Low resistance to high temperatures of cold-adapted bumblebee species unveils a global threat for Arctic pollinators

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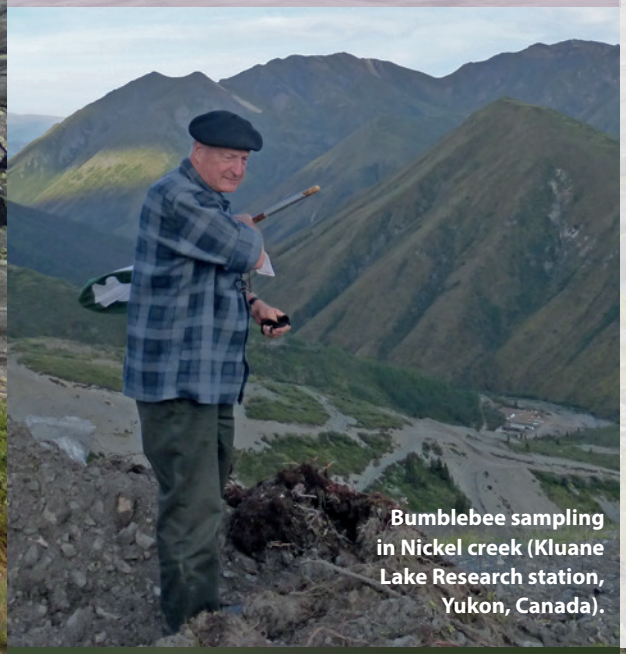
Current global warming is impacting ecosystems by modifying species geographic ranges and fostering local extinctions. While most studies focus on the consequences of gradual modifications of climate, impacts of extreme events such as heat waves (hyperthermic stress) have been poorly investigated. The Arctic regions experience extreme warming events, and these will cause major continuing problems such as the dramatic decline in both diversity and abundance of wild, pollinating, bees.

AIMS OF THE PROJECT

We focus on the bumblebees, a diverse group of important pollinators in temperate and cold areas. Bumblebees (Bombus) are social insects like honeybees and ants. They are the most important pollinator group in mountains, Arctic, Subarctic and boreal regions. They are robust and hairy warm-blooded bees well adapted to cold climates. Their populations have been strongly declining and shifting in altitudinal and latitudinal ranges, at least partially triggered by climate change. To conserve these wild bees, we need to know their current population status, and also how they respond to heat stress.

WHAT DID WE DO?

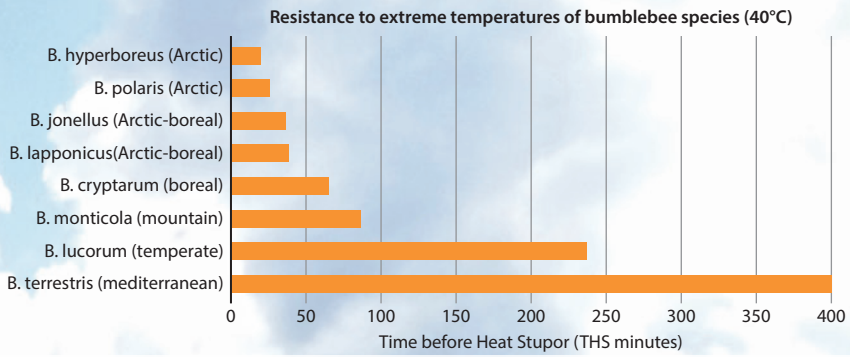
We sampled 2,386 bumblebee specimens, across three continents and twenty regions with latitudinal and continental gradients. We assessed heat stress resistance for 39 different bumblebee species from different eco-climatic regions in relation to body mass. We investigated the relationship between heat stress resistance and population trends. We used only males because (i) they display simple and constant behaviour contrary to females; (ii) they do not take shelter in thermoregulated underground nests as the females do; (iii) they are more exposed to meteorological events while collecting nectar and making their nuptial behaviour in open areas; and (iv) to reduce sampling effects on bumblebee populations. Our sampling allows comparison of the genetic diversity to identify potential refuge zones in bumblebee distribution.



Bumblebee sampling in Nickel creek (Kluane Lake Research station, Yukon, Canada).

***Bombus polaris* on *Potentilla palustre* in Chokurdakh (Siberia).** (Pierre Rasmont)

Arctic landscape in Abisko (Sweden). (Pierre Rasmont)



Simplified results of heat stress resistance of bumblebee species. The time before heat stupor corresponds to the time spent by the specimen at 40°C before falling into a "heat coma" (intraspecific and inter-individual variation are not shown in this figure). (Martinet B., 2020)

WHERE DID WE WORK?

With support from INTERACT, we have sampled different Arctic, boreal and mountain regions such as N. Sweden (Abisko, Tarfala), N. Alaska (Toolik Field Station), Yukon (Kluane Lake Research Station), Khanymey (W. Siberia), North-East Canada (Whapmagoostui and Salluit), North-East Siberia (Chokurdakh). Moreover, we added data from Scotland (Hebrides), Norway (Narvik), Finland (Kilpisjärvi), the Alps, the Pyrenees, the Apennine Mountains and the Lebanon mountains.

WHAT DID WE FIND?

Our results show significant variability in heat stress resistance between species but low variability within species. This supports the concept that hyperthermic stress is a species-specific trait. Species associated with cold habitats (polar, boreal and mountains) are much more sensitive to heat stress than temperate or Mediterranean species. However, cold and temperate areas are likely to experience heat waves. We suggest that expansion or decline of bumblebee species and range changes can be impacted by their species-specific thermo-tolerance during heat waves. Limited local adaptations and low genetic variability in heat stress resistance represents a critical physiological mechanism making some species very sensitive to environmental changes.

WHY ARE THE RESULTS IMPORTANT?

While gradual changes in climate cause progressive shifts in the geographical distribution of species, heat waves can quickly induce local extinctions that drastically alter animal and plant communities. The genus Bombus is a vast group of more than 260 species worldwide, with a key role in maintaining the integrity of cold ecosystems. Our work allows us to assist in international bee conservation, particularly as we use criteria defined by the International Union for Conservation of Nature, IUCN. We showed the high sensitivity of bumblebees to heat stress which could play a key role in understanding their drastic decline worldwide. All species are not equal in the face of this threat. The ecological void left by declining species will not be filled by the minority of expanding species. We need an inclusive picture of the different threats to our pollinators which could ultimately contribute to safeguarding one of the most important players on our planet.

THE ADVENTURE

We have been able to experience the diversity and beauty of numerous Arctic and boreal landscapes and their bumblebee fauna. Thanks to the INTERACT project, we discovered a new bumblebee species and we decided to name it *Bombus interacti*. Compared to our highly urbanised Western Europe, the Arctic still offers the possibility to study a nature less disturbed by humans. During our expeditions, we have encountered every possible weather condition (hot, cold, wind, snow, frost), and used no less than 10 different vehicles (boat, canoe, quad, bike, plane, helicopter, truck, train, etc.). The ambiance and working atmosphere of all the stations were very nice, organised by extraordinary people to coordinate the different teams of researchers. However, some scars from mosquito bites and other biting insects are likely to last a lifetime!

New bumblebee species discovered in Alaska (Toolik field station): *Bombus interacti nov.* sp.