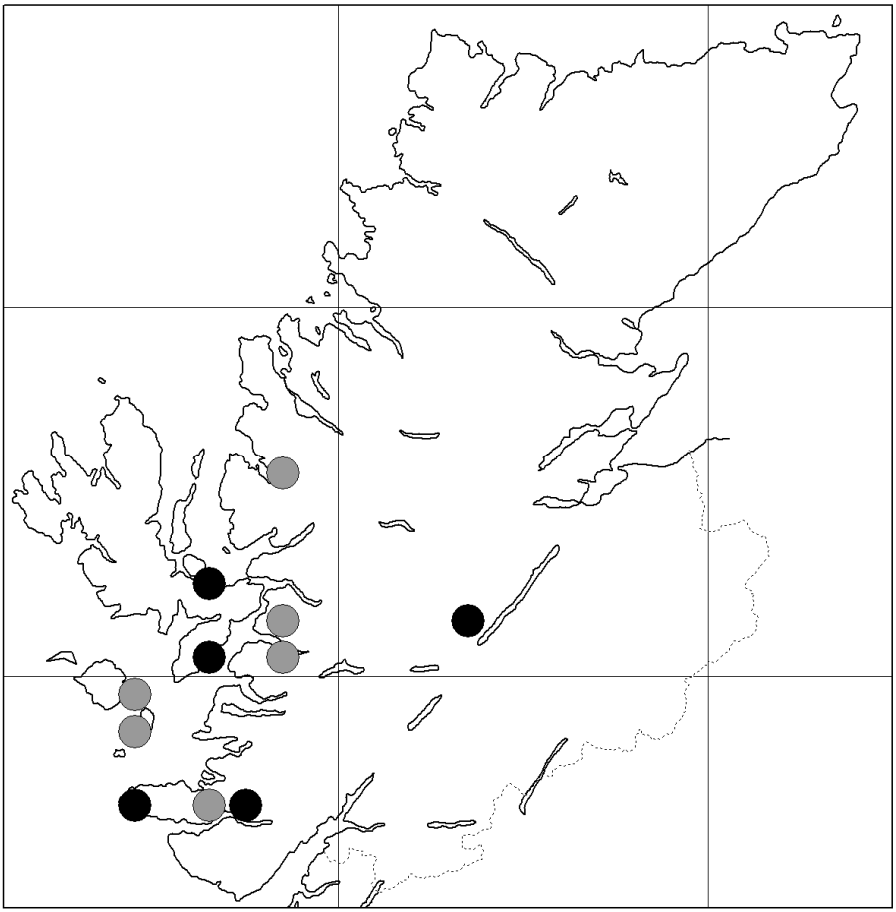


Plate 17. Thorax of Formica fusca *showing the lack of short hairs (compare Plate 18). © April Nobile, www.antweb.org.*

Formica lemani A black ant

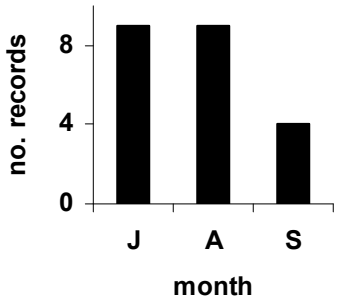
Formica lemani Bondroit, 1917. BRC no. 5905. NHMSYS0000875957.

Recognition: Workers are shining black with grey reflections on the gaster, and very short erect hairs on top of the thorax (Plate 18), and a long hair near the base of the middle femur. The black *Lasius* are more matt, often obviously brownish, and with long erect hairs on top of the thorax. The possibility of *F. fusca* should always be considered, especially in the west (see p. 50). Queens have the same features as workers. Males are black, with long hairs on the petiole.

Habitat: This very common ant may be found almost anywhere that is warm and not too wet. Altitude range 0-575m.

Nest: Nests may be established under stones, dead wood, moss or metal sheets; or in open soil, sand or peat.

Alates: July to September (22 records).



Distribution and abundance: It is present throughout the area and is generally abundant, though it appears to be less able than *Myrmica ruginodis* to do well in N Skye and the far north of the mainland. It is found throughout the UK, except the Western Isles (one record, 1992), Orkney and Shetland, but in the south of England it is generally less common than *F. fusca*.

Comments: This is one of our two commonest and most widespread ants (the other being *Myrmica ruginodis*), more or less ubiquitous in our area (noted in 75% of hectads with records), and found in a great variety of habitats. It is the host of the Slaver Ant *F. sanguinea*. This ant was only separated from *F. fusca* in 1954 (Yarrow, 1954), so records of '*F. fusca*' before that date must be checked.

References: Wormell (2006).

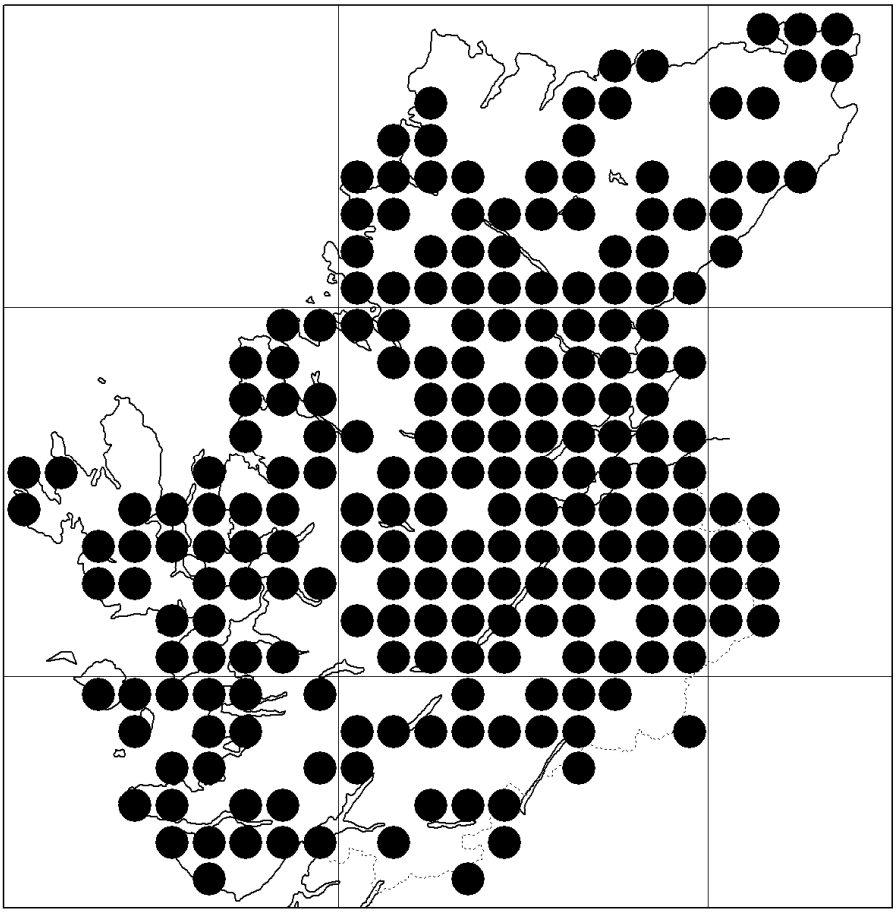


Plate 18. Thorax of Formica lemani *showing the typically numerous short hairs (compare Plate 17). © Erin Prado, www.antweb.org.*

Tetramorium caespitum Turf Ant

Tetramorium caespitum (Linnaeus, 1758). BRC no. 4901. NHMSYS0000876751.

Recognition: This is a black ant resembling a tiny dark *Myrmica*. It is distinguished by the very short spines on the back of the thorax, and raised ridges on the sides of the clypeus.

Distribution and abundance: A male was recorded at Scourie NC14 in July 1949 (Collingwood, 1961), and a nest was reported by Haddow (1939) on Canna NG20 in 1936. A rare ant in Scotland, it occurs mainly on the E Lothian coast and in Edinburgh on the slopes of Arthur's Seat, with one record from Colonsay. Elsewhere in the UK it is largely coastal in S England and Wales. No map.

Comments: Collingwood suggested that it might be adventive in Highland, but it may yet exist on the west coast or islands where survey has not been intense. It should be sought under stones on dry sunny slopes, especially at the base of rocks.

Lasius fuliginosus Jet-black Ant

Lasius fuliginosus (Latreille, 1798). BRC no. 6005. NHMSYS0000876224.

Recognition: This very shiny black ant might be confused with *Formica lemani* or *F. fusca* at a casual glance, but is distinguished from all British ants except the very different *F. exsecta* by its strongly notched head.

Distribution and abundance: This is an extremely rare ant in Scotland, with one Highland record from Glen Feshie (around NN88 or NN89) in 1933 and one from the Borders in 1922. Doubt has been expressed about the Highland record in the absence of supporting evidence, but it is distinctive and the report came from an experienced entomologist (Haines, 1936). It is not uncommon in S England, becoming rarer northwards, and it is known in Ireland (Co. Galway).

Comments: The life cycle is complex, as it is a temporary social parasite on *L. umbratus* or *L. mixtus*, which themselves are temporary social parasites on other *Lasius* ants. *L. fuliginosus* is unique amongst European ants in that it nests in hollow trees in a 'carton' made of wood dust, honeydew derived from aphids, and a fungus *Cladosporium myrmecophilum* only found in association with this ant (Tyler, 2008). With that amazing range of symbiotic relations, it is a real regret that it is not one of our current Highland residents. If it should still survive here, the shiny cuticle and notched head will make it instantly recognisable.

Ant anatomy

Plate 19. Profile of Myrmica ruginodis *illustrating basic anatomy. © www.antweb.org.*

Explanation of terms (numbers in brackets refer to Plate 19 above)

Abdomen:	The rear section of the insect body, behind the legs and wings. In ants the obvious 'abdomen' is properly the *gaster* (see below).
Antennae:	The 'feelers'. The first segment is the *scape* (see below).
Clypeus:	The lower part of the face, below the antennae and above the mouthparts (Plate 16).
Femur (6):	One of the major segments of the insect leg, above the tarsus and tibia.
Gaster (5):	The correct name for the rear part of the ant body, casually called the '*abdomen*'.
Pedicel:	The 'waist' of ants, in front of the gaster. In *Lasius* and *Formica* consists of the leaf-like petiole. In other Highland genera comprises the *petiole* and *postpetiole*.
Petiole (3):	The leaf-like segment in front of the gaster in *Lasius* and *Formica*, or the forward of the two 'waist' segments in other genera.
Postpetiole (4):	The hinder of the two 'waist' segments in *Myrmica* and related genera.
Pronotum (1):	The first segment of the thorax, just behind the head.
Propodeum (2):	The part of the body immediately in front of the 'waist'. In Myrmicines it carries two spines.
Scape:	The long, angled segment at the base of the antennae, important in separating *Myrmica* species (Fig. 5).
Spiracle:	A small opening in the exoskeleton allowing gas exchange (breathing). The position of the spiracle on the propodeum differs in *Lasius* and *Formica* (Plate 20).
Thorax:	The middle part of the insect body, carrying the wings and legs. In ants the section between head and waist is properly the alitrunk, as it includes part of the abdomen.

Identification of ants

General

Although it is possible to identify ants to genus in the field after a little training, to do so to species level requires experience and a lens. To begin with, and always with some species, identification will involve taking specimens for examination with a microscope. It is preferable that *Formica lemani*/*fusca* and *F. aquilonia*/*lugubris* specimens should be collected into alcohol to preserve them against abrasion that might remove hairs.

Beginners' keys to workers of the Highland species follow, but all identifications should be checked against a technical key until experience is acquired. Workers never have wings. Males of all except *Formicoxenus nitidulus* are winged. Queens are generally like large workers with a much more bulky thorax to hold the flight muscles, winged when freshly emerged, but the wings are lost after mating. The wing bases of queens can be seen with a lens even when the wings are missing.

Antennae of Myrmica *workers*

The separation of the *Myrmica* workers requires examination of the scape (the long basal segment) of the antennae. Two views of the scape are required (Fig. 5), and the antenna can be rotated to provide the correct aspect. The first view is from the front, so that the shape of the bend can be seen clearly. Depending on the species, the bend will appear as a gentle curve, an abrupt curve, or a sharp bend with a clear angle. The second view looks at the top of the bend, in the plane of the bend of the scape, when any lobes will be apparent.

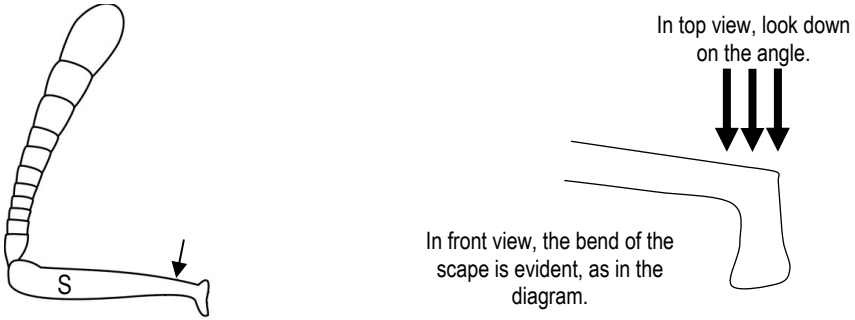


Figure 5. Examining the antennae of Myrmica *workers. The scape is labelled S, and the position of the angle is arrowed. Use front view first. That will recognise* lobicornis*,* sulcinodis*,* rubra/ruginodis*, and* scabrinodis/sabuleti*. Then* scabrinodis *and* sabuleti *can be distinguished on top view. Antennal diagram © Eli Sarnat, http://antkey.org.*

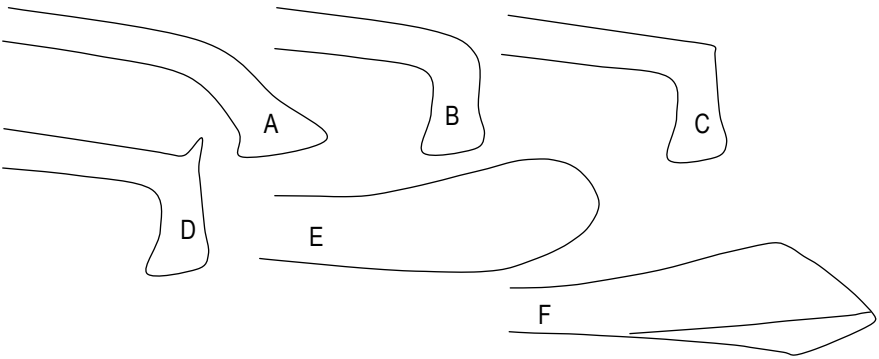


Figure 6. Myrmica *scapes. A*- Myrmica ruginodis *(*M. rubra *is similar), obtuse curve; B* - M. sulcinodis*, right-angled curve; C* - M. scabrinodis *(*M. sabuleti *is similar), sharp bend; D* - M. lobicornis *(vertical lobe); E* - M. scabrinodis*; F* - M. sabuleti, M. lonae*. A to D are as viewed from the front, E and F from the top.*

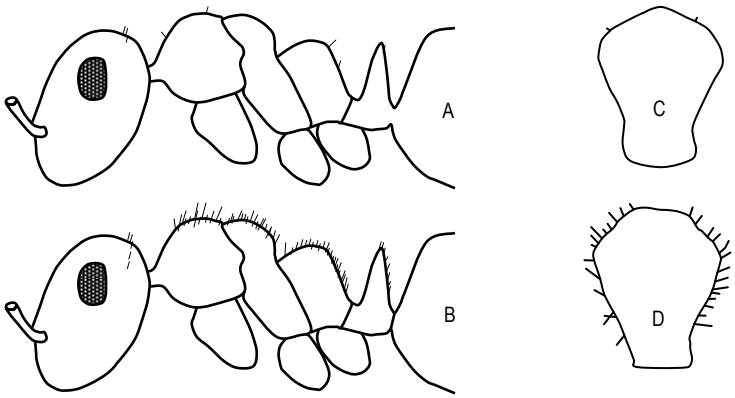


Figure 7. Formica aquilonia *(A, C), and* F. lugubris *(B, D). A, B - side view showing typical distribution and numbers of hairs on the top of the head and thorax. C, D - petioles showing typical distribution and numbers of hairs.* F. aquilonia *usually shows 0-3 (-7) hairs above the widest part.* F. lugubris *usually shows >7 (0-20). The difference in shape is not significant. Some worn* F. lugubris *can appear similar to* F. aquilonia*. Identification of the latter should never be made from a single individual. At least 5 workers from each nest should be examined.*

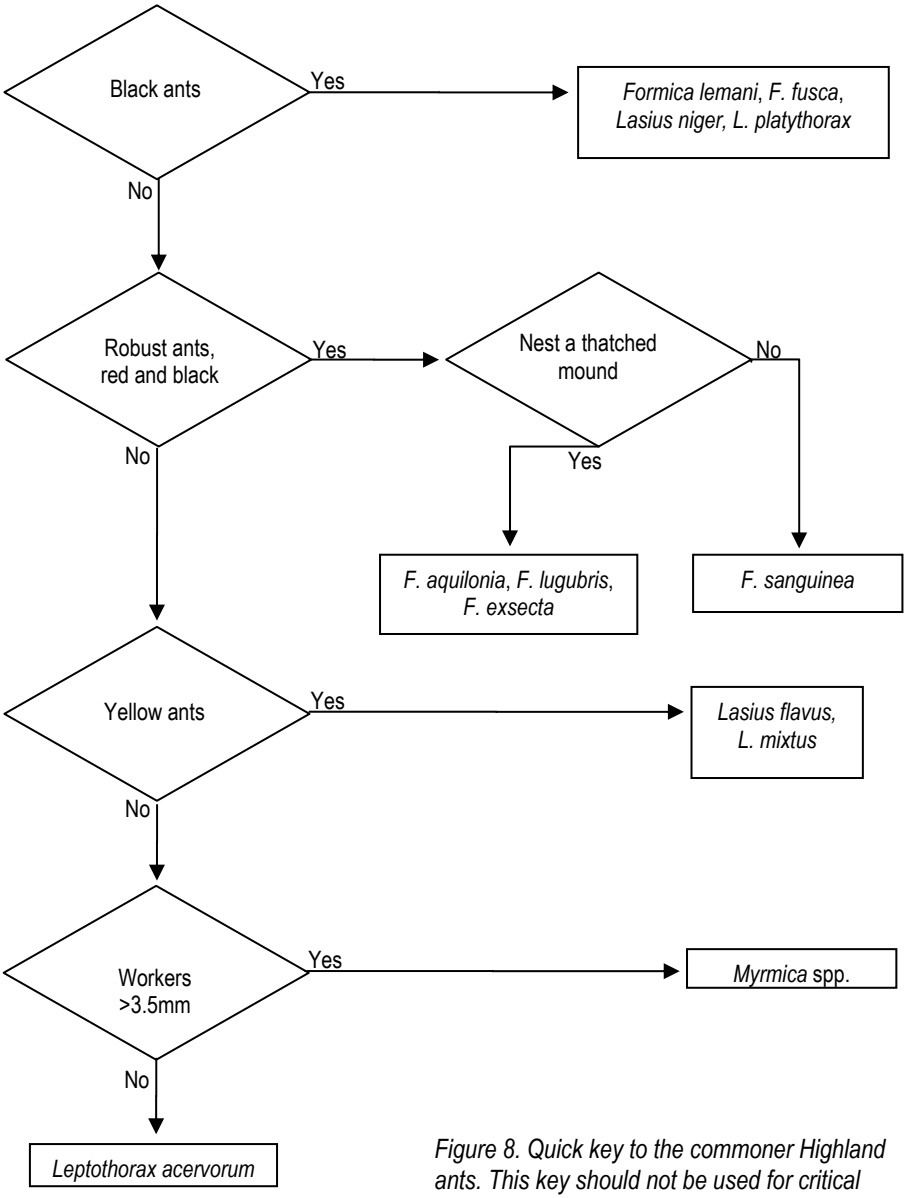


Figure 8. Quick key to the commoner Highland ants. This key should not be used for critical work, but will assist learning and give a preliminary identification.

Some hints on field recognition

When getting to know the local ants, the quick key (Fig. 8), the notes which follow, and the starter-key on p. 60 should help.

- *Lasius niger* often appears black, but on closer inspection will be seen to be dark brown. It is usually smaller than *Formica lemani*.

- *Lasius flavus* is readily recognised by its colour, but occasionally *Myrmica* workers may appear yellow. The waist (1 segment in *Lasius*, 2 in *Myrmica*) easily removes any doubt. The rare *L. mixtus* (also yellow) is found in our area.

- *Formica lemani* usually appears very black, with greyish bands across the abdomen. A lens will show the long hairs on top of the thorax of black *Lasius*, separating them from black *Formica* which have at best very short and inconspicuous hairs.

- *F. aquilonia* and *F. lugubris* are usually noticed by virtue of their large thatched nests. *F. lugubris* colonies include some workers larger and more robust than those of *aquilonia*.

- Any apparent wood-ants found away from nest mounds should always be checked for *F. sanguinea*.

- The various *Myrmica* species come in various shades of reddish, sometimes pale (almost yellow) and sometimes dark (almost black, especially in *M. lobicornis)*. They are difficult to determine easily in the field, but with a lens they may be assorted on antennal characters as *ruginodis*/*rubra*, *sabuleti*/*scabrinodis*, *sulcinodis*, and *lobicornis*. The rare *M. lonae* might be confused with *sabuleti* or *lobicornis*. Firm identification should only be done with a microscope.

- *Leptothorax acervorum* is usually readily recognised by its small size, slender build, and red/black/red colour scheme, but on *Formica* mounds be aware of the possibility of *Formicoxenus nitidulus*, and there are old records of the black *Tetramorium caespitum* from the west coast.

Keys to the Highland species

These keys will help to put a name to the workers of Highland ants. It is not for use outside Highland, where other species occur. Queens and males are not considered. A 15x lens or (for some species) a microscope is essential for critical identification. Definitions are given on p. 55. For critical identification use Bolton and Collingwood (1975) or Skinner and Allen (1996), though both of these omit some recently recognised species. An update to the Bolton and Collingwood handbook is in preparation.

Key A: Is it a worker ant, and which group is it in?

1a	Wings or wing-base scars present.	Definitely not a worker ant, though may be a male or queen.
1b	Wingless	2
2a	Lacking distinctively shaped segments between thorax and abdomen.	Not an ant.
2b	One or two distinctively shaped segments between thorax and abdomen.	Probably a worker ant. 3
3a	Waist comprising a single leaf-shaped segment.	*Formica* or *Lasius*, ***Key B***
3b	Waist comprising two bead-like segments.	Other genera, ***Key C***

Key B: Worker ants with a waist comprising a single leaf-shaped segment.

1a	Body yellow (yellowish *Myrmica* have two waist segments).	2
1b	Body not yellow.	3
2a	Long erect hairs on top of thorax.	***Lasius flavus***
2b	No long erect hairs on top of thorax.	***L. mixtus***
3a	Body black or dark brown, no extensive red markings.	4
3b	Body extensively reddish on head and/or thorax.	6
4a	Body dark brown. [Spiracle on rear of propodeum, Plate 20 A.]	***Lasius niger, L. platythorax*** [1]
4b	Body black, somewhat shining; reddish brown on legs. [Spiracle on side of propodeum, Plate 20 B.]	5
5a	Numerous very short hairs on pronotum (Plate 18), long hairs under mid femur. Abundant.	***Formica lemani***
5b	0-2 hairs on pronotum (Plate 17), no long hairs under mid femur. (Beware worn *F. lemani* - examine >=5 workers.) Rare.	***F. fusca***
6a	Head behind eyes notched and obviously concave. Petiole scale notched above.	***F. exsecta***
6b	Head behind eyes convex.	7
7a	Clypeus notched (Plate 16).	***F. sanguinea***
7b	Clypeus not notched.	8

8a	Petiole leaf and thorax above with many long hairs (view with lens from side against the light; Fig. 7).	***F. lugubris***
8b	Petiole leaf and thorax with few if any hairs (Fig. 7). (Beware of worn *F. lugubris* - examine at least 5 workers.)	***F. aquilonia***

Key C: Worker ants with a waist of two bead-like segments.

1a	Spines on propodeum long and pointed (Plate 7), larger species (≥4mm head + body).	2
1b	Spines on propodeum short and rather blunt (Plate 10), smaller species (<4mm).	8
2a	Bend of antennal scape with a vertical semi-circular lobe (Plate 5, Fig. 6).	***Myrmica lobicornis***
2b	Antennae otherwise.	3
3a	Bend of scape seen from front curved into a strongly obtuse angle.	4
3b	Antennae otherwise.	5
4a	Spines of propodeum as long as the distance between their tips (Plate 7).	***M. ruginodis***
4b	Spines of propodeum shorter than the distance between their tips (Plate 6).	***M. rubra***
5a	Bend of scape seen from front *curved*, forming a near right-angle. Sides of petiole heavily sculptured with lengthwise folds.	***M. sulcinodis***
5b	Bend of scape *sharply angled*, forming a near right-angle.	6
6a	From above, shows a horizontal lobe on the angle (Fig. 6).	7
6b	No horizontal lobe (Fig. 6).	***M. scabrinodis***
7a	Uniform pale body, lobe smaller.	***M. sabuleti***
7b	Dark on head and gaster, lobe larger.	***M. lonae***
8a	Sculptured above. Free-living, but often on *Formica* nests.	***Leptothorax acervorum*** [2]
8b	Shining above. Always in mounds of *Formica* wood-ants.	***Formicoxenus nitidulus***

1 - *L. alienus* may occur in Highland and will key out here. It lacks erect hairs on the scape of the antenna.
2 - *Tetramorium caespitum* will key out here. Its clypeus is raised into a ridge below the antennae.

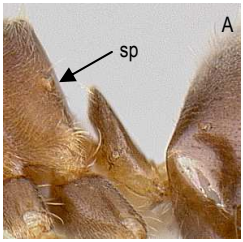
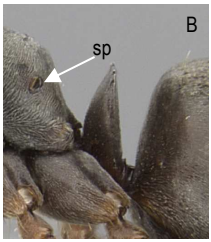


Plate 20. A - Waist of Lasius niger *showing the single leaf -shaped petiole segment and position of the spiracle (sp). © Michael Branstetter, www.antweb.org. B - The same of* Formica lemani. *© Shannon Hartman, www.antweb.org.*



Acknowledgements

This Atlas could not have been produced without the help of the following recorders:
Geoff Allen, David Ashford, David Baldock, Barbara Ballinger, David Barbour, Donald Beaton, Nick Blacker, Keith Bland, Paul Boswell, Jane Bowman, Hugh Brown, Stephen Bungard, C. Cheffings, John Chester, Cedric Collingwood, Graham Collins, Susan Cooksley, Gordon Corbet, Roger Cottis, A. Davidson, Mike Davidson, Norman Davidson, Bob Dawson, G.H.L. Dicker, Henry Dobson, R.M. Dobson, A.B. Duncan, Mike Edwards, George Else, W.A. Ely, Philip Entwistle, Ian Evans, Lyn Evans, Lyn Fairchild, Carl Farmer, Lynne Farrell, Cathy Fiedler, Vin Fleming, Aaron Forsyth, A.P. Fowles, Greg Fullarton, D.J. Gibbs, Jim Gillies, David Glass, Robert Glass, Derek Gunn, Geoff Hancock, Martin Harvey, Peter Harvey, Ken Hill, Martin Hind, P.J. Hodge, Alice Holt, A. Horner, David Horsfield, Mike Howe, Jonathan Hughes, Julian Jacobson, Andrew Jarman, Owen Jarman, Gus Jones, Andrew Kennedy, Roger Key, Peter Kirby, Adrian Knowles, Kenny Kortland, Annie Lamb, Tina Lloyd-Jenkins, Mike Lush, Richard Lyszkowski, Murdo Macdonald, Iain MacGowan, Jessie Mackay, L.D. Macrae, Barbara MacRitchie, Peter Madden, Helen Mainwood, Fred McCreadie, Jimmy McKellar, Jon Mercer, R Moore, Stephen Moran, M. Morrison, Gill Nisbet, David O'Brien, Katie O'Brien, Don O'Driscoll, John Paul, M. Pavett, Alan Phillips, David Phillips, Gwen Potter, Tim Ransom, Elva Robinson, Ro Scott, Jouni Sorvari, Melanie Spirit, Jean Stewart, Ian Strachan, Ron Summers, Stewart Swinney, Sue Tarr, Stewart Taylor, Mark Telfer, Chris Vasey, Jeff Waddell, Jackie Webley, David Whitaker, Jonathan Willet, Hayley Wiswell.

Thanks are due to BWARS for permission to map some records from their database, and to Jane Bowman and Stewart Taylor for permission to use their plates. Jenni Stockan, Andrew Jarman, Jouni Sorvari, Mike Fox, Jonny Hughes, and Cedric Collingwood provided information and advice. Jimmy McKellar and Sue Tarr kindly read parts of the draft, improving it with many helpful comments, and Hayley Wiswell heroically read through every word with me to identify errors. Any that remain are of course entirely my responsibility.

Funding for some fieldwork was provided through a grant from Scottish Natural Heritage. The high-quality images of ant anatomy are from www.antweb.org under the same Creative Commons Licence to which this book is subject. I am very grateful that I am able to use this excellent resource.

References and other resources

Books, papers and reports

Anon. 2012. *Population Projections for Scotland's Strategic Development Plan Areas and National Parks (2010- based).* National Records of Scotland. Available at:
http://www.gro-scotland.gov.uk/statistics/theme/population/projections/sdp-areas-national-parks/2010-based/index.html.

Attewell, P. 2006. A new angle on *Myrmica* scapes - an extra character for determination. *BWARS Newsletter*, Autumn 2006, pp. 19-20.

Barbero, F., Bonelli, S., Thomas J. A., Balletto, E. and Schönrogge K. 2009. Acoustical mimicry in a predatory social parasite of ants. *J. Exp. Biol.* 212, pp. 4084-4090. Available at: http://jeb.biologists.org/content/212/24/4084.full.pdf, with audio at http://www.sciencemag.org/content/suppl/2009/02/05/323.5915.782.DC1.

Barrett, K.E.J. 1979. *Provisional Atlas of the insects of the British Isles, part 5 Hymenoptera: Formicidae, Ants*, 2nd edition. BRC/ITE.

Bernaskoni, C., Cherix, D., Seifert, B., and Pamilo, P. 2011. Molecular taxonomy of the *Formica rufa* group (red wood ants) (Hymenoptera: Formicidae): a new cryptic species in the Swiss Alps? *Myrmecological News* 14, pp. 37- 47. Available at: http://www.landesmuseum.at/pdf_frei_remote/MyrmeNews_014_0037-0047.pdf.

Bolton, B. and Collingwood, C.A. 1975. *Handbooks for the Identification of British Insects vol. VI, part 3(c) Hymenoptera, Formicidae*. Royal Entomological Society of London.

Brian, M.V. 1977. *Ants*. Collins.

Brian, M.V. and Brian, A. D. 1949. Observations on the taxonomy of the ants *Myrmica rubra* L. and *M. laevinodis* Nylander (Hymenoptera: Formicidae). *Trans. Roy. Ent. Soc. Lond.* 100, pp. 393-409. Available at: http://ia600204.us.archive.org/9/items/ants_06531/6531.pdf.

Brian, M.V. and Brian, A. D. 1955. On the two forms macrogyna and microgyna of the ant *Myrmica rubra* L. *Evolution* 9 (3), pp. 280-290.

Chapuisat, M., Oppliger, A., Magliano, P. and Christe, P. 2007. Wood ants use resin to protect themselves against pathogens. *Proc. R. Soc. B* 274, pp. 2013–2017. Available at: http://rspb.royalsocietypublishing.org/content/274/1621/2013.full.pdf.

Collingwood, C.A. 1951. The distribution of ants in North-west Scotland. *Scottish Naturalist* 63, pp. 45-49. Available at: http://ia700300.us.archive.org/7/items/ants_11481/11481.pdf.
Collingwood, C.A. 1957. The species of ants of the genus *Lasius* in Britain. *J. Brit. Ent. Soc.* 5, pp. 204-214. Available at: http://ia700307.us.archive.org/15/items/ants_11307/11307.pdf.
Collingwood, C.A. 1961. Ants in the Scottish Highlands. *Scottish Naturalist* 70, pp. 12-21. Available at: http://ia700508.us.archive.org/21/items/ants_11311/11311_text.pdf.
Dalrymple, S.E. 2007. Biological Flora of the British Isles: *Melampyrum sylvaticum* L.. *Journal of Ecology* 95, pp. 583–597. Available at: http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2745.2007.01234.x/pdf.
Dobson, R.M. 1993. The natural history of the Muck Islands, North Ebudes. *Glasgow Naturalist* 22(3), pp. 255-258.
Donisthorpe, H.StJ.K. 1927a. *British Ants, their Life Histories and Classification*, 2nd edition. Routledge. First edition of 1915 available at: http://archive.org/download/britishantstheir00donirich/britishantstheir00donirich.pdf.
Donisthorpe, H.StJ.K. 1927b. *The Guests of British Ants.* Routledge.
Elmes, G.W. 1976. Some observations on the microgyne form of *Myrmica rubra* L. (Hymenoptera, Formicidae). Insectes Sociaux, Volume 23, Issue 1, pp. 3-21. Abstract available at: http://link.springer.com/content/pdf/10.1007%2FBF02283902.
Fiedler, K. 1989. European and North West African Lycaenidae (Lepidoptera) and their associations with ants. *Journal of Research on the Lepidoptera* 28(4), pp. 239-257. Available at: http://lepidopteraresearchfoundation.org/journals/28/PDF28/28-239.pdf.
Finér, L., Jurgensen, M.F., Domisch, T., Kilpeläinen, J., Neuvonen, S., Punttila, P., Risch, A.C., Ohashi, P. and Niemelä, P. 2012. The role of wood ants (*Formica rufa* group) in carbon and nutrient dynamics of a boreal Norway spruce forest ecosystem. *Ecosystems*, October 2012, pp. 1-13. Abstract available at: http://link.springer.com/article/10.1007%2Fs10021-012-9608-1.
Godden, C. and Cosens, D. 1987. Ant species (Hym., Formicidae) native to North Knapdale, Argyllshire. *Entomol. Mon. Mag.* 127, pp. 209-216.
Haddow, A.J. 1939. Report on the Glasgow University expedition to Canna. *Proc. Roy. Phys, Soc. Ed.* 23, pp. 1-71.
Haines, F.H. 1936. List of insects found near Aviemore, Inverness-shire, from June 20th to July 2nd, 1933. *J. Soc. Brit. Ent.* 1, pp. 131-141.
Hughes, J. 1997a. The status of the wood ants *Formica lugubris* and *Formica aquilonia* (Hym: Formicidae) in Ross-shire and Sutherland. Unpublished report for Scottish Wildlife Trust and Scottish Natural Heritage.
Hughes, J. 1997b. Review of the distribution of *Formica exsecta* Nylander in Scotland with a survey of sites with no recent records. *Scottish Natural Heritage Commissioned Research Report F96AC308*.
Hughes, J. 2006. A review of wood ants (Hymenoptera: Formicidae) in Scotland. *Scottish Natural Heritage Commissioned Report No. 178*. Available at: http://www.snh.org.uk/pdfs/publications/commissioned_reports/F04AC319.pdf.
Hughes, J. and Broome, A. 2007. Forests and Wood Ants in Scotland. Forestry Commission Information Note, November 2007. Available at: http://www.forestry.gov.uk/pdf/fcin090.pdf/$FILE/fcin090.pdf.
Jilkova, V., Frouz, J., Domisch, T. and Finér, L. 2010. The effect of wood ants (*Formica* s. str.) on soil chemical and microbiological properties. 19th World Congress of Soil Science, 1-6 August 2010, Brisbane, Australia, pp. 119-122. Available at: http://www.iuss.org/19th%20WCSS/Symposium/pdf/2316.pdf.
Karhu, K.J. 2004. Effects of ant exclusion during outbreaks of a defoliator and a sap-sucker on birch. *Ecological Entomology* 23(2) pp. 185–194. Available at: http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2311.1998.00116.x/abstract.
Macdonald, M.A. 2009. Notes on *Formica sanguinea* in Scotland. *BWARS Newsletter* Autumn 2009, pp. 20-23.
Martin, S.J., Jenner, E.A., and Drijfhout, F.P. 2007. Chemical deterrent enables a socially parasitic ant to invade multiple hosts. *Proc. R. Soc. B* 274, pp. 2717–2721. Available at: http://rspb.royalsocietypublishing.org/content/274/1626/2717.full.pdf.
Martin, S.J., Vitikainen, E., Helantera H, and Drijfhout, F.P. 2008. Chemical basis of nest-mate discrimination in the ant *Formica exsecta*. *Proc. R. Soc. B* 275, 1271–1278. Available at: http://rspb.royalsocietypublishing.org/content/275/1640/1271.full.pdf.
Nielsen, C., Anurag, A., Agrawal, A.A. and Hajek A.E. 2010. Ants defend aphids against lethal disease. *Biol. Lett.* 6, pp. 205–208. Available at: http://www.eeb.cornell.edu/agrawal/pdfs/2010/nielsen-et-al-2010-ants-aphids-and-disease.pdf.
Orledge, G.M. 2005. *The* BWARS *Lasius* study: differences between the workers of *L. niger* and *L. platythorax* illustrated with scanning electron micrographs. *BWARS Newsletter* Autumn 2005, pp. 22-24.
Owen, J.A. 1986. *Formica aquilonia* Yarrow (Hym., Formicidae) and some beetle associates in the Isle of Skye. *Entomologist's Monthly Magazine* 122, p. 120.
Phillips, D. 2000. Wood ants postal survey: Report on the period 1995-1999. *Scottish Natural Heritage Commissioned Report* AS/SPECIES/DSP1 (unpublished report).
Pisarski, B. and Czechowski, W. 1990. The course of artificial colonisation of red wood ants in the Gorce National Park. *Memorabilia Zoologica* 44, p. 37-46.
Punttila, P., Niemelae, P. and Karhu, K. 2004. The impact of wood ants (Hymenoptera: Formicidae) on the structure of the invertebrate community on mountain birch (*Betula pubescens* ssp. *czerepanovii*). Ann. Zool. Fenn. 41(2), pp. 429–446. Available at: http://www.sekj.org/PDF/anzf41/anzf41-429.pdf.
Rosengren, R., Fortelius, W., Lindstrom, K. and Luther, A. 1987. Phenology and causation of nest heating and thermoregulation in red wood ants of the *Formica rufa* group studied in coniferous forest habitats in southern Finland. *Ann. Zool. Fennici* 24, pp. 147-155. Available at: http://www.annzool.net/PDF/anzf24/anz24-147-155.pdf.

Seifert, B. 1991. *Lasius platythorax* n. sp., a widespread sibling species of *Lasius niger*. *Entomol. Gener*. 16(1), pp. 69-81. Available at: http://archive.org/download/ants_02559/2559_text.pdf.
Seifert, B. 2000. *Myrmica lonae* Finzi, 1926 - a species separate from *Myrmica sabuleti* Meinert, 1861 (Hymenoptera: Formicidae). *Abh. Ber. Naturkindemus. Görlitz* 72(2), pp. 195-205. Available at: http://ia700502.us.archive.org/11/items/ants_21142/21142_text.pdf.
Seifert, B. 2007. *Die Ameisen Mittel- und Nord-Europas*. Lutra.
Seifert, B., Kulmuni, J. and Pamilo, P. 2010. Independent hybrid populations of *Formica polyctena* X *rufa* wood ants (Hymenoptera: Formicidae) abound under conditions of forest fragmentation. *Evol. Ecol.* 24, pp. 1219-1237.
Available at: http://link.springer.com/content/pdf/10.1007%2Fs10682-010-9371-8.
Skidmore, P. 1979. Notes on some Insects of the Glenfinnan area, Inverness-shire. *Entomol. Mon. Mag.* 114, p. 118.
Skinner, G.J. and Allen G.W. 1996. *Ants*. Richmond.
Smith, J.E. and Menzel, F. 2007. New records of British sciarid flies with description of two new species (Diptera, Sciaridae). *Dipterists' Digest* 14, pp. 75-86.
Sorvari, J. 2009. Foraging distances and potentiality in forest pest insect control: an example with two candidate ants (Hymenoptera: Formicidae). *Myrmecol. News* 12, pp. 211-215.
Available at: http://www.myrmecologicalnews.org/cms/images/pdf/volume12/mn12_211-215_non-printable.pdf.
Tyler, J. 2008. The ant, the aphid and the fungus. *Field Mycology* 9(1), pp. 22-23.
Wagner, D. and Kay, A. 2002. Do extrafloral nectaries distract ants from visiting flowers? An experimental test of an overlooked hypothesis. *Evolutionary Ecology Research* 4, pp. 293–305.
Available at: http://mercury2.iab.uaf.edu/diane_wagner/index_files/wagner_kay_02.pdf.
Weatherill, L.H. 1939. Ants in the north of Scotland. *Ent. Rec.* 51, pp. 5-6.
Available at: http://ia600309.us.archive.org/15/items/entomologistsrec511939tutt/entomologistsrec511939tutt.pdf.
Wormell, P. 2006. Scottish entomologists' survey Isle of Rum 2000. *Glasgow Naturalist* 24(4), pp. 125-153.
Yarrow, I. H. H. 1954. The British ants allied to *Formica fusca* L. (Hym., Formicidae). *Trans. Soc. Brit. Ent.* 11, pp. 229-44.
Available at: http://ia700204.us.archive.org/5/items/ants_03526/ants_03526.pdf.
Yarrow, I. H. H. 1955. The British ants allied to *Formica rufa* L. (Hym., Formicidae). *Trans. Soc. Brit. Ent.* 12, pp. 1-48.
Available at: http://ia700204.us.archive.org/13/items/ants_03528/ants_03528.pdf.

Website content

Bolton, B. 2013. Bolton World Catalog Ants. [Online] Available at: http://www.antweb.org/world.jsp. [Accessed 1 March 2013].
Collingwood, C.A. 2005a. BWARS Species Account: *Formica fusca* Linnaeus, 1758. [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/formicinae/formica-fusca. [Accessed 1 March 2013].
Collingwood, C.A. 2005b. BWARS Species Account: *Formica lemani* Bondroit, 1917. [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/formicinae/formica-lemani. [Accessed 1 March 2013].
Groden, E. 2004. European Fire Ant: A New Invasive Insect in Maine. [Online].
Available at: http://umaine.edu/publications/2550e/ [Accessed 1 March 2013].
Hoy, S.P. 1997a. BWARS Species Account: *Lasius fuliginosus* (Latreille, 1798). [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/formicinae/lasius-fuliginosus. [Accessed 1 March 2013].
Hoy, S.P. 1997b. BWARS Species Account: *Formica exsecta* Nylander, 1846. [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/formicinae/formica-exsecta. [Accessed 1 March 2013].
Hoy, S.P. 1998a. BWARS Species Account: *Myrmica lobicornis* Nylander, 1846. [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/myrmicinae/myrmica-lobicornis. [Accessed 1 March 2013].
Hoy, S.P. 1998b. BWARS Species Account: *Leptothorax acervorum* (Fabricius, 1793). [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/myrmicinae/leptothorax-acervorum. [Accessed 1 March 2013].
Hoy, S.P. 2001a. BWARS Species Account: *Myrmica sulcinodis* Nylander, 1846. [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/myrmicinae/myrmica-sulcinodis. [Accessed 1 March 2013].
Hoy, S.P. 2001b. BWARS Species Account: *Tetramorium caespitum* (Linnaeus, 1758). [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/myrmicinae/tetramorium-caespitum. [Accessed 1 March 2013].
Hoy, S.P. 2001c. BWARS Species Account: *Formica aquilonia* Yarrow, 1955. [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/formicinae/formica-aquilonia. [Accessed 1 March 2013].
Fox, M.G. 2008. BWARS Species Account: *Lasius flavus* (Fabricius, 1781). [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/formicinae/lasius-flavus. [Accessed 1 March 2013].
Orledge, G.M. 2002a. BWARS Species Account: *Formicoxenus nitidulus* (Nylander, 1846). [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/myrmicinae/formicoxenus-nitidulus. [Accessed 1 March 2013].
Orledge, G.M. 2002b. BWARS Species Account: *Formica lugubris* Zetterstedt, 1838. [Online].
Available at: http://www.bwars.com/index.php?q=ant/formicidae/formicinae/formica-lugubris. [Accessed 1 March 2013].

Antkey http://antkey.org
AntWeb. www.antweb.org
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UK Wood Ants http://www.woodants.org.uk/

This book is a companion to *Highland Bumblebees* published in print by HBRG in 2006. It deals with the 19 species of ant found in the Highland region of Scotland, and is designed for the interested layman, amateur naturalist, professional biologist and land manager.

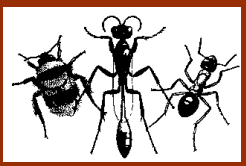
It has information on the biology and ecology of these fascinating insects in a Highland context, but with wider relevance. This will help to raise awareness of the importance of ants, inform conservation projects and land management, and provide a baseline against which to measure future changes in distribution.

Ants are not the favourite insects of most people, yet their lives are full of surprises, totally unsuspected by the casual passer-by.

The main chapters cover

- Biology of ants – an introduction to the amazing facts of ant life.
- Relationships with other species - ants have a wide range of interactions with other species, from protecting aphids to kidnapping other ants as slaves.
- Finding ants – learn where ants live, and how to discover their nests.
- Conservation of ants – how to maintain ant populations as key components of natural communities.
- Species accounts – maps and information on the Highland species.
- Keys to Highland species – to help beginners and others with identification.

Highland Biological Recording Group



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ISBN 978-0-9552211-4-9