Family or fashion? Colour patterns in arctic bumblebees.

ARTICLE · MARCH 2016

1 AUTHOR:

Paul Hugh Williams

NHM, London / CAAS IAR, Beijing

161 PUBLICATIONS **11,172** CITATIONS

Bombus alpinus

Image credit: Arnstein Staverløkk

Family or Fashion? Colour Patterns in Arctic Bumblebees

Written by: Paul H. Williams (Natural History Museum, UK / CAAS Institute for Apicultural Research, China)

Bumblebees are remarkably homogeneous in morphology. More than two centuries of bumblebee taxonomy have led to suspicions that the striking colour patterns of the hair – most often used to describe species – are in fact highly variable within species, making species difficult to recognise. Recently, species have come to be viewed in theory as evolutionarily independent lineages (EILs). Barcodes could be of enormous help because, despite the potential pitfalls and the need for corroboration from nuclear genes, the rapid evolution of barcodes is presenting many new characters that could help in the practice of recognising species as EILs.

Barcodes showed their value for bumblebee taxonomy whilst producing the recent *Bumble Bees of North America, an Identification Guide*, the first of its kind in a century (Williams *et al.* 2014). Barcodes helped reveal patterns of variation that largely corroborated the traditional ideas of species. As a result, barcodes are currently being used extensively in revising the much larger, but far less well-known, bumblebee fauna of China (An *et al.* 2014, DOI: 10.11646/zootaxa.3830.1.1). Now, a research programme is building on these studies to compare evolutionary patterns in the bumblebee groups that specialise in the most extreme alpine and arctic environments worldwide. In the Arctic, barcodes are showing some unexpected results.

In comparison to other bumblebee groups, taxonomic revisions for the primarily arctic bumblebees of the subgenus *Alpinobombus* have been rather unusual in that they have all reached different conclusions on the number of species present. Revisions based on morphology concluded that there are between four and six species, while variation in colour patterns suggested at least seven. In the most recent study (Williams *et al.* 2015, DOI: 10.1371/journal.pone.0144544), based on the view of species as EILs and on barcodes of samples from across the Arctic, nine species are supported.

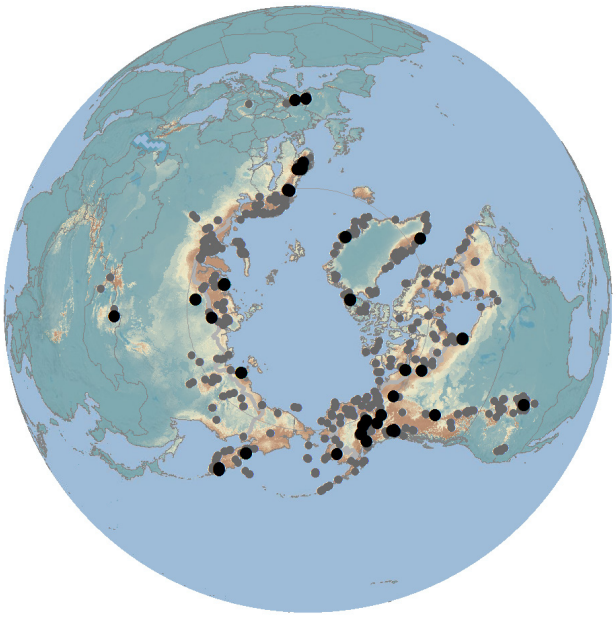
In Alpinobombus, "the resemblances in colour pattern among some parts of many species are due to persistent ancestral polymorphisms."

In practice, EILs are recognised not simply by a particular genetic distance, but rather from the gene coalescents that provide direct evidence for the evolutionary independence of their lineages, using techniques based on mixed Yule/coalescent models or Poisson-tree process models. In this case, the same result was also obtained with BOLD's BIN method. Evidence from the nuclear PEPCK gene adds further support for some of the same species and is consistent with the others, although this nuclear gene evolves more slowly, making it less informative. The new species are mostly prevented from interbreeding by oceans, but one new species, which appears to be endemic to mountains in southern Alaska and the Yukon, is overlapping.

The most unexpected result for *Alpinobombus* is that the resemblances in colour pattern among some parts of many species are due to persistent ancestral polymorphisms. This contrasts with the usual explanation for the common colour-pattern resemblance between parts of different species occurring in the same place – which is usually interpreted as the result of mimetic convergence. For *Alpinobombus*, reconstructing ancestral colour-pattern states shows that speciation is likely to have cut across taxonomically and geographically widespread ancestral polymorphisms. This pattern has not been known previously for bumblebees.

Arctic bumblebees are expected to be under particular threat from climate change. Modelling predicted range shifts depends on understanding their current distributions, so discovering the geographic limits of species is important. For *Alpinobombus* bumblebees, grouping individuals by morphology, by colour pattern, or by barcodes shows little agreement. This helps explain the lack of agreement among previous taxonomic revisions. Barcodes, however, with their rapid evolution, appear to be especially valuable in helping us to get closer to understanding species as EILs (www.nhm.ac.uk/bombus).

Above: *Alpinobombus* habitat in Greenland.



Above: Map showing climatic suitability (favourable in brown), specimen records (grey), and barcodes (black).

Below: Example of evolution of *Alpinobombus* bumblebee tail colour patterns, with orange spots for pale, black for dark, and mixed for polymorphic.