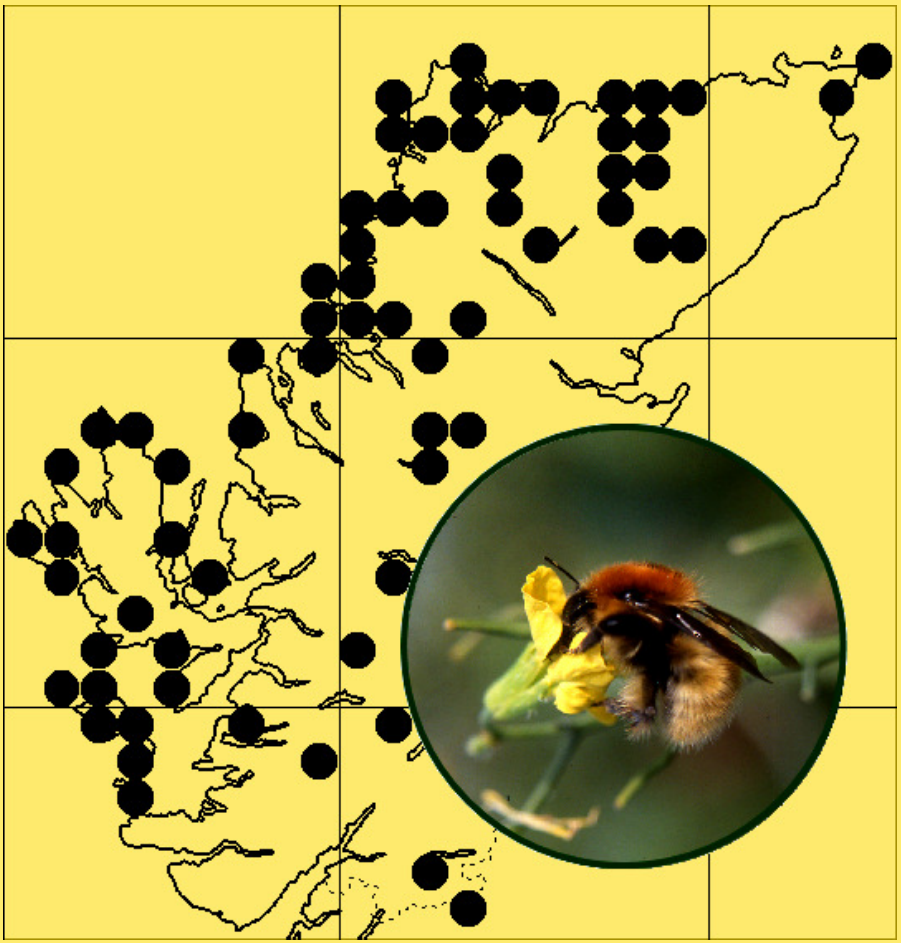
Highland Bumblebees

Distribution, Ecology and Conservation



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Highland Biological Recording Group

Highland Bumblebees: Distribution, Ecology and Conservation

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Front cover illustration: *Bombus muscorum* © John Crossley.
Back cover illustration: *Bombus monticola* male © Gill Nisbet.

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Introduction

During the 1990s, it became clear that many species of bumblebee in Britain had declined in range and numbers as a result of changing land use. One English species, *Bombus subterraneus*, even became extinct in Britain around 1990. This was only partly compensated by the establishment in southern England of *B. hypnorum* from mainland Europe. The loss of bumblebees was worrying to agriculturalists and horticulturalists as well as naturalists. Bumblebees are essential as pollinators, valuable economically as well as ecologically. Because they rely on a continuous supply of flowers for food, they are good indicators of the wider health of a natural community.

When the UK Biodiversity Action Plan was launched in 1994, the concern became official for the five bumblebees on the BAP Priority list: four English species (*B. ruderatus*, *B. humilis, B. sylvarum* and the now extinct *B. subterraneus*), and one confined to Scotland, the Great Yellow Bumblebee *B. distinguendus*. Their current distribution was determined, and measures designed to maintain and enhance the populations put in place. Four other species (*B. soroeensis, B. monticola, B. muscorum* and *B. ruderarius*, all of which occur in Scotland) are now on the English Nature Species Recovery Programme and are being proposed for the revised UK BAP priority list.

Twenty-six species of bumblebee (including the five cuckoo bumblebees) are recorded from Britain. Three are now extinct: *B. pomorum* was recorded once in Kent in 1864 and may have been only a vagrant; *B. cullumanus* was lost from the chalk grasslands of S. England in 1941; and *B. subterraneus* (see above). Scotland has 18 species, 16 of which have been found in the Highlands since 1990 (Table 1). Recent reports of *B. vestalis* in S. Scotland are unconfirmed.

One of us (MAM) has studied bumblebees in Highland since 1989. The mapping work was taken up by the Highland Biological Recording Group as a major project in 2000. Similar schemes have recently been carried out in Shetland and Orkney under the auspices of their Local Records Centres, and there are plans to survey the rest of the UK.

Such work provides information on current distribution and reveals changes with time. The last national atlas of bumblebees covered the period 1960-75 (ITE, 1980). The present work provides comparative data from 1990-2005 to show changes in Highland over thirty years. It also establishes a reliable baseline against which to detect and measure, for example, the effects of climate change or of changing land management.

The ecological data collected in the course of mapping should inform land management to benefit a wide range of wildlife through Local and UK Biodiversity Action Plans, agri-environment schemes, and other initiatives.

Latin name	English name
Bombus soroeensis	Broken-belted Bumblebee
Bombus lucorum	White-tailed Bumblebee
Bombus cryptarum	
Bombus magnus	Northern White-tailed Bumblebee
Bombus terrestris	Buff-tailed Bumblebee
Bombus jonellus	Heath Bumblebee
Bombus monticola	Bilberry Bumblebee
Bombus pratorum	Early Bumblebee
Bombus lapidarius	Red-tailed Bumblebee
Bombus hortorum	Garden Bumblebee
Bombus muscorum	Moss Carder Bee
Bombus pascuorum	Common Carder Bee
[*Bombus ruderarius*]	[Red-shanked Carder Bee]
Bombus distinguendus	Great Yellow Bumblebee
Bombus (Psithyrus) bohemicus	Gypsy Cuckoo Bumblebee
[*Bombus (Psithyrus) barbutellus*]	[Barbut's Cuckoo Bumblebee]
Bombus (Psithyrus) campestris	Field Cuckoo Bumblebee
Bombus (Psithyrus) sylvestris	Forest Cuckoo Bumblebee

Table 1. The Scottish species of bumblebee. The English names are not universally recognised. There are no recent records of B. ruderarius *or* B. barbutellus *in Highland though they occur on Coll and Tiree and may yet be found in the area.* B. cryptarum *has only recently been confirmed as occurring in Britain. The cuckoo bumblebees were previously placed in the genus* Psithyrus *but are now generally placed in* Bombus*.*

We have used Latin names for bumblebees, while providing English names to aid beginners (Table 1). Naming of plants is less consistent, and we have used Latin or English as seems appropriate in context. Generally, Latin is used in tables and the species accounts, while English is preferred in the text. A table of all plant names used is given in Appendix 1.

Biology of bumblebees

Bumblebees are social insects which, like honeybees, form a colony and produce non-breeding workers to rear new reproductive offspring. However, unlike honeybees, bumblebee colonies do not survive the winter, and each spring fertilised queens emerge from hibernation and start to build a new colony single-handedly. These queens were produced the previous summer, mated, and then hibernated over the winter.

The timing of emergence from hibernation is likely to be triggered by soil temperature, and varies between species. If forage is not quickly located, queens may return to their burrows to wait for flowers to appear. The earliest species to be seen in the Highlands are *B. lucorum* and *B. pratorum*, which usually appear in the middle of March. These rely heavily on garden flowers in the absence of plentiful wild flowers. Other species, like *B. soroeensis*, do not emerge until June when native forage is abundant, but they have a shorter season in which to complete their cycle. The active season varies within Highland. It starts earlier and ends later in the Moray Firth area, than inland and in the west. Timing can be affected by the presence of early and late forage in gardens.

The newly emerged queen feeds on energy-rich nectar and protein-rich pollen to build up her ovaries, while prospecting for a suitable nest site. This may be a hole in the ground (such as an old mouse-hole), or in tussocks of grass, depending on the species. She makes a nest of dry moss or grass and collects pollen which is moistened with nectar, moulded into a lump, and the first eggs are laid in it. She builds a wax honey-pot to store nectar on which to feed while incubating or during bad weather. The queen is able to raise the temperature of the brood by rapidly vibrating her flight muscles. After about four days, the eggs hatch into maggot -like larvae, which feed on the pollen until ready to pupate. The larvae spin cocoons, from which worker bees emerge. The total development time is about five weeks. The queen continues to lay batches of eggs throughout the life of the colony.

Workers are female bumblebees, usually smaller than queens. They do not normally reproduce, but take over the work of the queen, foraging, feeding the larvae, and maintaining the nest. The queen remains in the safety of the nest, laying eggs and tending the brood. The number of workers produced varies from one colony to another and also between species. Some species attain a colony size of over 300 individuals, while others may not reach 30.

The apparently altruistic behaviour of worker bees is a result of the unusual method of sex-determination in bees, ants and wasps, whereby females result from fertilised eggs and males from unfertilised eggs. Workers are more closely related to their sisters than they would be to their own daughters. Therefore, more of their genes are passed on to future generations by caring for their sisters than by producing their own progeny.

In mid to late summer some eggs develop into new queens. At the same time, unfertilised eggs are laid which develop into males. More males than queens are usually produced, but they play no part in the upkeep of the colony, spending much time drinking nectar. Males patrol a scent-marked route to engage virgin queens, or may wait outside nests for queens to emerge. Only once the new queens have mated has the nest succeeded in providing the next year's generation. The old queen, workers and males die, and the colony is finished. However, bright new queens may be seen feeding, building up fat reserves to maintain them over winter.

Known hibernation sites are usually sheltered spots on north-facing banks, or in the shade of trees. In such places the temperature remains fairly constant and queens are less likely to waken prematurely due to a burst of winter sunshine. The queen burrows into the soil for a few centimetres and forms a small oval chamber in which to pass the winter.

Cuckoo bumblebees have similar life cycles to bumblebees except that they take over a colony of their host. Females emerge from hibernation a little later than the host species, which will already be producing workers. The cuckoo female enters the host nest, may kill the host queen, and then lays her own eggs to be reared by the host workers. There is no worker caste in cuckoo bumblebees, they do not forage for the nest, and have no pollen baskets. Each cuckoo bumblebee has its own host species, or group of related hosts.

Little is known about the dispersal of bumblebees. Young queens clearly move long distances, appearing in places well outside the normal range and sometimes establishing nests there. It is an effective way of colonising new areas, as only one fertilised queen is needed to found a nest if suitable habitat is located. We have examples of bees appearing out of range in Highland: *B. terrestris* breeding at Tongue in N Sutherland; a vagrant *B. lapidarius* in NW Sutherland and assumed immigrants from Coll and Tiree on the Small Isles; *B. pratorum* and *B. hortorum* high in the mountains; *B. distinguendus* briefly in S Skye; *B. campestris* as a vagrant in mid Ross. Reports of bumblebees over the sea several km from land are frequent.

Bumblebees are strong fliers and may cover distances of 5 kilometres or more from the nest, searching for forage. The front and hind wings hook together to form a single surface, and beat up to 200 times a second, moving the bee at more than 20 km/h with a load of half or more of its body weight.

Bumblebees possess a sting, which they use to defend themselves and their nests from predators and parasites. Since the sting is a modification of the female egg-laying apparatus (ovipositor), only queens and workers can sting. However, unlike honeybees, the sting is only lightly barbed and they are able to withdraw it and so do not die. In this country, bumblebees will usually sting only if severely provoked.

Habitats

The Highland region contains a wide range of land types: mountain and moorland; natural and planted forest; intensive arable and livestock farms; non-intensive croftland; built-up areas; coasts and islands. Climate is similarly variable, with the west generally milder and wetter than the east, and the inland parts more extreme than the coasts. The Moray Firth basin is especially mild and dry, the climate rapidly becoming more extreme as one moves inland.

The many combinations of land type and climate create a range of conditions more or less suitable for bumblebees. Species diversity decreases rapidly above 500m (Fig. 1) and tends to decrease away from the Moray Firth/Strathspey area (Fig. 2). This reflects the presence in the more diverse and richer habitats in the east of several species (*terrestris*, *monticola*, *lapidarius*, *bohemicus* and *sylvestris*) which are scarce or absent in the north and west.

No species is confined to one habitat. Bumblebees are essentially opportunistic, and will thrive in any habitat with suitable forage and nest sites. Many species nevertheless show distinct habitat preferences which are likely to be the expression of preferences for particular forage plants. For example, the association of *B. monticola* and *B. jonellus* with moorland reflects the habitat of their main forage plants, Blaeberry and heaths respectively. These bees rarely occur on moorland where the preferred forage is scarce or absent. Some typical habitat associations are listed in Table 2.

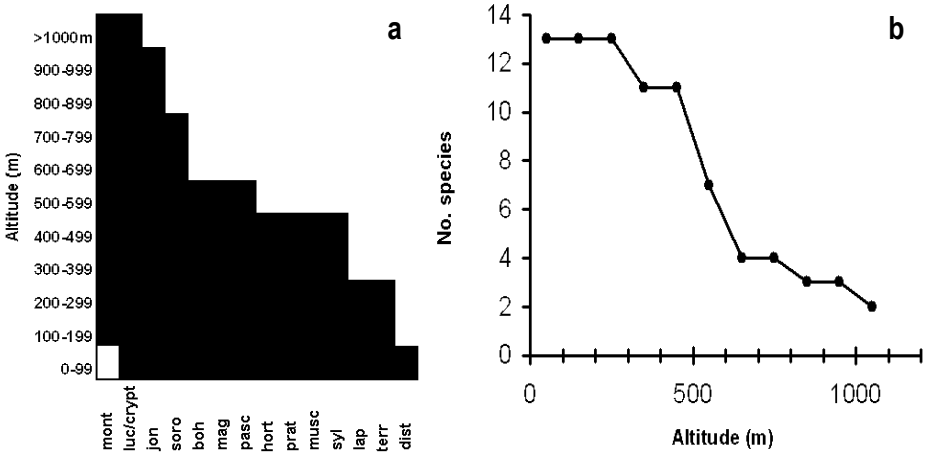


Figure 1. The normal distribution of Highland bumblebees with altitude. a) Altitudinal range of individual species (shown by abbreviated Latin specific names). Some exceptional records are outside these ranges. b) The decrease in number of species with altitude.

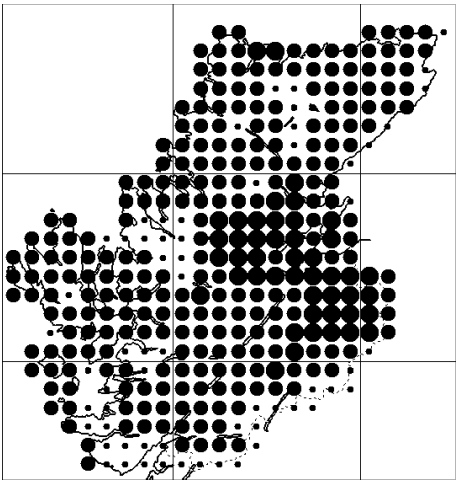


Figure 2. Species diversity of bumblebees in Highland. Circles in each 10km square represent the total number of species recorded in that square and the three (where present) bounding it on the E, SE and S. This method smoothes variations due to uneven survey effort, but tends to reduce the score of E and S edge squares. Large circles: 11-14 species; medium: 7-10; small <7.

Habitat	*Typical* Bombus *spp.*	*Some typical forage plants*
Coastal meadows and dunes	*lucorum/cryptarum, terrestris, lapidarius, hortorum, muscorum , pascuorum, distinguendus*	*Anthyllis vulneraria, Lotus corniculatus, Vicia cracca, Trifolium repens, T. pratense, Thymus polytrichus, Centaurea nigra*
Marshy areas	*lucorum/cryptarum, magnus, hortorum, pascuorum*	*Salix* spp., *Filipendula ulmaria, Stachys palustris, Cirsium palustre*
Gardens	*lucorum/cryptarum, terrestris, pratorum, lapidarius, hortorum, pascuorum, bohemicus*	*Erica carnea, Ribes sanguineum, Acer* spp., *Pulmonaria officinalis*, *Origanum majorana, Salvia officinalis, Buddleia* spp.
Hedgerows		*Rubus idaeus*, *R. fruticosus, Prunus avium, V. cracca*, *Stachys* spp., *Cirsium* spp.
Roadside verges	*lucorum/cryptarum, pratorum, hortorum, muscorum*, *pascuorum, distinguendus*	*L. corniculatus, V. cracca, T. repens, T. pratense, Chamerion angustifolium, Th. polytrichus, Digitalis purpurea, C. nigra*
Forest edge and rides	*soroeensis, lucorum/cryptarum, hortorum, bohemicus, sylvestris*	*Salix* spp., *Vaccinium* spp., *R. idaeus*, *R. fruticosus, P. avium, D. purpurea*, *Cirsium* spp.
Moorland	*soroeensis, lucorum/cryptarum, magnus, jonellus, monticola, muscorum*	*Salix* spp., *Calluna vulgaris, E. tetralix, E. cinerea, Vaccinium vitis-idaea, V. myrtillus, Pedicularis sylvatica, Succisa pratensis*
Mountains	*lucorum/cryptarum, magnus, jonellus, monticola*	*Arctostaphylos uva-ursi, C. vulgaris, E. tetralix, E. cinerea, V. myrtillus, Thymus polytrichus*

Table 2. Typical bumblebee fauna in some important habitats in the Highlands.

Forage and pollination

Bumblebees feed almost entirely on nectar (supplying sugar and water) and pollen (supplying protein for the queen and larvae) produced by flowers. Some species will take honeydew (the sugar-rich excreta of aphids and other plant-sucking bugs, also used as a food source by ants) from the surface of leaves and twigs, but this is always a minor food source. This reliance on flowers, and their long breeding season (in the Highlands, from March to October) makes a continuous supply of appropriate forage essential for the maintenance of successful bumblebee colonies – those that produce breeding queens and males.

Nectar is collected in a special honey stomach while pollen is carried in the pollen-baskets (corbiculae) formed by stiff hairs on the hind legs. The pollen-loads can easily be seen as coloured masses on the hind legs of foraging females, the colour varying with the source plant. On average, bumblebees carry about 25% of their body weight, but they are able to carry much heavier loads.

Because of their long tongues, hairy bodies, and their ability to forage in poor weather, bumblebees are excellent pollinators and are economically important for the production of food crops such as soft fruit, tomatoes and beans, and fodder crops like Alfalfa and Red Clover. The ability of bumblebees to cross-pollinate the self-sterile Red Clover was the reason for the importation of British bumblebees to New Zealand in the 19th century. Now captive colonies are used commercially in glasshouses, with 95% of tomatoes being pollinated by bumblebees. This forms the basis of a multi-million pound international business.

Tongue length varies between species. Those with longer tongues specialise on foraging from flowers with long corolla tubes such as Honeysuckle or Foxglove, whose nectar shorter-tongued species cannot reach. The short-tongued *B. lucorum* and its close relatives are able to take nectar from deep flowers by 'robbery'. They bite through the base of the flower, insert the tongue, and take the nectar without contacting the reproductive parts. This breaks the evolutionary 'pact': the flower provides food (pollen and nectar), and the insect executes pollination. Bites are readily found on the spurs of Columbine (Plate 3).

The *lucorum* group are the most likely to forage high in trees, to feed at honeydew, and to collect pollen from nectarless flowers. They are good exponents of 'buzz pollination', vibrating their wings to shake pollen from the anthers of Tomato, Borage and roses.

No Scottish bumblebee is inflexibly associated with particular forage plants, but rather each species picks its own preferred forage from the choice available. If suitable forage is absent in an area, so also will be the bees. There are, however, striking and widespread associations between some species and their forage plants (Table 3), notably *B. pratorum*, *B. monticola* and *B. hortorum* with Raspberry, Blaeberry and Foxglove respectively.

In general, bumblebees must learn for themselves the flowers that allow efficient foraging. This is called 'sampling'. There is no equivalent to the communication 'dances' of honeybees, but in older nests of *B. terrestris* successful workers can communicate the scent of good flowers to their sisters for them to search out. This presumably leads to enhanced foraging efficiency, workers learning from the success of others.

Species	*Key forage plants in Highland*
Bombus soroeensis	In July, 42% of 136 records mentioned *Erica cinerea*, 13% *E. tetralix*, 17% *Rubus fruticosus*, and 10% *Cirsium palustre*.
B. lucorum *B. cryptarum*	Dependent on gardens for early forage. The species most likely to forage at tree flowers. 39% of 142 native forage records in April and May were at *Salix* spp. The species most often seen taking honeydew (13 of 19 records).
B. terrestris	Very dependent on gardens. 76% of 70 forage records, and all 24 records between 21 March and 2 May, were exotic species.
B. jonellus	In June, *Erica cinerea* and *E. tetralix* were cited in 23% and 13% of forage records respectively (N=62). In July, 57% and 32% respectively (N=259). In August-September, 26%, 9% and 48% *Calluna vulgaris* (N=296). (Native forage only.)
B. pratorum	From 23 April to 31 May, 70% of 37 records mentioned *Vaccinium myrtillus*. 68% of 61 records in June were on *Rubus idaeus* and 7% on *R. fruticosus*. In July, 34% of 109 records were on *R. fruticosus* and 8% on *R. idaeus*. (Native forage only.)
B. monticola	In May, 45% of 60 records were on *Vaccinium myrtillus*, and 35% on *Salix* spp. In June, 48% of 61 records were on *Lotus corniculatus* and 21% on *Vaccinium* spp. In July, of 35 records frequency of *Erica* spp., *Trifolium repens* and *L. corniculatus* were 29%, 26% and 20% respectively. In August-October, 34% of 99 records mentioned *Erica* spp., and 16% *Calluna vulgaris*.
B. lapidarius	28% of 75 forage records were of exotic species. 28 (37%) mention Asteraceae, of which 16 were yellow.
B. hortorum	74% of 59 forage records to the end of May were exotic species. 47% of 379 records from 10 June to 31 July mentioned *Digitalis purpurea*. 33% of 119 records in August were *Cirsium vulgare*, and another 18% were other *Cirsium* and *Centaurea* species.
B. muscorum	In July, 24% of records were on *Erica tetralix*; 9% on *E. cinerea*; and 31% on 5 species of Fabaceae (N=55).
B. pascuorum	39% of 378 forage records from 10 June to 31 July mentioned Fabaceae (in rank order, *Trifolium repens*, *T. pratense*, *Lathyrus pratensis, Vicia sepium*, *Lotus corniculatus*); 18% were on *Digitalis purpurea*. (Native forage only.)

Table 3. Some forage associations of Highland Bumblebees taken from the atlas dataset.

Conservation of bumblebees

Several Highland bumblebees are of conservation significance because they are nationally threatened, because Highland still holds significant stocks of species which may be declining elsewhere in the country, or because they are scarce or restricted in Highland (Table 4).

Status	Species
Serious national decline	***B. distinguendus*, [*B. ruderarius*]**
UK-wide concern	***B. soroeensis*, *B. monticola*, *B. muscorum***
Scarce or restricted in UK, significant Highland population	***B. soroeensis*, *B. magnus*, *B. jonellus*, *B. monticola*, *B. muscorum*, *B. distinguendus***
Nationally abundant, scarce or restricted in Highland	*B. terrestris*, *B. pratorum*, *B. lapidarius*, *B. bohemicus*, *B. campestris, [B. barbutellus], B. sylvestris*
Nationally abundant, common in Highland	*B. lucorum*, *B. hortorum*, *B. pascuorum*
Unknown status nationally, common in Highland	*B. cryptarum*

Table 4. Conservation status of the Highland species of Bombus*. Species of greatest significance are in bold type. Species in [ ] have been lost from Highland since 1975.*

Conservation of bumblebees is achieved by ensuring a plentiful supply of appropriate forage through the active season, and sufficient habitat in the form of rough ground for nests and hibernation sites. Each species has different habitat requirements and must be considered separately.

For example, both *B. jonellus* and *B. monticola* require moorland, but the latter is more abundant in a species-rich heath where dwarf shrubs (especially Blaeberry) and herbs are present as well as the dominant Heather. This can be achieved by actively managing moorland, as for grouse, by periodic burning (muirburn) to remove old, lanky heather and encourage new growth and the regeneration of Blaeberry and Bell Heather, which tend to dominate in the early years after burning. *B. jonellus*, however, makes much more use of Heather for forage and is less dependent on Blaeberry. Wet moorland is important for *B. muscorum*, providing important forage plants such as Cross-leaved Heath and Marsh Thistle.

Hedgerows and field edges can be managed for the benefit of bumblebees. Leaving an uncropped strip of ground next to hedgerows and at field margins will encourage the growth of wild flowers and also provide suitable nest and hibernation sites. This has the added advantage of providing useful crop pollinators. Unimproved grassland should be protected and

long-term set-aside land managed to encourage flowering plants. These measures should be supported by agri-environment schemes which discourage summer grazing or cutting.

Sensitive management of road verges, e.g. by not cutting until late summer after the flowers have set seed, will benefit bumblebees and other insects. There have recently been demands for the eradication of Ragwort, but it is a valuable late nectar source for bumblebees, butterflies, hoverflies and other insects. It is an important part of our native flora, and should be removed only where it is a direct threat to horses.

Woodland edges and the banks of forest tracks should be allowed to develop a diverse flora of Foxglove, thistles, Blaeberry, Raspberry and Bramble, all of which are attractive to bumblebees, especially *B. hortorum* and the cuckoo bumblebees. The bases of large mature trees can also provide suitable hibernation sites. Forest managers should be aware of this useful habitat.

For amenity planting in parks and gardens, flowering shrubs such as *Berberis* and *Cotoneaster* and perennial herbs are much more valuable to bees than displays of annual bedding plants. These days there is a tendency to be too tidy. Areas of 'waste ground' can be very valuable for bumblebees and other wildlife providing a diverse flora and undisturbed ground for nest sites. We should think twice about 'tidying-up' every unused corner.

Gardens are important for most bumblebee species, often providing an oasis in the midst of arable land or the concrete and asphalt of towns. They are especially valuable in early spring when there is little forage available in the wild, when Winter Heath and Flowering Currant will attract many bees. A continuous supply of forage throughout the season must be ensured, which means establishing a succession of plants to provide both nectar and pollen. If you feed the birds in your garden, it will be full of birds – the same is true for bumblebees!

When planting for wildlife we are often encouraged to use native plants. However, bumblebees do not know if a plant is native or not, and will use any flower which supplies readily accessible nectar and pollen. Not all flowers are suitable. Annual plants are rarely used by bumblebees, and modern plant varieties often produce no nectar or it is inaccessible due to the flower structure (Plate 4). Hybrids may not produce pollen. The best flowers for bumblebees are those with a natural and little-modified structure. Some bee-friendly plants include Lungwort, Sage, Marjoram, Butterfly Bush and Columbine. As well as forage, gardens can also provide nest and hibernation sites. A wild corner or an old compost heap can supply nest sites for bumblebees, as well as being valuable for other wildlife.

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 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

Much of the recording between 1990 and 1999 was done casually and opportunistically, special attention being given to recording bumblebees in more inaccessible mountain and island locations. When HBRG adopted the project in 2000, recording became more systematic. From 2001 onward, targeted mapping was introduced. This has disadvantages, as rare species might be missed during relatively brief visits to an area. Attempts were made to ensure that significant habitats and sites in the square were searched as diligently as time and resources allowed once the common species had been found.

Inevitably, the more densely populated areas are better covered than the inaccessible parts, but the result is a realistic picture of the distribution of bumblebees in the Highlands as a whole. The maps should not be interpreted too precisely on a more local scale.

Most identification was done in the field, except for some of the more difficult species. No records of *B. soroeensis*, *B. muscorum*, or the cuckoo bumblebees were accepted from non-specialists unless a specimen or photograph was available. All unusual reports were investigated, and discounted if we considered them incorrect, or if supporting information was not provided. The majority of records are unsupported by voucher specimens, but misidentification is not considered to be a significant problem.

For all species except *B. lucorum*, *B. pratorum*, *B. hortorum*, *B. pascuorum* and *B. bohemicus*, all contacts were logged and entered in the database.

Data

Along with the locality and date, additional data (sex, caste and numbers of bees; their forage plants; 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 therefore be traced to a fully detailed record. All taxon records have been submitted to the national aculeate database held by the Bees, Wasps and Ants Recording Society, and are available on the National Biodiversity Network Gateway (www.searchnbn.net).

Coverage and maps

Coverage for this Atlas extended to 341 (97%) of the 351 10km grid squares (Fig. 3). Most of the unsurveyed squares are marginal to the area, often with very little land area within Highland. Mapping effort in the Highlands for the 1960-1975 Atlas (ITE, 1980) was much less complete. This could lead to a mistaken conclusion that some species have expanded their range in the interval. It has also proved difficult to trace the source of many of the records plotted in the previous Atlas. Each map has a comment on the probable changes in distribution taking the differences in effort and cover into account. A summary appears in Table 5.

The records plotted here are all from the period 1990 to 2005 inclusive, 30 years after the original Atlas, to allow comparisons.

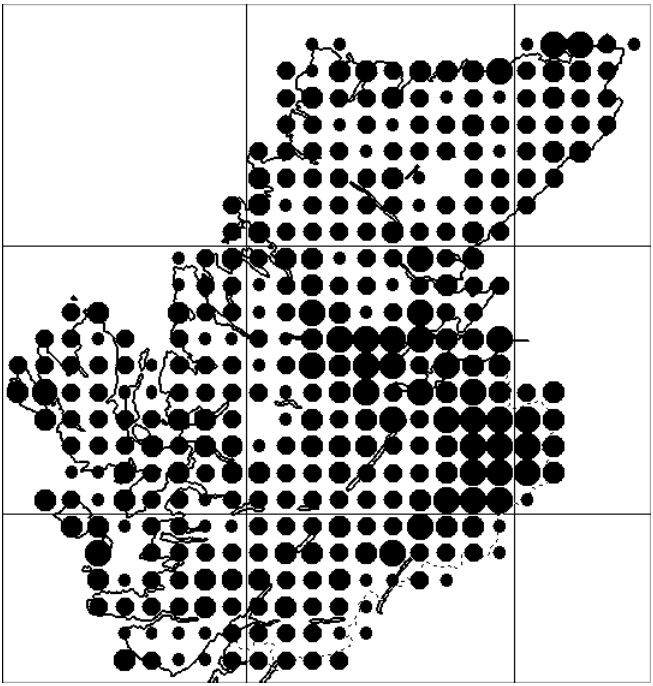


Figure 3. Survey coverage for the Atlas, 1990-2005. Each dot represents the number of species recorded in each of the 351 10km grid squares in the area. From smallest to largest dots: 1-3 species, 4-6

Total no. 10km squares:	351	No. with >=1 record: 341 (97%)
Average no. spp. / 10km square:	5.5 (all squares); 5.7 (surveyed squares)	
Total records mapped	1943	
Total records in database	6277	
Species recorded in	>249 squares	*lucorum* with *cryptarum*, *jonellus*, *hortorum*, *pascuorum*
	100-249 squares	*soroeensis*, *magnus*, *pratorum*, *bohemicus*
	50-99 squares	*monticola, muscorum*
	25-49 squares	*lapidarius*, *sylvestris*
	<25 squares	*terrestris*, *distinguendus*, *campestris* (vagrant)
Range change within Highland since 1975:	lost	*ruderarius*, *barbutellus* (both were rare)
	contracted	*distinguendus*, *monticola*(?), *sylvestris*(?)
	stable	*soroeensis*, *lucorum* with *cryptarum*, *magnus*, *jonellus*, *hortorum*, *muscorum*, *pascuorum*, *bohemicus*, [*campestris*]
	expanded	*terrestris*, *pratorum*, *lapidarius*

Table 5. Summary of coverage, extent of range, and change in range 1975-2005 of Bombus *species in Highland.*

The species accounts

Each species account contains the following information:

Latin name English name

Full Latin name and author. BRC number. NBN number. Conservation status: Any RDB, BAP or similar listing. For cuckoo bumblebees, their hosts.

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

Phenology: A chart showing the main seasons of queens, workers and males, and a brief comment. Solid bars - main season; hatching - other dates.

Forage: A brief note on the main forage plants used.

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

Distribution and abundance: A general statement of the distribution and abundance in Highland, with the number of 10km squares in which the species was recorded. Brief description of UK distribution and status.

Conservation: Brief advice on any specific conservation measures.

Change since 1975: A statement of changes evident since the 1960-1975 atlas (ITE, 1980), with interpretation where relevant.

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

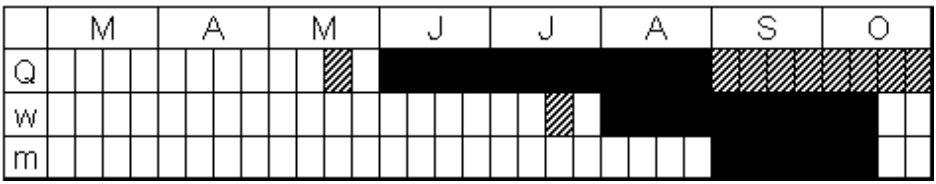
Comments: A brief comment on any points to be emphasised.

References: Any relevant published work on the species, full details in the References section on p. 52.

Bombus soroeensis Broken-belted Bumblebee

Bombus soroeensis (Fabricius, 1777). BRC no. 15015. NBNSYS0000009839.
English Nature Species Recovery Programme. Proposed for UKBAP list.

Recognition: Two yellow bands, white or reddish tail. Easily confused with *B. lucorum* but generally smaller. Abdomen more rounded (less square) with an often indistinct break of black hair in the middle of the abdominal yellow band (beware of worn *lucorum* which can show black cuticle). Most females have a small patch of yellow hair at the side of the first abdominal segment, a good distinction from *lucorum* which can be used in the field (see Fig. 5). Males have noticeably long antennae, and white or reddish tail; can be confused with male *B. jonellus*, but usually has no yellow on the rear of the thorax.



Phenology: A late bee, queens usually obvious in June-July collecting pollen after the bulk of the *B. lucorum* queens have finished. Probably timed to allow workers to exploit late flowers - here often *Calluna*.

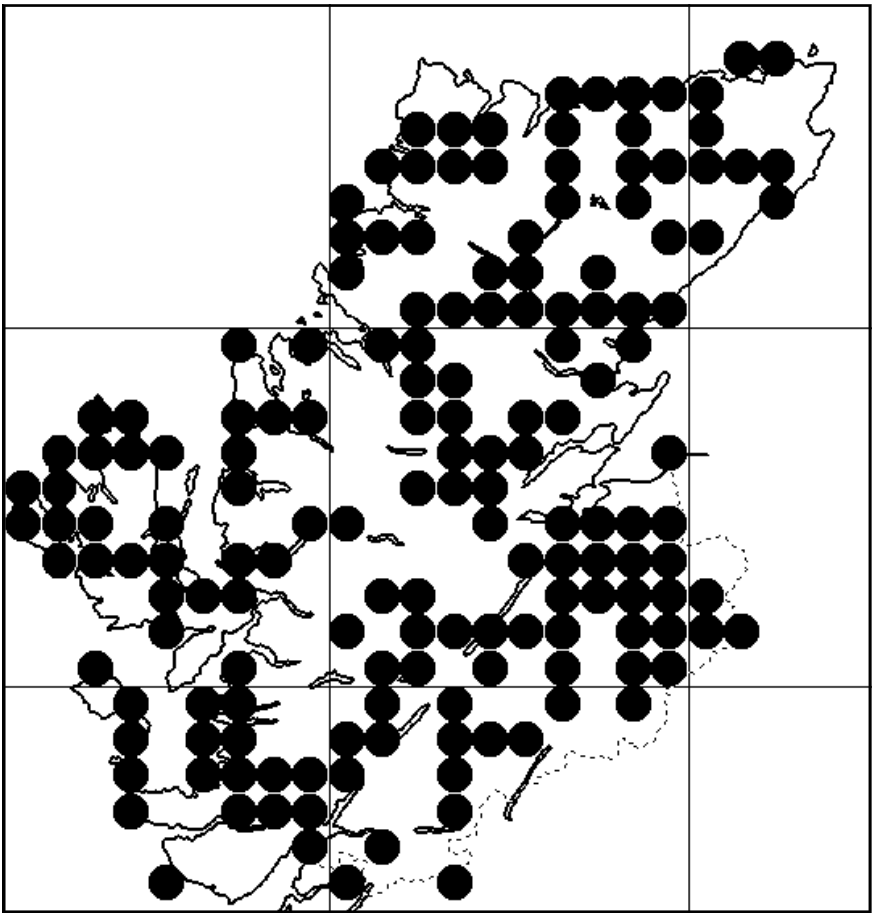
Forage: Queens feed at a wide variety of flowers, but predominantly at *Erica* spp., T*rifolium repens*, and *Rubus* spp. Workers usually on *Calluna*. Males are frequently found at *Succisa pratensis*.

Habitat: Usually found on *Erica* moorland or on forest edges. Nests in short burrows in moss or grass. Altitude range 0-710m.

Distribution and abundance: Present throughout the area. 161 squares. Generally uncommon, but locally frequent and in some years abundant. Found throughout the UK except N. Ireland.

Conservation: Maintain *Erica/Calluna* moorland and *Rubus* hedgerows.

Change since 1975: Probably little real change, though its known range is considerably expanded.



Comments: Clearly commoner than was once thought, identification difficulties in the past being at least partly responsible. Workers are especially easy to overlook, and records of males and workers are scarce because of their late season. Distribution and ecology unclear outside Highland. In view of concerns in England, Highland must be treated as an important refuge for the species.

References: Macdonald (2000b), Nisbet (2005).

Bombus lucorum White-tailed Bumblebee
Bombus cryptarum

Bombus lucorum (Linnaeus, 1761). BRC no. 15007. NBNSYS0000009836.
Bombus cryptarum (Fabricius, 1775). BRC no. 15019. No NBN number.

Recognition: *B. cryptarum* has only recently been recognised in Britain. It was previously included with *B. lucorum*. For distinctions see Fig. 4. Females with two yellow bands, white tail. Distinguished from *B. magnus* by the less extended collar, only slightly below the wing-bases and narrowing (Fig. 4). For distinctions from *B. soroeensis* see p. 16 and Fig. 5. Workers easily confused with *B. terrestris*, but tail pure white, lacking the thin brown line at the base. Some may be indistinguishable from *terrestris*. Males very variable, some like females, others very yellow on thorax and abdomen. Males not separable from those of *B. magnus*. Variation may relate to taxonomy in a way which is still unclear. See *B. magnus* and p. 22.

Phenology: The first bee active in spring (exceptionally active from mid-February), and one of the latest to finish. Chart shows both species combined, but *B. cryptarum* tends to emerge earlier.

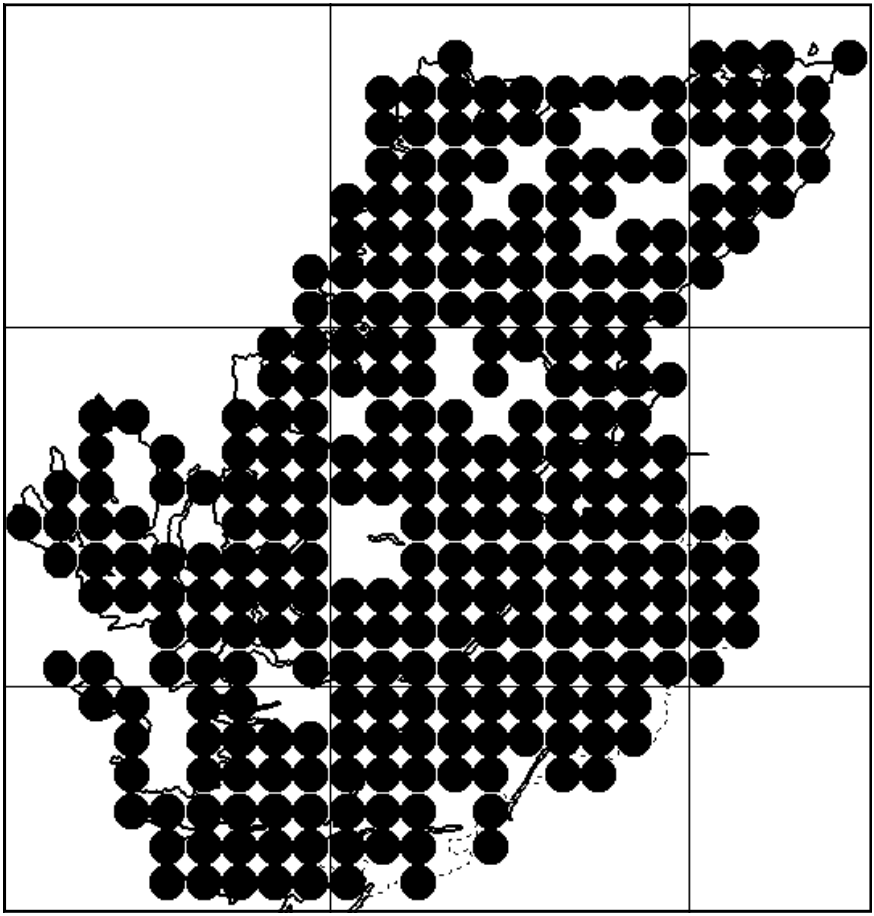
Forage: The most versatile feeder of our bumblebees. A good 'buzz-pollinator'; frequently high in trees, at nectarless flowers, and at honeydew; an accomplished robber of deep flowers.

Habitat: Can be found almost anywhere. Abundant at low altitudes and in gardens. Nests typically underground in deep burrows. Altitude range 0-1030m.

Distribution and abundance: Present throughout the area. 301 squares. Very common. Found throughout the UK except for Shetland.

Conservation: Maintain flower-rich grassland, gardens, verges and hedgerows. Encourage trees (*Salix*, *Prunus avium*, *Acer*, *Hippocastanum castaneum*).

Change since 1975: None in Highland, though recent records of *B. cryptarum* from Orkney and the Western Isles may indicate recent colonisation.



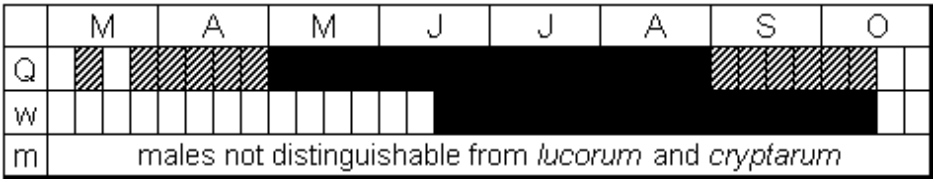
Comments: All records assigned to *B. lucorum sensu lato* (*B. lucorum*, *B. cryptarum*, male and worker *B. magnus*) are mapped here for comparison with the distribution in ITE (1980). See also maps on p. 22. *B. lucorum*, *B. magnus* and *B. cryptarum* form a taxonomically difficult group, on which research continues. *B. cryptarum* is easier to recognise than *B. lucorum sensu stricto.*, so records of the latter are scarce.

References: Bertsch *et al.* (2004), Macdonald (1998), Nisbet (2005).

Bombus magnus Northern White-tailed Bumblebee

Bombus magnus Vogt, 1911. BRC no. 15020. NBNSYS0000009837.

Recognition: Very like *B. lucorum*, but the collar of females is broader and extended well beyond and typically below the wing bases (Fig. 4). Tail, especially of fresh queens, can be buffish and has led to confusion with *B. terrestris*, but that species has a narrow, short, dark-yellow collar. Workers difficult to identify and many will be recorded as *B. lucorum sensu lato*. Males not distinguishable from those of *B. lucorum*. Sometimes regarded as a form of *B. lucorum*, but behaves in Highland as a different species. See also p. 22.



Phenology: Emerges late, with queens founding nests in June-July.

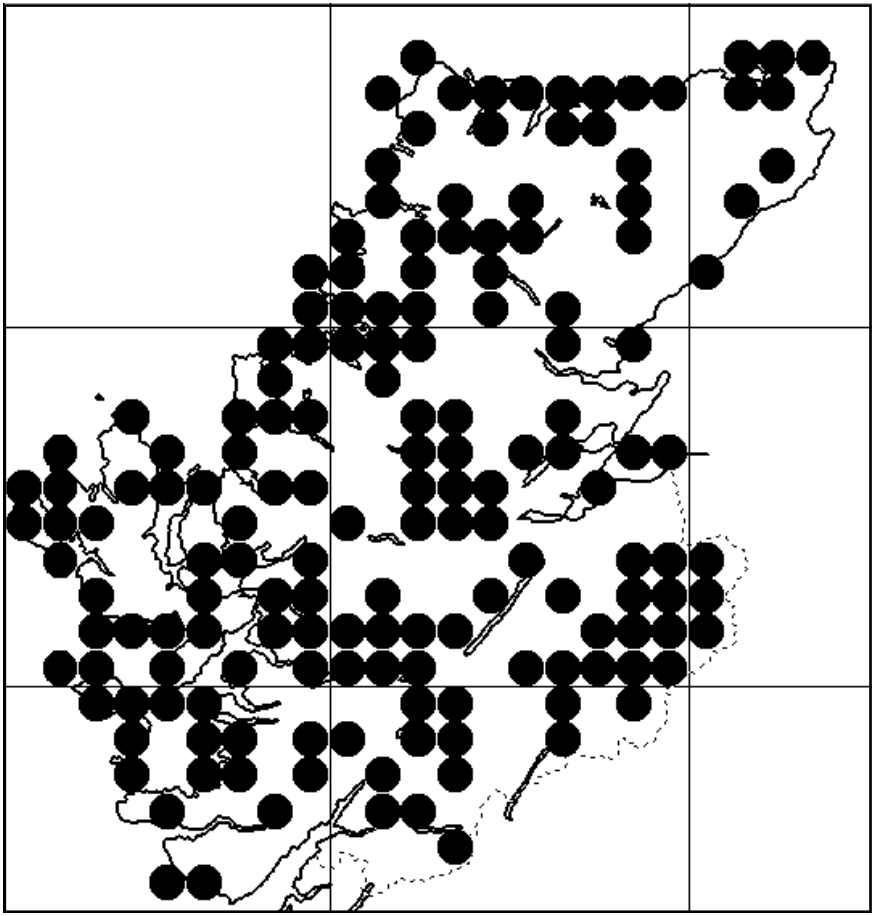
Forage: Probably as versatile as *B. lucorum* but usually lacking its opportunities. *Erica cinerea* and *Thymus polytrichus* are favoured forage.

Habitat: Usually found on *Erica*-rich moorland, but can be found in almost any habitat in the west, including coastal meadows. Altitude range 0-560m.

Distribution and abundance: Present throughout the area, but scarce at low altitudes in the east. 161 squares. Easily found in the north and west, where it may be more numerous than *B. lucorum*. Found throughout the UK apart from SE England, but concentrated in the west and north.

Conservation: Maintain moorland and machair with suitable flowers.

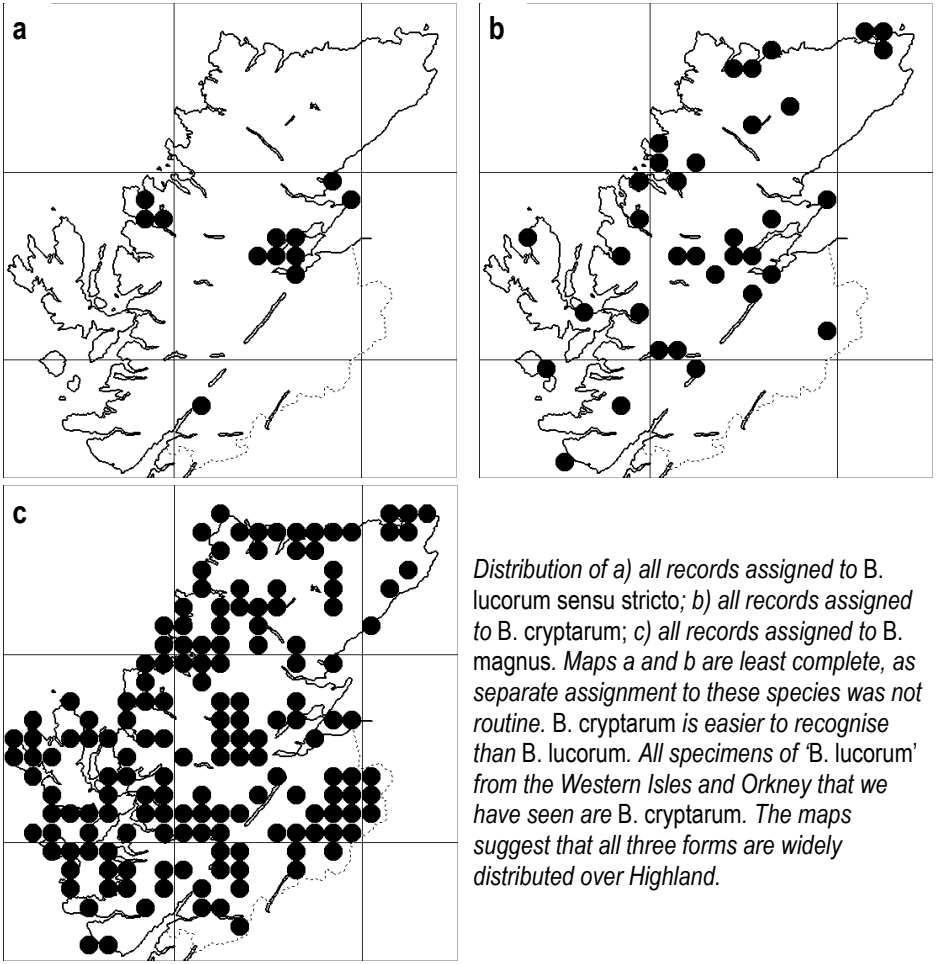
Change since 1975: No apparent change.



Comments: See under *B. lucorum* and the maps on p. 22. Future taxonomic work may require that distribution, phenology and ecology of the *lucorum* group is re-assessed. However, it is likely that if the specific status of *magnus* is upheld, this view of its distribution will remain essentially unaltered

References: Bertsch *et al.* (2004).

The *Bombus lucorum / cryptarum / magnus* group



Distribution of a) all records assigned to B. lucorum sensu stricto*; b) all records assigned to* B. cryptarum; *c) all records assigned to* B. magnus*. Maps a and b are least complete, as separate assignment to these species was not routine.* B. cryptarum *is easier to recognise than* B. lucorum*. All specimens of* 'B. lucorum' *from the Western Isles and Orkney that we have seen are* B. cryptarum*. The maps suggest that all three forms are widely distributed over Highland.*

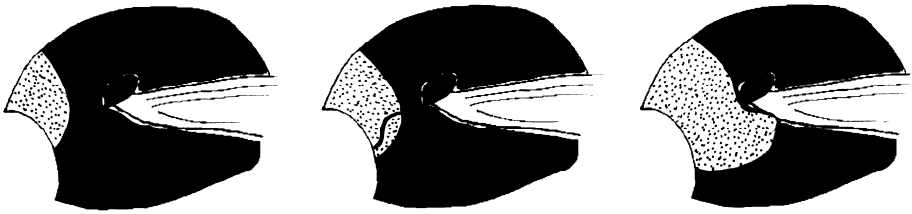


Figure 4. Diagrams of the thoraxes of queens of Bombus lucorum *(left),* B. cryptarum *(middle), and* B. magnus *(right) to show differences. In* B. lucorum s.s. *the collar narrows near the tip, whereas in* B. magnus *it maintains or increases its breadth.* B. cryptarum *has a slightly extended collar with a distinctive black 'S' visible in the field. (Stipple shows yellow hair; otherwise black with wings unshaded.)*

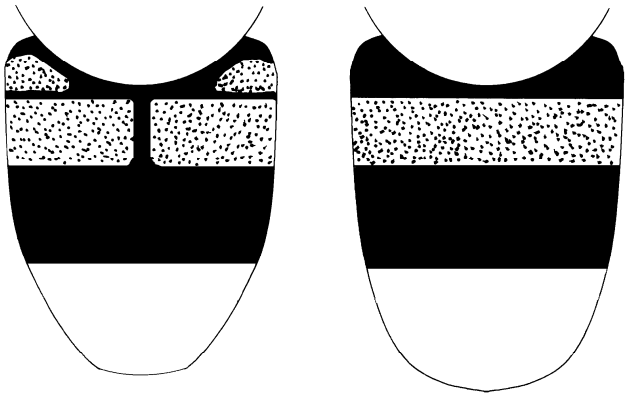
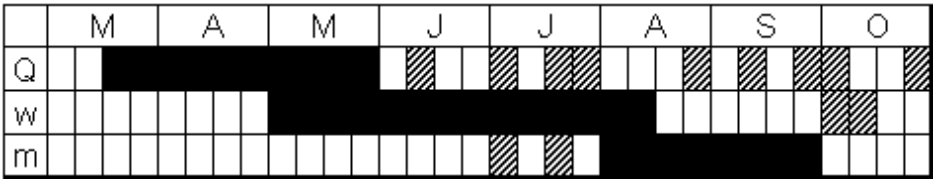


Figure 5. Diagrammatic illustration of the abdomen of queen Bombus soroeensis *(left) and* B. lucorum *(right) to show differences. Some* soroeensis *have much less yellow (exceptionally none) on the first segment, and the black divide in the yellow band may be obscure. (Stipple shows yellow hair; otherwise black and white.)*

Bombus terrestris Buff-tailed Bumblebee

Bombus terrestris (Linnaeus, 1758). BRC no. 15018. NBNSYS0000009838.

Recognition: Females with two yellow bands, buff or white tail. Queens noticeably darker than *B. lucorum*, the collar narrower and brownish, and tail buff to brown. Queens have been confused with fresh queens of *B. magnus* which has a much brighter, broader and longer collar (Fig. 4). Workers easily confused with *B. lucorum* but white tail has thin brown line at the base. Some are indistinguishable from *lucorum*. Males are similar to queens.



Phenology: Emerges early, similar to *B. lucorum*. Once recorded on 14 November.

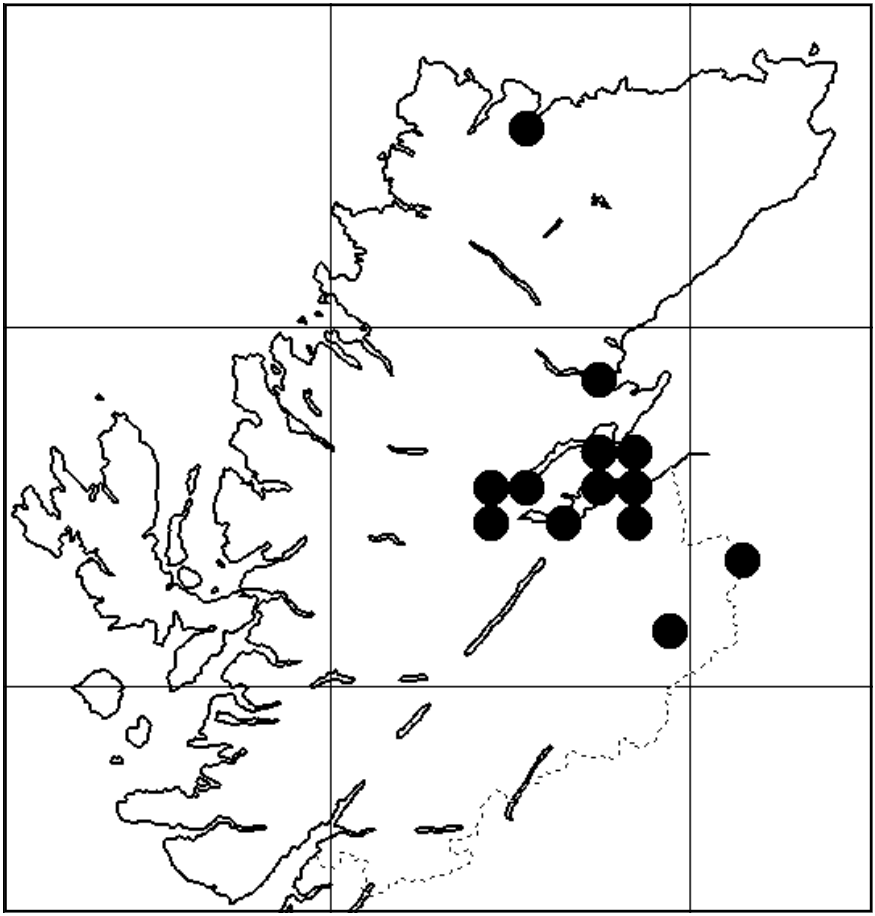
Forage: Probably as versatile as *B. lucorum* but rarity in Highland means data are poor. *Sonchus arvensis* on the shore is important in late summer.

Habitat: A lowland bee, found mostly on the coast and in gardens. Altitude range 0-240m.

Distribution and abundance: Scarce to frequent in the Moray coastal area, rare elsewhere. 13 squares. Found throughout the UK, except for much of Highland Scotland, Orkney, Shetland and the Hebrides. Found on Gigha in 2004 (Ben Darvill, pers. comm.).

Conservation: Maintain flower-rich gardens, verges and hedgerows, and coastal *Sonchus* stands.

Change since 1975: Has extended up the east coast from the Tay to the Dornoch Firth. The isolated N. Sutherland record involved breeding in at least two years.



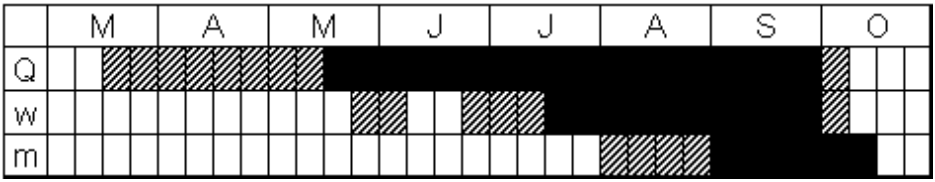
Comments: Further expansion northwards and inland may be anticipated, but it remains very scarce away from the Moray Firth coastal area. Appears to have difficulty establishing in more inland localities, and is much scarcer than *B. lapidarius* which has shown a similar expansion northwards.

References: Macdonald (2001).

Bombus jonellus Heath Bumblebee

Bombus jonellus (Kirby, 1802). BRC no. 15005. NBNSYS0000009842.

Recognition: Three yellow bands, white tail. Similar to *B. hortorum*, but face only as long as wide. Queens smaller on average than *B. hortorum*, bands less bright yellow, and appear later. Males similar to queens, but smaller, with noticeably long antennae and yellow hairs on face. Males can be confused with male *B. soroeensis*, but the latter usually lacks yellow on the rear of the thorax. On Shetland, the Western Isles, and rarely on Orkney, the tail is reddish.



Phenology: A late-emerging species. Queens seen occasionally from mid-March, but not common until mid-June, timed to coincide with flowering of *Erica*. Workers peak in August to take advantage of *Calluna vulgaris* flowers. Males seen late in season.

Forage: Most important forage plant for queens is *E. cinerea* and to a lesser extent *C. vulgaris* and *T. repens*. Where *Erica* is absent, *Thymus* will substitute. *C. vulgaris* is the main food plant of both workers and males.

Habitat: Common on heath and moorland. Queens occasionally visit gardens in spring. Nests in short burrows in peat or amongst moss or in the base of a grass tussock. Elsewhere reported from a squirrel's nest, bird's nests, and roof spaces. Altitude range: 0-935m

Distribution and abundance: Present throughout the area. Common and often abundant on moorland, but scarcer than *B. monticola* at high altitude. 273 squares. Present on all the Scottish island groups, with red-tailed races on Shetland and the Western Isles. Occurs widely in England, Wales, and N Ireland. Most extensive populations in Scotland.

Conservation: Maintain moorland, with plentiful flowering *Erica cinerea* and *Calluna vulgaris*.






Plate 1. Top L: *This grounded* Bombus cryptarum *queen shows the broad surface of the hind tibia which acts as the pollen basket.* ***Top R:*** *A male* B. lucorum/cryptarum. *These are very variable in the amount of yellow hairs (both © Murdo Macdonald).* ***Middle L:*** B. magnus *queen showing the very broad extended collar (© Bill Neill).* ***Middle R:*** *The* B. terrestris *queen has a buff tail and a dark narrow collar (© Jimmy McKellar).* ***Bottom L:*** B. jonellus *queens will use Wild Thyme, when Bell Heather is not available (© Murdo Macdonald).* ***Bottom R:*** *A queen* B. monticola *on Blaeberry, one of its most favoured forage plants (© Helen Boulden).*

Plate 2. Top L: *Male* B. lapidarius *are less distinctive than queens, and may be confused with other species.* ***Top R:*** *A queen* B. hortorum *with pollen load (both © Murdo Macdonald).* ***Middle:*** *The rare* B. distinguendus *on Black Knapweed, an important late summer forage. The black banding on the abdomen is cuticle, not black hair. The keys use only hair colour (© Bill Neill).* ***Bottom L:*** B. pascuorum *is universally abundant in Highland (© Donald Mitchell).* ***Bottom R:*** The very similar B. muscorum *is much rarer and has a distinctive silvery sheen on the abdomen. (© John Crossley).*



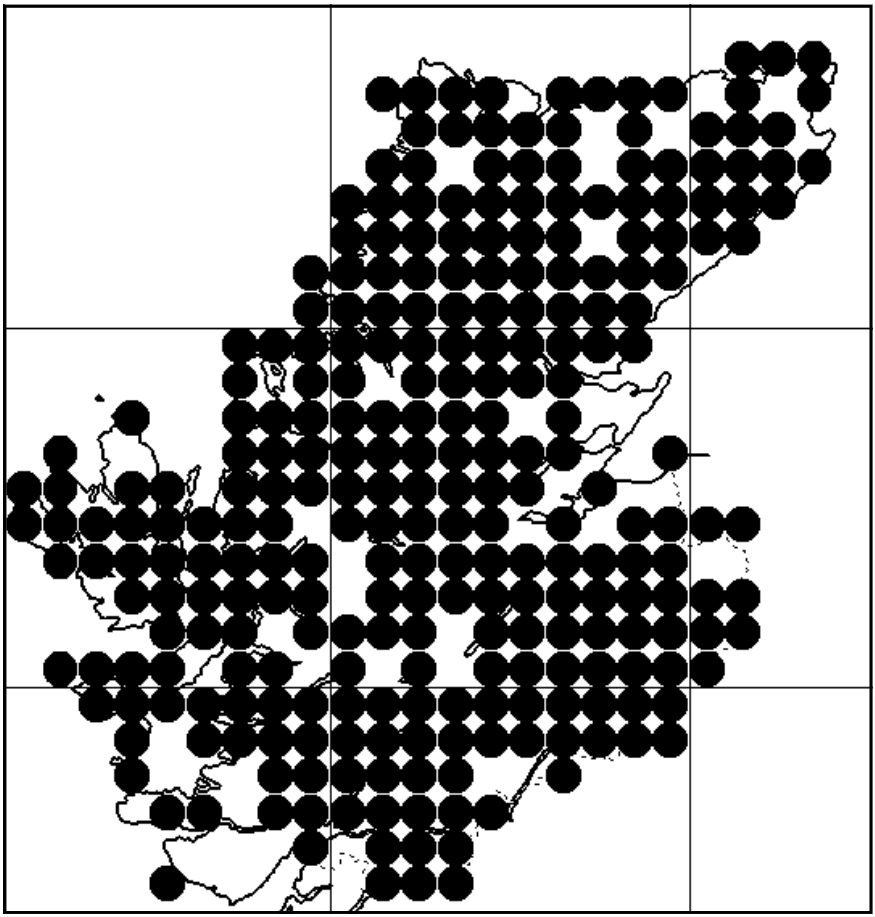



Plate 3. Top L: *Female* Bombus bohemicus *have only one yellow band, and do not collect pollen.* ***Top R:*** *A rare colour form of male* B. bohemicus *with a brownish tail. Usually the tail is white, and occasionally bright yellow.* ***Middle L:*** *Columbine is frequently robbed of nectar by* B. lucorum *biting through the spur.* ***Middle R:*** *Wild roses provide abundant pollen, but in the modified garden varieties (inset) the pollen may be inaccessible.* ***Bottom L:*** *Broad Beans are very dependent on long-tongued bumblebees like* B. hortorum *for pollination.* ***Bottom R:*** *Broom (and Gorse) lack nectar, but have copious pollen and are adapted to pollination by bumblebees (all © Murdo Macdonald).*





Plate 4. Top L: *Bell Heather is a very important forage plant for* Bombus soroeensis *and* B. jonellus *especially (© Murdo Macdonald).* ***Top R:*** *White and Red Clover on waste ground or verges will attract bumblebees.* ***Middle:*** *Foxgloves provide* B. hortorum *with much of their native forage in July, and these bees can be found even in remote places where Foxgloves flower (both © Gill Nisbet).* ***Bottom L:*** *The red bell-like flowers of Blaeberry provide essential forage for* B. monticola. ***Bottom R:*** *Wild Raspberry clumps are excellent forage for B. pratorum particularly (both © Murdo Macdonald).*



Change since 1975: Probably little change, though known range vastly extended. May have been under recorded in the past because of its often remote habitat.

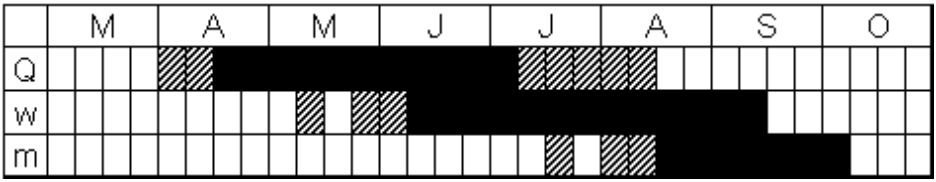
Comments: Strongly associated with *Erica* and *Calluna*, and absent where these are scarce as in Morvern and W Ardnamurchan.

References: Macdonald (2000a), Nisbet (2004a).

Bombus monticola Bilberry Bumblebee

Bombus monticola Smith,1849. BRC no. 15008. NBNSYS0000009843. English Nature Species Recovery Programme. Proposed for UKBAP list.

Recognition: Bright orange tail extending to two thirds of the abdomen. A single yellow band on the thorax but usually also a few yellow hairs on the rear edge. Queens intermediate in size between *B. lucorum* and *B. pratorum*. Workers similar to queens, but smaller. Males have a wide yellow collar and yellow hairs on the face. Might be confused with *B. pratorum*. This has a much less extensive orange tail which is tucked under, and a yellow abdominal band. Could also be confused with B. *lapidarius* males, but the red tail in *lapidarius* occupies less than half the length of the abdomen. Their ranges scarcely overlap at present.



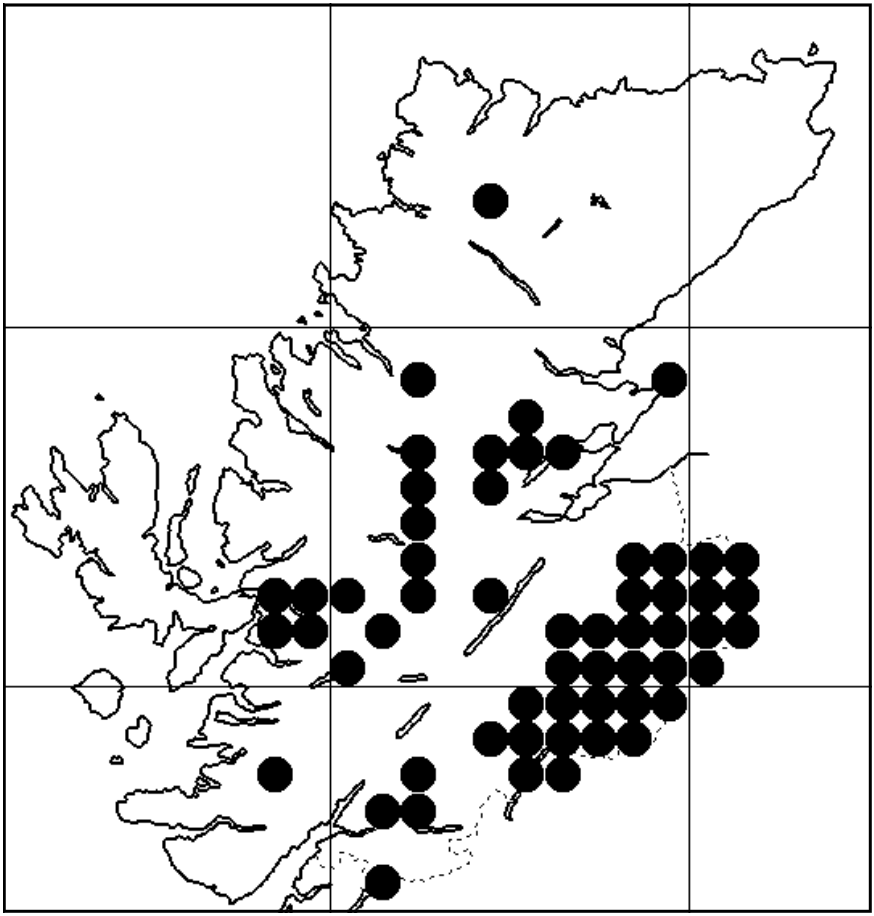
Phenology: A fairly short season. Emerges in April as *Vaccinium myrtillus* comes into flower. Workers normally finished by mid-September. Males often seen into October.

Forage: Queens typically on *Salix* and *V. myrtillus*. Workers also use these, then *Trifolium repens* and *Lotus corniculatus* until *Erica* is in flower, which is then preferred. *Calluna vulgaris* only utilised when *Erica* is not available. Males also forage on *C. vulgaris* and *Erica* spp., but towards the end of the season turn to *Succisa pratensis* and *Senecio jacobaea*.

Habitat: Moorland with *V. myrtillus* and *Erica*, often at quite high altitude. In spring, queens forage on *V. myrtillus* at forest edges, but do not nest here. Usually nests underground, in nests of small mammals. Altitude range: 100-1050m.

Distribution and abundance: Mainly in the Central Highlands where it can be abundant. Less frequent elsewhere, but regular in SW Ross and sporadic in E and W Ross and Sutherland. Absent from all islands including Skye. 57 squares. In upland areas throughout mainland Britain, but recent severe decline in England and Wales.

Conservation: Periodic burning of moorland to encourage *Vaccinium* and *Erica*. Encourage *L. corniculatus* and *T. repens* at woodland margins, moorland edges and tracksides.



Change since 1975: In Highland there may have been a northward extension of range but away from the Grampian Highlands populations appear small, variable and sometimes transient. Declining in England and Wales, possibly due to lack of management of grouse moors and consequent loss of *V. myrtillus*.

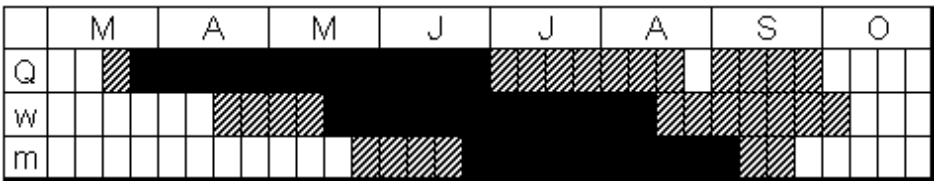
Comments: A beautiful bee, strongly associated with *V. myrtillus*. At high altitude it can outnumber all other bumblebee species including *B. lucorum* and *B. jonellus*. Declining in the UK and possibly Highland Scotland to a lesser extent.

References: Nisbet (2004b).

Bombus pratorum Early Bumblebee

Bombus pratorum (Linnaeus, 1761). BRC no. 15012. NBNSYS0000009844.

Recognition: Queens with two yellow bands (that on abdomen broken in middle) and dull orange tail. Tail is held tucked under when foraging. Quite a small bee. Workers variable in size, some very small, and lacking yellow band on abdomen. Males similar to queens but face yellow. Yellow bands often wider with long hairs, giving a rough and untidy appearance.



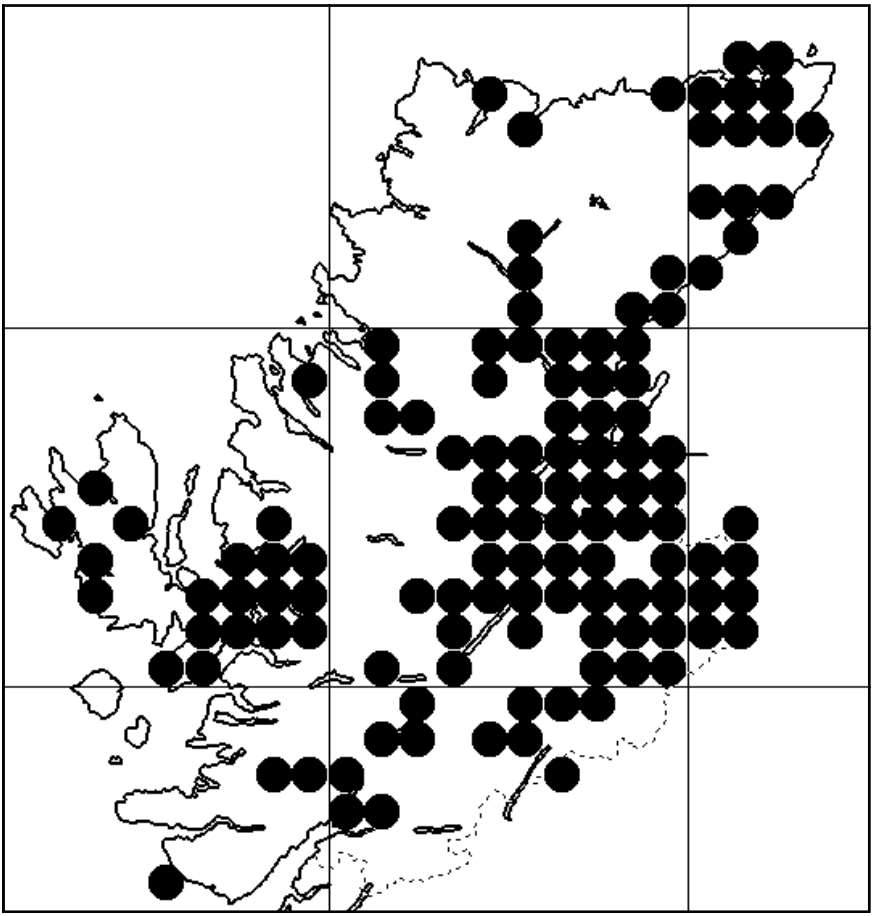
Phenology: Emerges early. One of the first bees to be seen in the garden. The first species to finish its cycle, with workers normally finished by the middle of August.

Forage: Uses a wide range of forage. Early queens use *Ribes sanguineum* and *Pulmonaria* in gardens. *Vaccinium myrtillus* is important in some areas until *Rubus idaeus* flowers. Often associated with *R. idaeus*, but where this is scarce uses *Trifolium repens*, *Lotus corniculatus* and *Erica*. Handles pendulous flowers well owing to its small size. Small workers can enter some deep flowers to reach nectar that is otherwise inaccessible. Males frequently found at *Succisa pratensis*.

Habitat: Gardens, forest edges, moorland, road verges. Usually a lowland bee, but sometimes on open moorland up to 450m. Nests in a variety of sites, often above ground, in disused nest-boxes and roof spaces. Altitude range 0-450m (once at 850m).

Distribution and abundance: Mainly in the east, but has recently spread through much of Skye. 124 squares. Absent from the Northern and Western Isles. One of the 5 common bumblebees in gardens in the east of the area. Found throughout the UK.

Conservation: Maintain flower-rich gardens, verges, forest edges and *Rubus* hedgerows.



Change since 1975: Now widespread on Skye but probably little other real change.

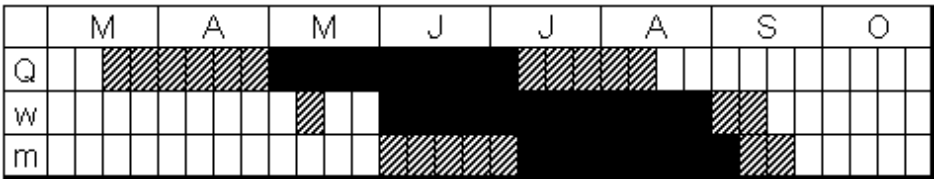
Comments: Strongly associated with *R. idaeus* in the western Highlands, but can use garden flowers as a substitute where available.

References: Nisbet (2005).

Bombus lapidarius Red-tailed Bumblebee

Bombus lapidarius (Linnaeus, 1758). BRC no. 15006. NBNSYS0000009840.

Recognition: Females jet black with bright red to orange tail, no yellow. Workers like queens, but smaller. Males with one or more yellow bands and red tail (fading to yellow) could be confused with male *B. pratorum*, which is less elongate and has a dull orange tail; or with *B. monticola* which has more extensive area of orange on abdomen (p.28). Otherwise, confusion only possible with *B. ruderarius* (no recent records from Highland) which has short, almost round abdomen. Females distinguished by the colour of the long hairs fringing the pollen baskets – black in *lapidarius*, reddish in *ruderarius*.



Phenology: A species with a short nesting cycle.

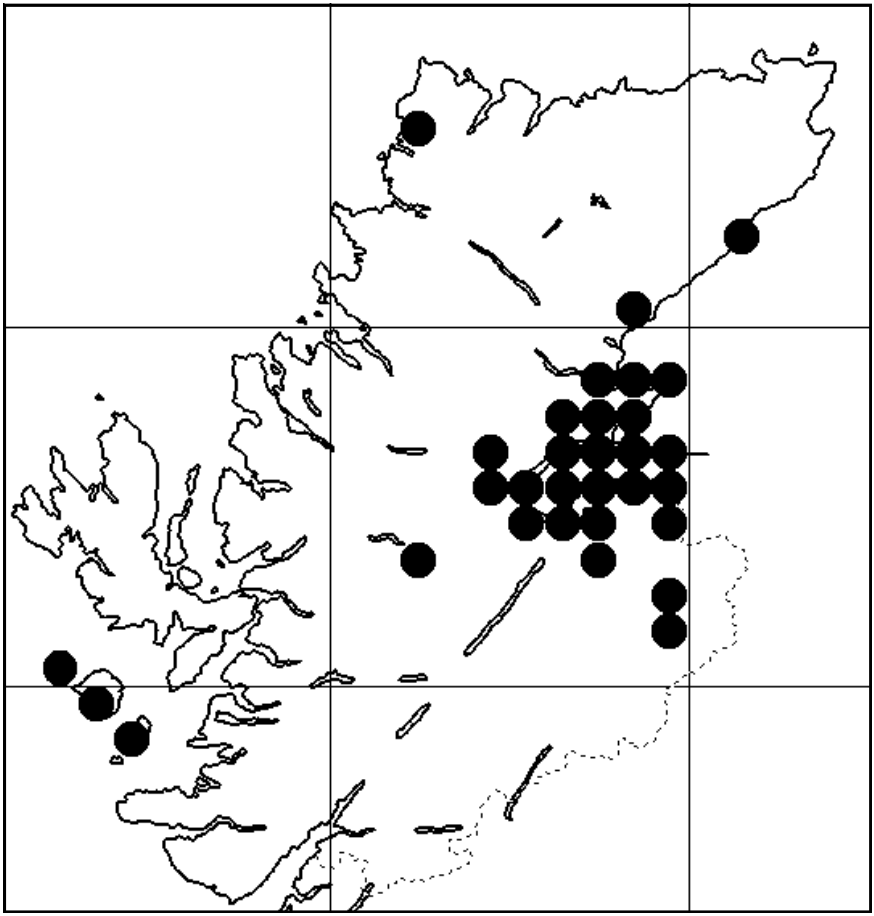
Forage: A generalist. Attracted to yellow Asteraceae, and *Sonchus arvensis* on the shore is very important in Highland.

Habitat: A lowland bee, found mostly on the coast and in gardens. Altitude range 0-280m.

Distribution and abundance: Frequent in the Moray Firth coastal area, rare elsewhere. 31 squares. Found throughout the UK, except for NW Scotland, Orkney, Shetland and the Western Isles. Relict population on Coll and Tiree. Found on Gigha and Lunga in 2004 (Ben Darvill, pers. comm.).

Conservation: Maintain flower-rich gardens, verges and hedgerows, and coastal *Sonchus* stands.

Change since 1975: Has extended up the east coast from the Tay to the Dornoch Firth. The isolated N. Sutherland record was of a single vagrant queen. Recent records from the Small Isles are probably immigrants from Coll and Tiree.



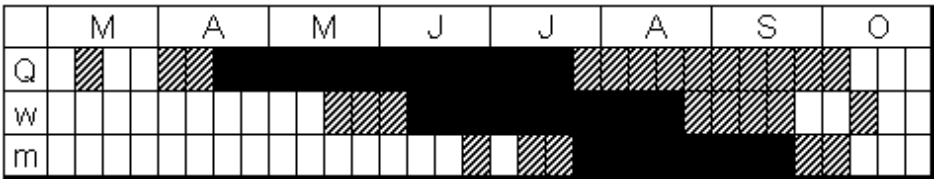
Comments: Further expansion northwards and inland may be anticipated. Has shown big changes in distribution in the past century, retreating from Orkney and N and W coasts before 1960, then colonising up the east coast since 1975. Signs of spread in the Inner Hebrides in 2003-05 should be monitored.

References: Macdonald (2001).

Bombus hortorum Garden Bumblebee

Bombus hortorum (Linnaeus, 1761). BRC no. 15003. NBNSYS0000009848.

Recognition: Three yellow bands and a white tail. Long narrow face; long tongue which is distinctive in the field as it remains extended in flight between flowers. Queens can be large. All castes larger, on average, than similar *B. jonellus*, which has a short face and (in queens), less bright yellow bands. Males similar to queens, but can be distinguished by obviously blunt tip to abdomen.



Phenology: Queens emerge later than *B. lucorum* in April. Activity largely finished by end of August.

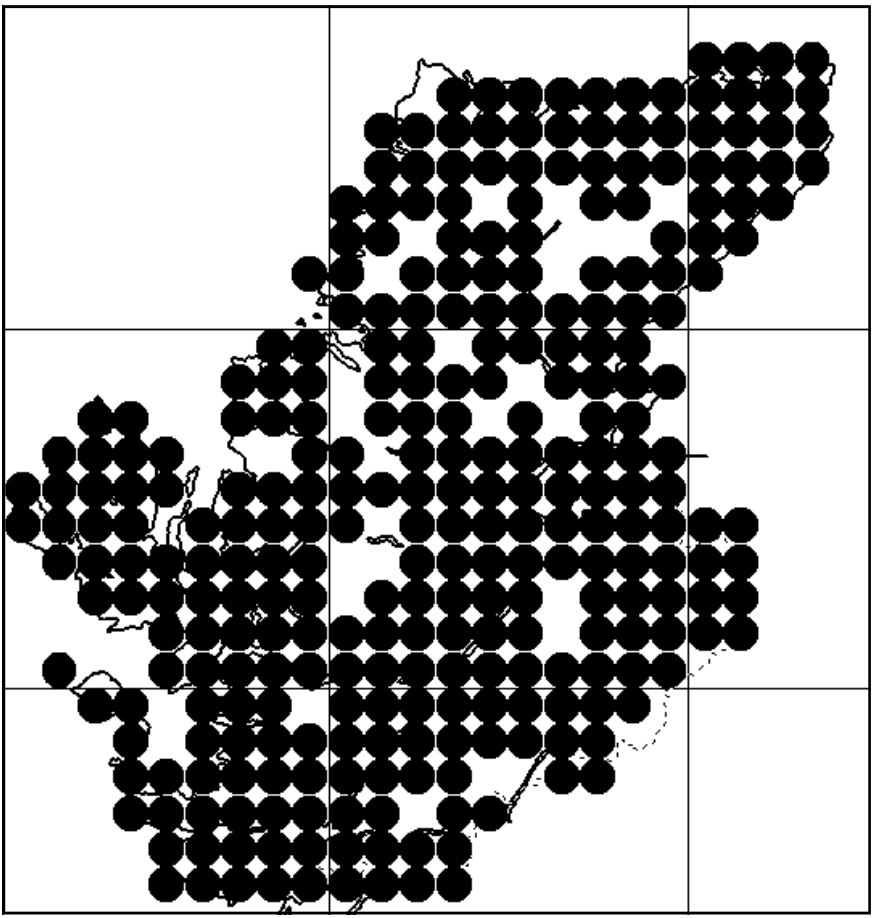
Forage: Long-tongued bee adapted to feeding from flowers with long corolla-tube such as *Lonicera periclymenum*, *Digitalis purpurea* and *Trifolium pratense*. Males frequently found at *Succisa pratensis*. Attracted to *Salvia*, *Nepeta*, *Aconitum* and *Linaria purpurea* in gardens.

Habitat: A lowland bee, found mostly in gardens and grassland, also forest edges and road verges. Particularly associated with *D. purpurea* and can be found far up valleys where this occurs. Nests among plant roots or litter, just above, or in short burrows below the soil surface. Altitude range: 0-450m (exceptionally to 1110m in the Cairngorms).

Distribution and abundance: Present throughout the area. One of the 5 common bumblebees found in gardens in the east of the area. 295 squares. Found throughout the UK including all island groups.

Conservation: Encourage the flowering of *Digitalis*, *Vicia* and *T. pratense*.

Change since 1975: No apparent change.



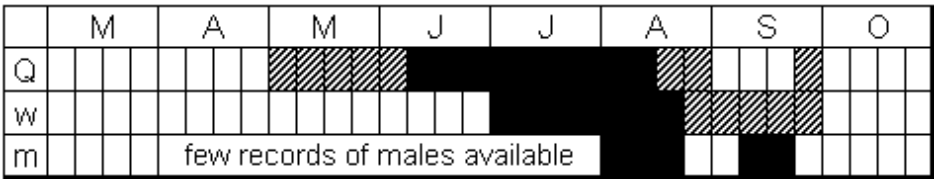
Comments: Most long-tongued bumblebees are declining in range. This is a notable exception.

References: Macdonald (1998), Nisbet (2005).

Bombus muscorum Moss Carder Bee

Bombus muscorum (Linnaeus, 1758). BRC no. 15009. NBNSYS0000009851. English Nature Species Recovery Programme. Proposed for UKBAP list.

Recognition: Thorax typically foxy-red and abdomen pale yellow with a silvery sheen. No bands on thorax or abdomen. Often indistinguishable from *B. pascuorum*, i.e. uniformly yellow/ brown, especially when old and faded. Normally no black hair on sides of abdomen. Where *B. muscorum* is suspected, a specimen should be taken for confirmation. In females the sting sheath can be used (Fig. 6). Males differ in antennal characters (Fig. 7) and the genital capsule. See also comments under *B. pascuorum*.



Phenology: Details uncertain due to lack of records. Main season seems to be June to August.

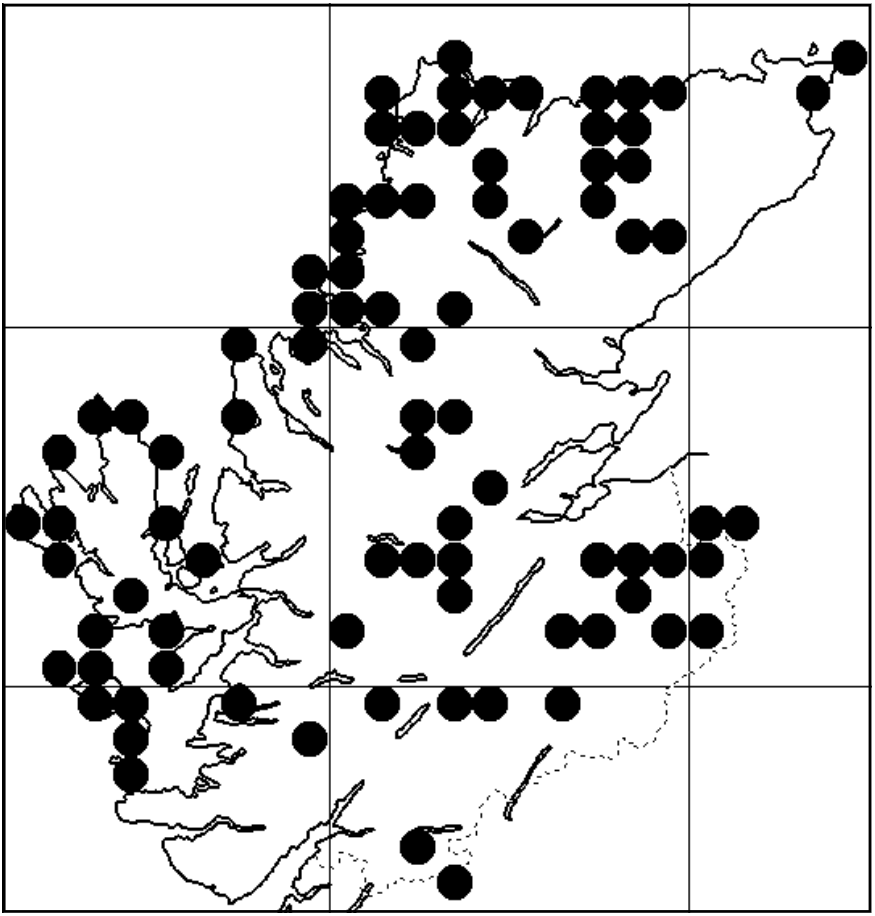
Forage: On coast, *Trifolium*, *Vicia* and *Lotus corniculatus*. On heaths, *Erica* spp., especially *E. tetralix* and also *Cirsium*.

Habitat: Coastal grassland, machair and heath. Inland associated with wet heath with *Erica tetralix*. Nests in vegetation on or just below the soil surface. Altitude range: 0-480.

Distribution and abundance: Majority of records from west and north coasts. Much more scattered inland. Never abundant. 85 squares. Thinly scattered in UK, mainly coastal, but range complicated by confusion with *pascuorum*. Distinct race on Shetland, Western Isles, Coll and Tiree has extensive black hair below.

Conservation: Maintain machair and coastal grassland with vetches and clovers. Inland, maintain wet heaths.

Change since 1975: Difficult to say because of problem of identification. Previously under-recorded. Probably little real change in Highland, though giving cause for concern in England.



Comments: Probably under-recorded due to difficulty in distinguishing from *B. pascuorum*. Old records may be suspect. For positive identification, anatomy must be examined.

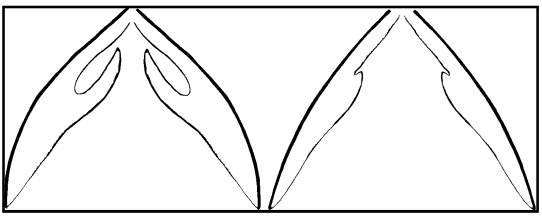


Figure 6. Sting sheaths of female B. muscorum *(left) and* B. pascuorum*. The sheath is exposed by pulling with forceps on the tip of the sting of a dead bee until the sting apparatus is fully exposed. A lens is required.*

Bombus pascuorum Common Carder Bee

Bombus pascuorum (Scopoli, 1763). BRC no. 15010. NBNSYS0000009852.

Recognition: Thorax uniformly light brown to foxy-red. Abdomen yellow/brown. No bands on thorax or abdomen. Can only be confused with *B. muscorum*. Old keys use presence of black hairs on sides of abdomen to recognise *pascuorum*, but this now known to be unreliable - some specimens have no black hair. In the field, abdomen does not show silver sheen characteristic of *muscorum*. Some specimens may be indistinguishable from *muscorum* in the field, when anatomical features must be used. In females the sting sheath can be used (Fig. 6). Males differ in antennal characters (Fig. 7) and the genital capsule. S Scottish and English specimens more distinct with much more black on abdomen.

Phenology: Emerges in April later than *B. lucorum* and *B. pratorum*. One of the last bees to finish.

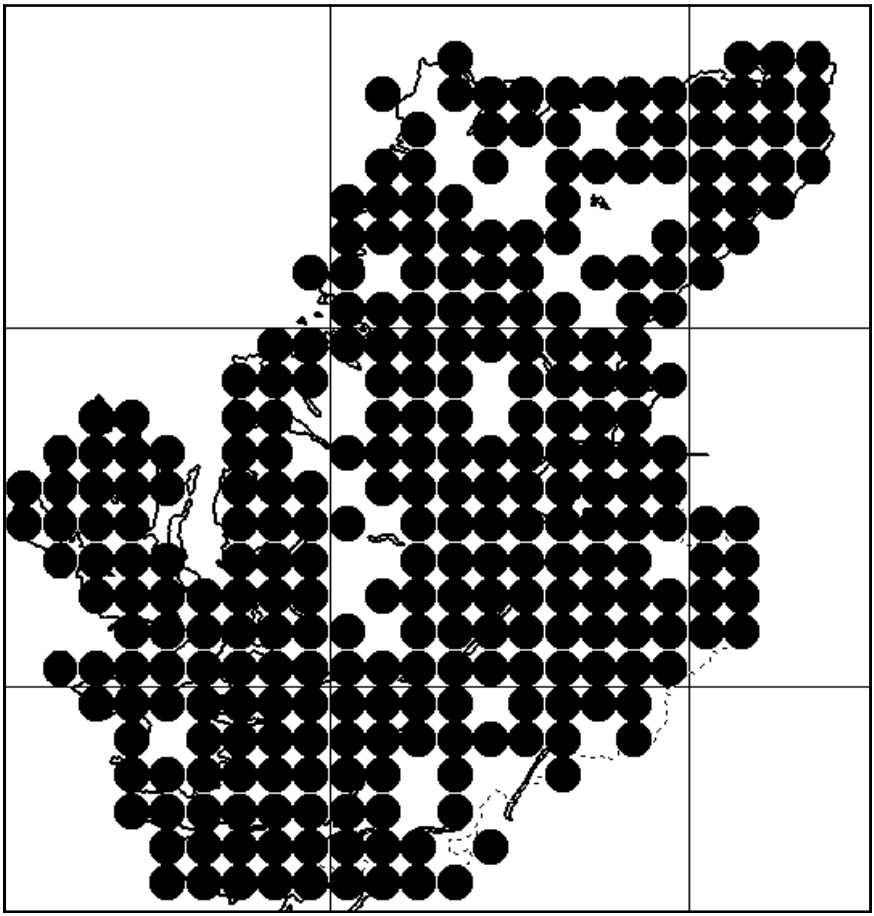
Forage: A long-tongued bee favouring flowers with a long corolla-tube such as *Trifolium*, *Vicia* and *Digitalis*. Feeds from a wide variety of garden and native plants.

Habitat: A lowland bee, found in parks and gardens, road verges, grassland, hedgerows and edges of farmland. Nests in vegetation above or just below the soil surface. Altitude range: 0-520m.

Distribution and abundance: Widespread and common throughout the area, except for the highest ground. 292 squares. Found throughout the UK except the Western Isles and Shetland.

Conservation: Maintain flower-rich gardens, verges, grassland and hedgerows.

Change since 1975: No apparent change in Highland but has recently colonised Orkney.



Comments: Another long-tongued species showing no decline in range. The commonest of the carder bees, so-called from their habit of combing the nest material as in carding wool.

References: Macdonald (1998), Nisbet (2005).

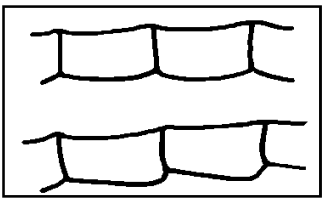
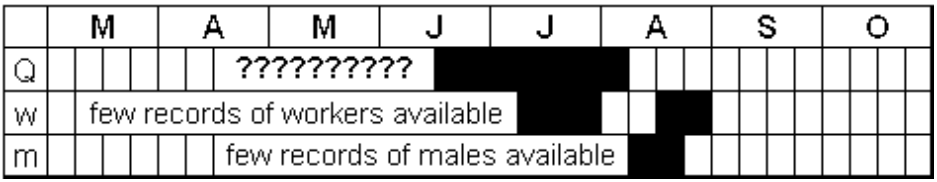


Figure 7. Mid-antennal segments of male Bombus muscorum *(top) and* B. pascuorum *showing the difference in shape. The tip of the antenna is to the right.*

Bombus distinguendus Great Yellow Bumblebee

Bombus distinguendus Morawitz, 1869. BRC no. 15002. NBNSYS0000009846.
Nationally scarce b; UKBAP Priority List.

Recognition: All sexes and castes identifiable by the combination of yellowish-brown abdomen, no contrasting bands or tail-patch, and band of black hair between the wings. Care required with occasional worn *muscorum* or *pascuorum* showing black cuticle on thorax, but that is typically circular and always shiny. English name can be misleading if used for identification — *muscorum*, *pascuorum* and male *lucorum* have been reported as this species because of their yellowish appearance.



Phenology: A late bee, queens founding nests in late June and July.

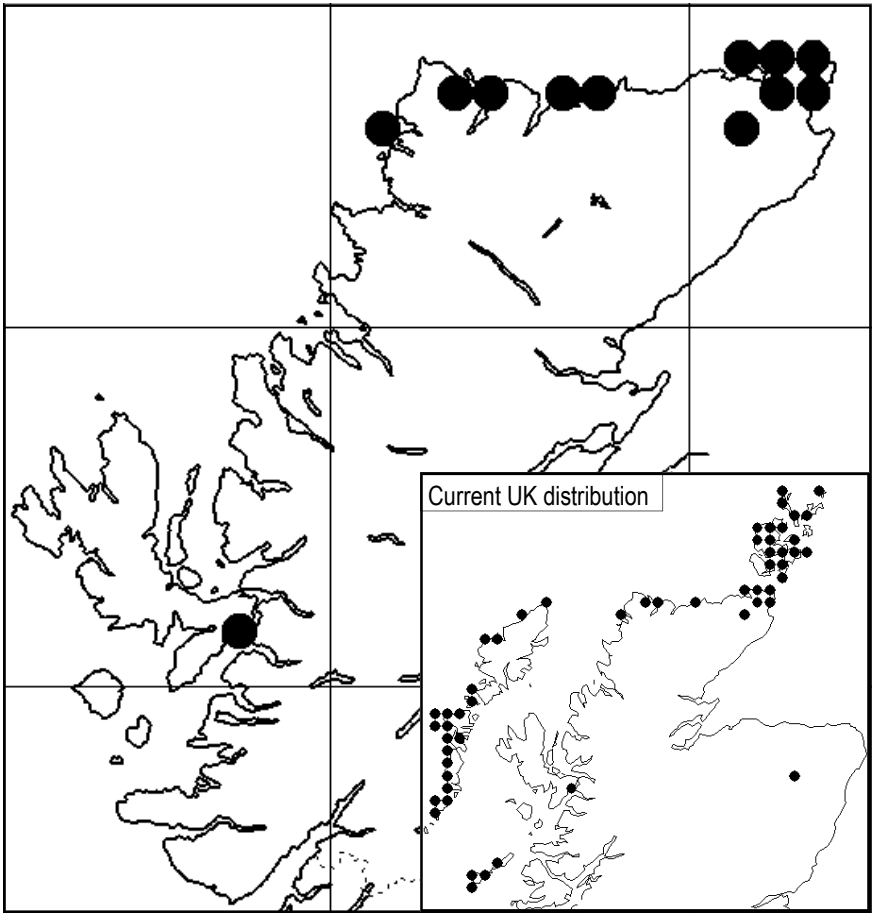
Forage: In Sutherland: *Vicia cracca*, *Trifolium pratense* and *Centaurea*. In Caithness: *Anthyllis vulneraria*, *Cirsium palustre*, *T. pratense* and *Centaurea*.

Habitat: A lowland bee, found mostly on coastal dunes and cliffs, but possibly overlooked inland. Altitude range 0-80m.

Distribution and abundance: Scarce on the north coast, found also in inland Caithness. Queen briefly present in S Skye, 2004. 12 squares. Extinct throughout the UK, except for Western Isles, Coll, Tiree, Orkney and N Highland (UK distribution post 1990 shown in inset map).

Conservation: Maintain extensive areas of the key forage plants and allow them to flower freely.

Change since 1975: Historical decline continued.

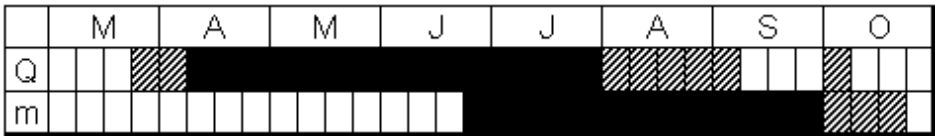


Comments: Further declines will take place unless habitat restoration and conservation measures are introduced. The small and scattered Highland population is at serious risk without effective habitat management to maintain key forage plants.

Bombus bohemicus Gypsy Cuckoo Bumblebee

Bombus bohemicus (Seidl, 1837). BRC no. 15102. NBNSYS0100002025. Hosts: *Bombus lucorum*, *B. cryptarum*(?), *B. magnus*(?).

Recognition: Females with yellow band on thorax only. White tail with cuticle showing as a dark wedge in middle. Small yellow patches (tend to fade) at front corners of white tail. Abdomen appears elongate. Females have prominent callosities on underside of tip of abdomen (Fig. 8). Males usually have two yellow bands and scattered yellow hairs on other parts of the body; sometimes have yellow tails.



Phenology: Females emerge in early April, a few weeks after *B. lucorum/cryptarum* (the main host species). Males are obvious from July until the end of September on *Cirsium* spp.

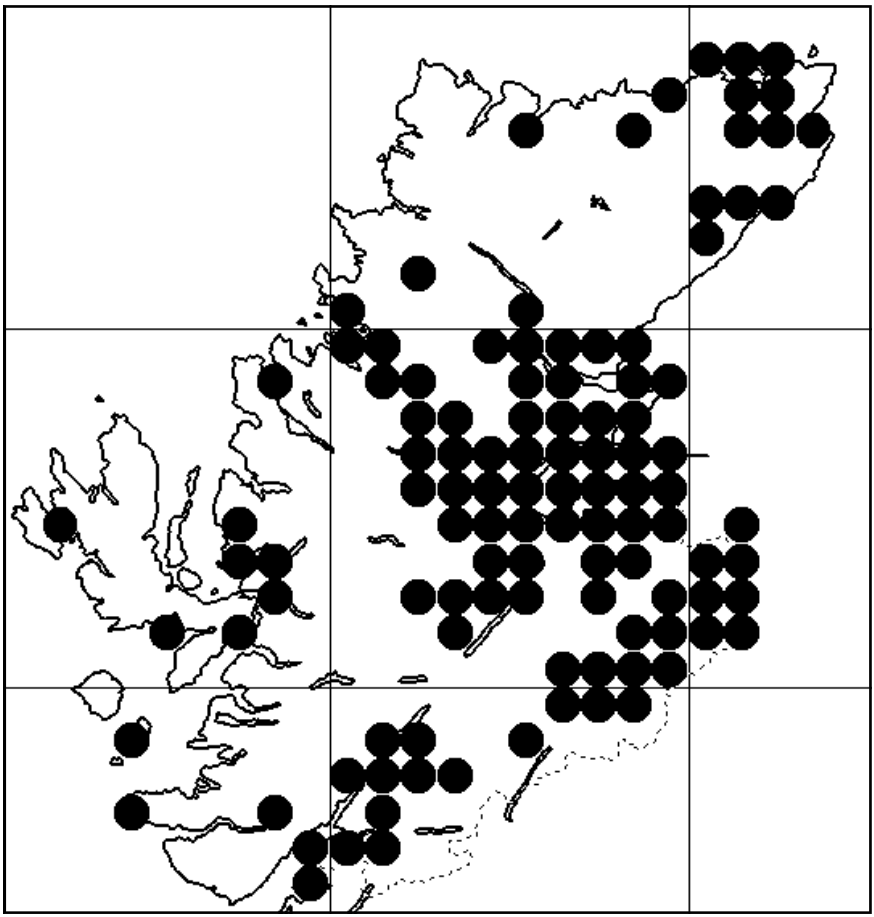
Forage: Appears to favour composite flowers, especially *Cirsium*. Males often found on S*uccisa pratensis*. Often feeds at flowers, such as *Taraxacum*, not normally used by other *Bombus*.

Habitat: Gardens, grassland, road verges, forest edges. Males frequently on moorland in late summer. Altitude range 0-565m.

Distribution and abundance: Widespread and fairly common in the E and S of Highland. Very scattered in N and W. 110 squares. Found throughout UK except Shetland. Occurs in Stornoway in W. Isles. In England, most common in N and W, also Wales.

Conservation: Maintain flower-rich gardens, verges, grassland and hedgerows. Also moorland.

Change since 1975: No apparent change.



Comments: Like the other cuckoo bumblebees much less widespread than its host. Factors limiting distribution are unclear.

References: Macdonald (1998), Nisbet (2005).

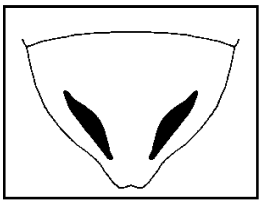
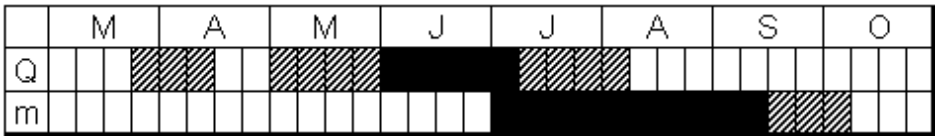


Figure 8. Underside of the tip of the abdomen of female Bombus bohemicus *showing the position of the callosities (ridges) which are important in identification of female cuckoo bumblebees.*

Bombus sylvestris Forest Cuckoo Bumblebee

Bombus sylvestris (Lepeletier, 1833). BRC no. 15105. NBNSYS0100002029. Hosts: *Bombus pratorum*, *B. jonellus*(?).

Recognition: Females with yellow band on thorax only. White tail with cuticle showing as a dark wedge in middle. No yellow patches at front corners of white tail. Tip of tail black (females) or reddish (males). Females have smaller, less conspicuous callosities than *B. bohemicus*, and tip of abdomen is distinctively tightly curled under. On average smaller than *B. bohemicus*. Male abdomen is distinctive: yellow, black, white, black, red. White on tail can be replaced by yellow.



Phenology: Females emerge in May and the first males are produced in July.

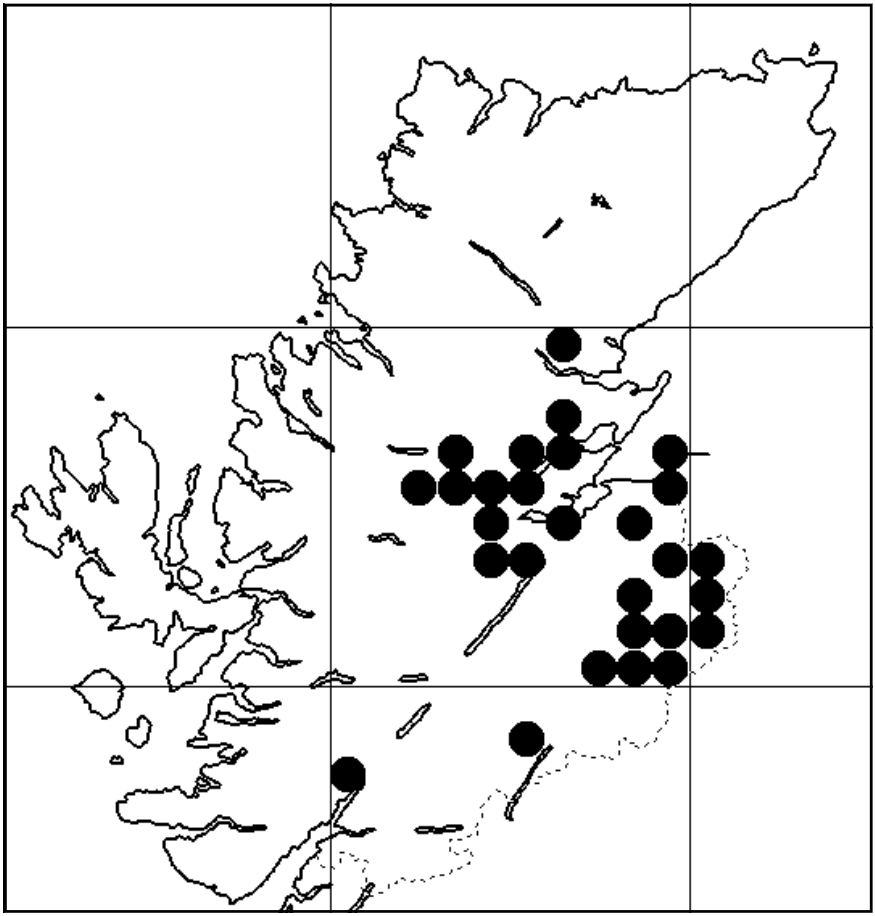
Forage: Thistles and other composite flowers. Males often feed on *Succisa pratensis*.

Habitat: Mainly associated with edges of coniferous woodland. Altitude range 0-500m.

Distribution and abundance: Mostly confined to E and Central Highland region, but never abundant. 28 squares. Scattered records from throughout the UK.

Conservation: Maintain floral diversity at forest edges and banks of forest tracks.

Change since 1975: Recorded in the N and W of Highland for the previous Atlas, but rarely recently. This implies a significant contraction in range SE-wards, but the reasons are obscure.



Comments: Most records are of the distinctive males. Females less obvious and probably under-recorded. Mostly confined to E and C Highland, although its hosts (especially *B. jonellus*) are common throughout the area, so other factors must be limiting its range.

Bombus ruderarius Red-shanked Carder Bee

Bombus ruderarius (Mueller, 1776). BRC no. 15013. NBNSYS0000009853. English Nature Species Recovery Programme. Proposed for UKBAP revised list.

Recognition: Very similar to *B. lapidarius*, but generally smaller, with a shorter abdomen. Females have characteristic reddish, rather than black, hairs surrounding the pollen baskets.

Distribution and abundance: Only recent Scottish records are from Coll and Tiree where it is widespread. Very scarce in S England. No map.

Change since 1975: There are old records from Highland from N Sutherland down the west coast to Skye, the Small Isles and Lochaber (also on the Western Isles).

Comments: It seems certain that this species, now rare in Britain as a whole, is lost from Highland. As long as the Coll and Tiree populations remain, there is a chance of re-colonisation to the SW of the area. These islands are very important refuges for this bee.

Bombus barbutellus Barbut's Cuckoo Bumblebee

Bombus barbutellus (Kirby, 1802). BRC no. 15101. NBNSYS0100002024. Host: *Bombus hortorum*.

Recognition: Might be overlooked as *B. bohemicus*, but females have a well developed yellow band on the rear of the thorax, and callosities below tip of abdomen broadly U-shaped. Tips of the male genitalia rounded (Fig. 9).

Distribution and abundance: Not recorded in Highland 1990-2005. Known to occur on Coll and Tiree, and also in Aberdeen. No map.

Change since 1975: There are old records from Skye, Inverness-shire and Lochaber (also on Orkney, where it is no longer present). Reasons for this apparent contraction in range are not known.

Comments: The host of this cuckoo bumblebee is one of the most widespread species in Highland, so its loss and continued absence from the area must have other causes.

Bombus campestris Field Cuckoo Bumblebee

Bombus campestris (Panzer, 1800). BRC no. 15103. NBNSYS0100002026. Host : *Bombus pascuorum*.

Recognition: Females and some males recognised from their very dark appearance, the darkest of all the Scottish species. Callosities very large. Males of the light forms have a bright yellow tail, but some males of *B. bohemicus* and *B. sylvestris* also have this feature. Tips of the male genitalia very robust (Fig. 9).

Phenology: Too few records to describe.

Forage: Nothing known from Highland.

Habitat: Three records from a garden, one from open scrub. Altitude range 20-107m.

Distribution and abundance: Exceptional in Highland, recorded 4 times since 1990 in NM66 (1 record in 1990) and NH45 (3 records in 1991, 1992, 2004). 2 squares. All contacts recorded. Found throughout UK except N and W Scotland. No map.

Change since 1975: No evidence that this species has ever occurred other than sporadically in Highland. Old records from Caithness and Ardnamurchan.

Comments: As with the other cuckoo bumblebees, the host is abundant and widespread, so other factors must be restricting its distribution.

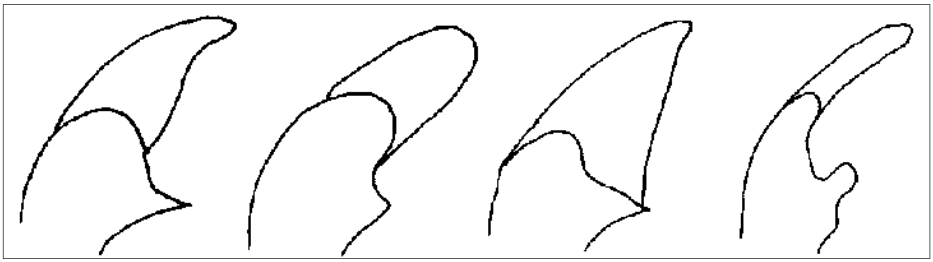


Figure 9. Volsellae (tips of the arms of the genital capsules) of male cuckoo bumblebees. From L to R, Bombus bohemicus*,* B. barbutellus*,* B. campestris *and* B. sylvestris*. The genital capsules can be extruded by firm pressure with a fingernail just behind the tip of the underside of the abdomen in a dead male bumblebee, when the volsellae are easily examined.*

Keys to the Highland species

These keys will help to put a name to Highland bumblebees. *B. ruderarius* and *B. barbutellus* are not included, though they occur in Scotland and might very rarely be met in the area. Characters in square brackets [ ] require a lens or microscope. Definitions are given on p. 51. Colours refer to hairs. Beware of coloured pollen-stains, which can radically alter appearance.

For critical identification use Prŷs-Jones & Corbet (1991) or Benton (2006).

Key A: Is it a bumblebee (including cuckoo bumblebees), and what sex is it?	
1a Body not obviously hairy.	Definitely not a bumblebee.
1b Hairy body, no narrow 'waist', *short* antennae of three segments.	Hoverflies or other dipterans.
1c Hairy body, narrow 'waist', *long* elbowed antennae.	Probably a bumblebee (can be confused with solitary bees). 2
2a Abdomen sharply pointed at tip, sting present, [antennae with 12 segments - see definitions]. Present from (Feb)/March on.	**Key to females (below)**
2b Abdomen blunt, no sting, [antennae with 13 segments - see definitions]. Normally not before mid-June.	**Key to males (p. 50)**

Key to females: Main colour groups.	
1a Abdomen mainly yellow/brown, no clear black or yellow bands of hair (though bands of black cuticle may show through).	**Key B**
1b Otherwise.	2
2a Tail (rear third of abdomen) brown, orange or red.	**Key C**
2b Tail white or whitish, or dull yellow.	**Key D**

Key B: Abdomen mainly yellow/brown, no clear black or yellow bands of hair.	
1a Thorax with a clear band of black hairs between the wing bases.	***B. distinguendus***
1b Thorax uniform (but beware of worn individuals which may show an area of shiny black cuticle).	2
2a Thorax often deep foxy red; abdomen pale yellow with silvery sheen. Scarce. (Some inseparable from *B. pascuorum* in field.)	***B. muscorum***
2b Thorax usually browner, abdomen pale brown with variable amounts of black at sides. Very common and widespread.	***B. pascuorum***

Key C: Tail (rear third of abdomen) brown, orange or red.	
1a Body entirely black, except for the red tail.	***B. lapidarius****
1b Body with at least one yellow band.	2
2a Most of abdomen reddish orange.	***B. monticola***
2b Less than half of abdomen brown, orange or red.	3

3a Two rather dark brownish-yellow bands, tail pale buff to brown.	***B. terrestris* queens**
3b Bands bright yellow, not brownish.	4
4a Tail dull orange, often hidden from above. 1 (some workers) or 2 yellow bands.	***B. pratorum***
4b Tail pale buff.	***B. magnus* (fresh queens)**

* *B. ruderarius* will also key out here.

Key D: Tail white or whitish, or dull yellow.

1a Tail dull yellow, general appearance very dark.	***B. campestris***
1b Tail white or whitish.	2
2a Three yellow bands (1 on collar, 1 on rear edge of thorax, 1 on abdomen). **	3
2b One or two yellow bands (1 on collar, 0 or 1 on abdomen).	4
3a Face long and narrow, tongue very long, [pollen baskets black].	***B. hortorum***
3b Face about as long as wide, tongue shorter, [pollen baskets reddish].	***B. jonellus***
4a Two yellow bands. [Pollen basket on hind leg.]	5
4b One yellow band. Tail white, cuticle showing as a dark wedge in the middle. [Ridges (callosities) beneath tip of abdomen (see Fig. 8). No pollen basket.]	8
5a Yellow on abdomen broken by a line of black hairs (often inconspicuous). Usually a small patch of yellow hair at sides of first abdominal segment (see Fig. 5).	***B. soroeensis***
5b No black hairs in the abdominal band (beware of worn specimens with black cuticle showing through). No yellow on first abdominal segment.	6
6a Yellow collar ends well below the wing base, not narrowing.	***B. magnus***
6b Collar ends at or only slightly below the wing base, narrowing.	7
7a Tail white, with a thin brown line at the base (care required).	***B. terrestris* workers**
7b Tail pure white, no brown line at the base. See Fig. 4 for distinctions.	***B. lucorum, B. cryptarum***
8a A small yellow mark (often fading) at front corners of the white tail. Last two segments mainly white-haired. Abdomen appears elongate.	***B. bohemicus***
8b No yellow marks in the white area, last two segments black-haired. Abdomen tightly curled under, appearing more rounded.	***B. sylvestris***

** *B. barbutellus* will also lead to couplet 3.

Key to males: Main colour groups

1a Abdomen mainly yellow/brown, no clear black or yellow bands of hair (though bands of black cuticle may show through).	**Key E**
1b Otherwise.	2
2a Tail (end of abdomen) at least partly buff, brown, orange or red.	**Key F**
2b Tail white, black, or yellow.	**Key G**

Key E: Abdomen mainly yellow/brown, no clear black or yellow bands of hair.

1a Thorax with a clear band of black hairs between the wing bases.	***B. distinguendus***
1b Thorax uniform (but beware of worn individuals which show a band of shiny black cuticle).	2
2a Thorax deep foxy red; abdomen pale yellow with silvery sheen. Scarce. [Antennal segments symmetrical, see Fig. 7.] (Some indistinguishable from *B. pascuorum* in field.)	***B. muscorum***
2b Thorax usually browner, abdomen brown with variable amounts of black at sides. [Antennal segments asymmetrical, see Fig. 7.] Very common and widespread.	***B. pascuorum***

Key F: Tail (rear third of abdomen) at least partly buff, brown, orange or red.

1a Most of abdomen reddish orange.	***B. monticola***
1b Less than half of abdomen brown, orange or red.	2
2a Tail dull orange, compact. Yellow bands often wide; hairs long and uneven.	***B. pratorum***
2b Tail red, buff or brown, more elongate.	3
3a Tail bright red, fading to yellowish. 1-3 yellow bands.	***B. lapidarius****
3b Tail pale buff to reddish brown.	4
4a Tail pale buff to reddish brown, (occasionally similar to workers, tail white with brown base), collar thin and brownish, no yellow on face. Broad-bodied.	***B. terrestris***
4b Tail pale to dark reddish brown, antennae relatively very long. Yellow face. Slender.	***B. soroeensis*** **(part)**

* *B. ruderarius* will also key out here.

Key G: Tail white, black, or yellow.

1a Very dark, tail black, sometimes some yellow at the sides.	***B. campestris*** **(dark form)**
1b Otherwise.	2
2a Tail white or yellow, black wedge of cuticle showing through hairs. [Genitalia as in Fig. 9.]	3
2b Tail white, no black wedge of cuticle showing through hairs.	5

3a	Extreme tip of abdomen reddish.	***B. sylvestris***
3b	Otherwise.**	4
4a	Usually white-tailed, with small yellow mark (often fading) at front corners of white tail-patch. Sometimes tail all yellow.	***B. bohemicus***
4b	Sides of abdomen yellow. [Check genital capsule, Fig. 9.]	***B. campestris*** **(light form)**
5a	Three distinct yellow bands (1 on collar, 1 immediately behind wing bases, 1 on abdomen).	6
5b	Two yellow bands, or extensively yellow; black on thorax between wings; black band in front of white tail.	7
6a	Face black, noticeably long and narrow, tongue very long.	***B. hortorum***
6b	Face yellow, about as long as wide, tongue shorter.	***B. jonellus***
7b	Slender, 2 yellow bands, antennae noticeably long. Often with scattered reddish hairs in tail.	***B. soroeensis*** **(part)**
7b	Broad-bodied. Two yellow bands, or extensively yellow on thorax and abdomen. Very variable.	***B. lucorum, B. cryptarum, B. magnus*** **(not separable)**

** *B. barbutellus* will also lead to couplet 4.

Explanation of terms

Abdomen:	The rear section of the insect body, behind the legs and wings. In bees the obvious 'abdomen' is the *gaster*, as part of the true abdomen is in front of the narrow waist.
Antennae:	The 'feelers', made up of 12 (females) or 13 segments (males). The first segment is elongated, and the second very small. Care is required when counting segments.
Callosities:	Paired ridges found on the underside below the very tip of the abdomen in female cuckoo bumblebees. Important in identification (see Fig. 8).
Collar:	The band immediately behind the head, often coloured yellow.
Colour:	The colour of the hairs. 'Yellow' can vary from bright yellow to a duller brownish-yellow. Pollen deposits may alter the apparent colour.
Cuticle:	The hard outer skeleton, always black. May be exposed if hair is worn off.
Genital capsule:	The male genitalia, important in identification. The shape of the volsella in cuckoo bumblebees is especially useful (see Fig. 9).
Pollen basket:	Long bristles (*corbicula*) on the hind legs of females, used to carry the pollen mass.
Tail:	The last few segments of the abdomen, occupying about one third of its length, often distinctively coloured white, buff, yellow or reddish.
Thorax:	The middle part of the insect body, carrying the wings and legs. In bumblebees, often has 1 or 2 yellow bands important in identification.

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Societies

Bees, Wasps and Ants Recording Society (BWARS). www.bwars.com.
Buglife. 170A Park Road, Peterborough PE1 2UF. www.buglife.org.uk.
Highland Biological Recording Group (HBRG). www.hbrg.org.uk
International Bee Research Association (IBRA). 18 North Road, Cardiff CF10 3DT. www.ibra.org.uk.

Appendix 1: Plant names in English and Latin

Latin	English	Latin	English
Acer	Maples	*Medicago sativa*	Alfalfa
Aconitum	Monk's-hoods	*Nepeta*	Catmint
Anthyllis vulneraria	Kidney Vetch	*Origanum majorana*	Marjoram
Aquilegia vulgaris	Columbine	*Pedicularis sylvatica*	Lousewort
Arctostaphylos uva-ursi	Bearberry	*Prunus avium*	Gean (Wild Cherry)
Berberis	Barberries	*Pulmonaria officinalis*	Lungwort
Borago officinalis	Borage	*Ribes sanguineum*	Flowering Currant
Buddleia	Butterfly Bush	*Rosa*	Roses
Calluna vulgaris	Heather	*Rubus fruticosus*	Bramble
Centaurea nigra	Black Knapweed	*Rubus idaeus*	Raspberry
Chamerion angustifolium	Rose-bay Willow-herb	*Salix*	Willows, sallows
Cirsium palustre	Marsh Thistle	*Salvia officinalis*	Sage
Cirsium vulgare	Spear Thistle	*Senecio jacobaea*	Ragwort
Cotoneaster	Cotoneaster	*Sonchus arvensis*	Field Sow-thistle
Cytisus scoparius	Broom	*Stachys palustris*	Marsh Woundwort
Digitalis purpurea	Foxglove	*Succisa pratensis*	Devil's-bit Scabious
Erica carnea	Winter Heath	*Taraxacum*	Dandelions
Erica cinerea	Bell Heather	*Thymus polytrichus*	Wild Thyme
Erica tetralix	Cross-leaved Heath	*Trifolium pratense*	Red Clover
Filipendula ulmaria	Meadowsweet	*Trifolium repens*	White Clover
Hippocastanum castaneum	Horse Chestnut	*Ulex europaeus*	Gorse
Lathyrus pratensis	Meadow Vetchling	*Vaccinium myrtillus*	Blaeberry
Linaria purpurea	Purple Toadflax	*Vaccinium vitis-idaea*	Cowberry
Lonicera periclymenum	Honeysuckle	*Vicia cracca*	Tufted Vetch
Lotus corniculatus	Bird's-foot Trefoil	*Vicia faba*	Broad Bean
Lycopersicon esculentum	Tomato	*Vicia sepium*	Bush Vetch

This book describes the current state of the 16 species of bumblebee found in the Highland region of Scotland. It is designed for everyone: the interested layman, amateur naturalists, professional biologists, land managers and gardeners.

There is information on all aspects of the biology and ecology of these valuable insects in a Highland context, but with wider relevance. The data collected over 16 years by the authors and members of the Highland Biological Recording Group will help to inform conservation projects and land management, and provide a baseline against which to measure future changes in distribution.

The main chapters cover

- Biology of bumblebees – an introduction to the life of bumblebees.
- Habitats – important Highland environments.
- Forage and pollination – plants and bumblebees are inextricably linked.
- Conservation of bumblebees – a vital task where everyone can help.
- Species accounts – maps and information on the Highland species.
- Keys to Highland species – to help beginners and others with identification.

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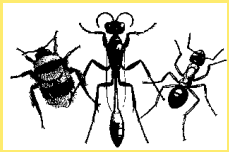

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