

Mitteilungen des Entomologischen Vereins Stuttgart

In Zusammenarbeit mit dem Staatlichen Museum für Naturkunde in Stuttgart

Jahrgang 51, Heft 1, 10. September 2016

ISSN 0937-5198



Bombus invaders (Hymenoptera: Apoidea) in Iceland: Correlation of human-assisted introduction and global change

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Introduction: Only one bee species is native in Iceland: *Bombus jonellus subborealis* Richards, 1933. Four other bumblebee species were introduced (not intended): *B. hortorum* (Linnaeus, 1761) in 1959; *B. lucorum* (Linnaeus, 1761) in 1979; *B. hypnorum* (Linnaeus, 1758); *B. pascuorum* (Scopoli, 1763) in 2010. Furthermore *B. terrestris* (Linnaeus, 1761) is used for tomato pollination in greenhouses (after 2002). From 1975 to 2008 Iceland has warmed up by about 1.2°C (Björnsson & Jónsson 2009). Extensions of *B. sylvarum* and *B. subterraneus* in Finland are associated with the warming up of the climate (Pekkarinen et al. 1981). *B. terrestris* has also extended its range northwards in Scandinavia (Løken 1973). *B. terrestris* and *B. lapidarius* colonised Northern Scotland (Macdonald 2001). Many islands in Northern Scotland were colonised by different bumblebee species: In 2014 *B. terrestris* s.l. was detected in the Shetland Islands (Macdonald & Harvay 2014), the Orkney Islands (Prŷs-Jones & Williams 2015) and Fair Isle. All introductions were caused by human impact, probably in cargo of ferry ships (Prŷs-Jones & Williams 2015). The consequence is that the population size of the native species will probably be reduced. This may lead to extinction. The current distribution of *Bombus* species in Iceland will be shown and we discuss probable trends of further development.

Material and methods: Personal observations in 2014 yielded the result of extensions of *B. lucorum* primarily in the north-east region of Iceland. The distribution of species is summarised (maps with 25x25km grids; older detections replaced by younger ones) in a review (Kratochwil 2016) using own data, literature data and data of different internet data bases, e.g. 'Global Biodiversity Information Facility' (GBIF 2015). Iceland covers 197 grids, but about 10 % are at least partly covered with ice and snow. About 177 grids are not ice- or permanently snow-covered.

Results: *B. jonellus subborealis*: Wide-spread and the dominant species (58 grids, 33 %, Fig. 1); in contrast to the introduced species stenoecious-hylophilous and with positive correlation to high frequency of winter thaws and negative correlation to higher temperatures in summer. *Salix* species are of high importance as pollen resources (we noticed: *S. callicarpaea*, *S. lanata*, *S. phyllicifolia*) as well as other indigenous species. The invader *Lupinus nootkatensis* is frequently visited. The species

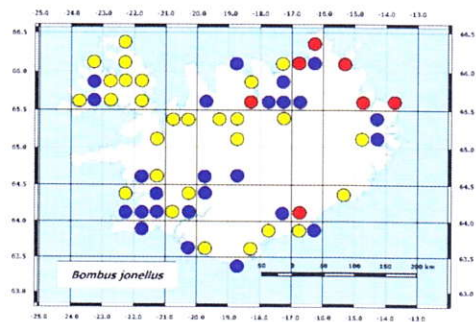


Fig. 1: Distribution of *B. jonellus*. Yellow circles: grids with records before 1960, blue circles: records between 1960 and 1980, red circles: own data 2014.

was not detected in cultivated areas until yet (Tab. 1). *B. lucorum*: 4 grid records between 1960 and 1980, 7 grid records from 2014 (in total: 9 grids, 5 %); Fig. 2. The species shows negative correlation with thaws and positive with higher thickness of protecting snow cover and dry weather conditions in summer. *B. lucorum* benefits from global warming and has similar flower visiting behaviour as *B. jonellus*. Colonies are large; the species is very competitive (Tab. 1). *B. hortorum*: 12 grid records (7 %); anthropogenic influences (garden plants) favour this long tongued bumblebee species (Tab. 1). *B. hypnorum*: 5 grid records. Nesting sites are in settlements (Tab. 1). *B. pascuorum sparreanus*: 2 grid records in settlements (two colonisation events?); Tab. 1. *B. terrestris*: imported to Iceland for tomato pollination in greenhouses.

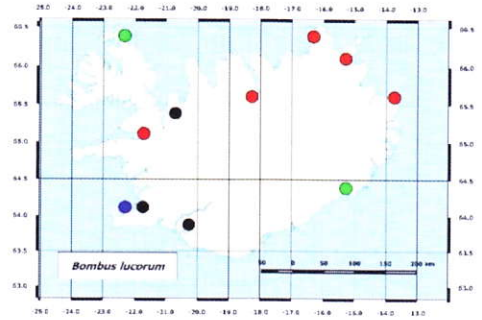


Fig. 2:

Distribution of *B. lucorum*. Blue circles: grids with records between 1960 and 1980 (green circles), red circles: own data 2014, black circles: 3 records of 'Global Biodiversity Information Facility' (GBIF 2015). red circles: own data 2014.

Outlook: In Iceland global warming effects may reduce *B. jonellus* populations (adapted to cooler summer temperatures) and favour introduced *Bombus* species which are sensitive to low temperatures. *B. lucorum* may expand in many regions of Iceland far from settlements but also in cultivated and settlement areas. *B. hortorum* and *B. pascuorum* are restricted to settlement areas with gardens. *B. lucorum* may compete with both species. *B. hypnorum* is also restricted to settlement areas, concerning special nesting behaviour. *B. terrestris* is probably not adapted to survive outside greenhouses in Iceland. Concerning the studied *Bombus* species in Iceland the process of a species turnover is going on.

Tab. 1: Ecological characterisation of *Bombus* species in Iceland.

species	ecological amplitude	abiotic key factors	flower visiting behaviour	habitat preferences	reproduction
<i>B. jonellus subborealis</i>	stenoecious-hytophilous	positive correlation with high frequency of winter thaws and low temperatures in summer	high importance of <i>Salix</i> -species and indigenous plant species, but also the invader <i>Lupinus nootkatensis</i>	<i>Salix</i> and <i>Betula</i> shrubs, <i>Calluna</i> <i>Vaccinium</i> heathland; no cultivated areas	small colony size; two generations per year
<i>B. lucorum</i>	euryoecious-hytophilous	negative correlation with thaws and positive with higher thickness of protecting snow cover and dry weather conditions in summer	high importance of <i>Salix</i> -species and indigenous plant species, but also the invader <i>Lupinus nootkatensis</i> ; very competitive.	similar to <i>B. jonellus</i> , but also in cultivated areas	larger colony size; one generation per year
<i>B. hortorum</i> <i>B. pascuorum</i> <i>B. hypnorum</i>	euryoecious-hytophilous	similar to <i>B. lucorum</i>	high importance of plant species of cultivated areas and settlements	cultivated areas and settlements	similar to <i>B. lucorum</i>

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