# Patterns of insect herbivory along altitudinal gradients in a polar region

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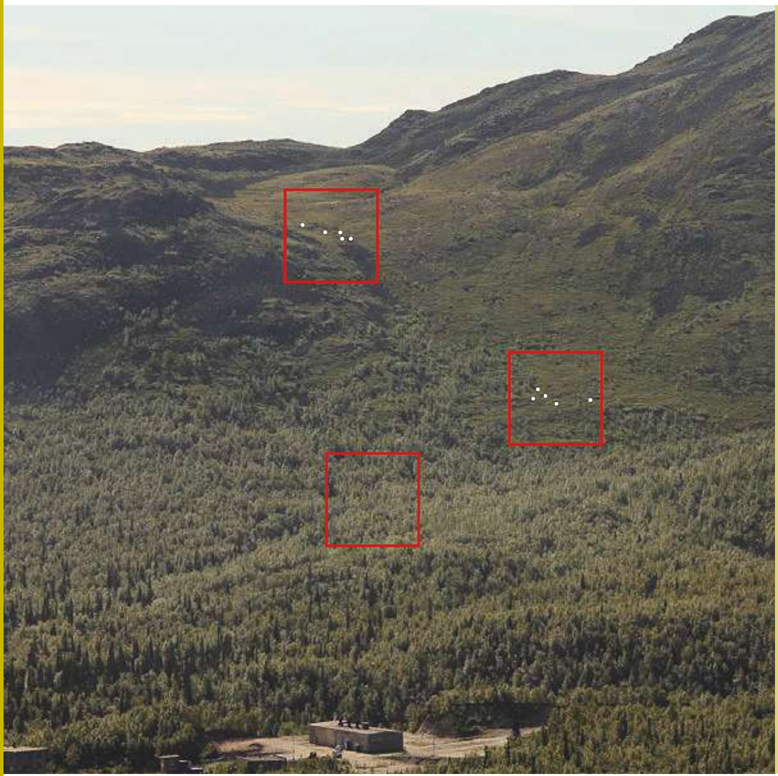


**Location of forest, sub-alpine and alpine study sites (showed by red frames) along the "ecological patch" of the Polar-Alpine Botanical Garden in the Khibiny Mountains. White spots seen at sub-alpine and alpine sites are passive greenhouse chambers established in June 2012** (Vitali Zverev).

*At the global scale, the larger part of herbivory is attributed to insects – "the little things that run the world". Levels of herbivory can be classified as "background", when insect populations are at their "normal" densities, which are typical for a given ecosystem in a long-term perspective, and "outbreak", when populations of some species occasionally reach very high numbers, dramatically damaging plants. Although background losses of plant foliage to insects in sub-Arctic forests are relatively minor, from 1.5 to 7.5 %, even a small increase in background herbivory due to climate warming can cause severe negative impacts on tree growth. Studies of insect-plant interactions along natural* abiotic *(physical environment) gradients are needed to evaluate the impacts of climate on insect herbivory and on this basis to predict effects of climate change on plant damage by insects. The earlier studies of this kind were mostly conducted in temperate ecosystems, and they demonstrated that herbivory usually decreases with both latitude and altitude of the study site. However, the recent research by our team hints that the strength of latitudinal and altitudinal changes in herbivory may well differ between low and high latitudes, and that it may vary with specific climatic conditions of the study year.*

## AIMS OF THE PROJECT

The aims of the project were to monitor the background (i.e., non-outbreak) losses of plant *biomass* to defoliating and leaf mining insects (the larvae that live and feed between the surface cell layers of a leaf) in several species of woody plants along altitudinal gradients in sub-Arctic mountains and experimentally assess the effects of temperature increase on these losses.

## WHAT DID WE DO?

We measured leaf/needle area that was lost to insects in 10 species of woody plants at different altitudes. We also established passive greenhouse chambers (which increase the mean summer air temperature by 1-2 °C) in early summer at different altitudes and compared plant damage inside and outside these chambers at the end of the growing season.

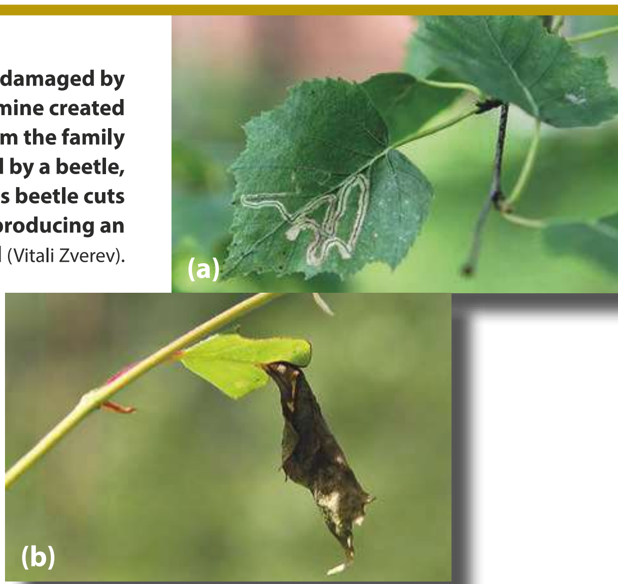
## WHERE DID WE WORK?

The unique geographical features of the Kola Peninsula, northwestern Russia, made this region best suited for the establishment of the properly replicated study. Several mountain systems located in the central part of the Kola Peninsula, close to the Khibiny Educational and Scientific Station (•26) of the M.V. Lomonosov Moscow State University, differ from each other in geology and in their floristic composition. Therefore the results of the studies conducted in this region can be generalized over a wide range of environmental conditions. Importantly, the steep slopes of Khibiny, Lovosero and Monche-tundra Mountains are relatively easy to access.

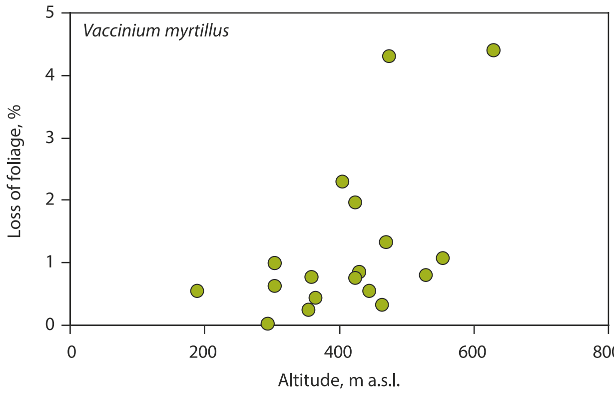
## WHAT DID WE FIND?

Our findings were somewhat surprising: we did not discover the expected decrease in foliar damage with altitude in any of the studied species of woody plants. Moreover, some plant species demonstrated paradoxical increase in foliar losses to insects with altitude, while others showed no altitudinal changes or a pattern of herbivory with the highest damage attained at the intermediate altitudes. Meta-analysis demonstrated that, in general, the losses of plant foliage to defoli-

**The leaves of a mountain birch are damaged by a number of insects. (a) Serpentine mine created by a larva of a minute moth from the family Nepticulidae. (b) Birch leaf rolled by a beetle, *Deporaus betulae*. The female of this beetle cuts most of the way through a leaf, producing an inverted cone, in which an egg is laid** (Vitali Zverev).




**A passive greenhouse chamber at a treeline site in the Khibiny Mountains. Mean summer air temperature within these chambers is 1-2 °C above the ambient level, thus mimicking a future warmer climate. However, the current weather conditions in a sub-alpine region can change very rapidly** (Vitali Zverev).




**The loss of bilberry *(Vaccinium myrtillus)* foliage to defoliating insects increases from 0-1% in forests to 1-5% above the upper tree limit (data from 2012).**



ating and leaf mining insects in our study region slightly but significantly increased with altitude. On the other hand, plant losses to insects in passive greenhouse chambers were generally higher than outside the chambers, and this effect was largest at the intermediate altitudes, in sparse sub-alpine birch woodlands.

## WHY ARE THE RESULTS IMPORTANT?

This is the first study of the altitudinal pattern in insect herbivory, which was conducted beyond the Polar Circle. Our results demonstrate that in harsh environmental conditions at the upper tree limit some unknown factors may facilitate insect herbivory relative to the more benign environment of low-altitude forests, counterbalancing adverse effects of lower temperatures on insects. The exploration of mechanisms behind the detected altitudinal pattern is likely to advance our knowledge on functioning of sub-alpine ecosystems and improve our predictions on climate change impacts on mountain and polar regions.

## THE ADVENTURE

We were extremely surprised by the force of the wind observed one day of June at the upper tree limit in the Monche-tundra Mountains. The wind was so strong that it was impossible to open the doors of the windward side of our car. After leaving the car from the opposite doors, we immediately understood that we needed to change our plans because it was impossible to do any work and even to walk to our study site.

*Further information*

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Kozlov, M.V., Filippov, B.Yu., Zubrij, N.A. and Zverev, V. 2015. Abrupt changes in invertebrate herbivory on woody plants at the forest-tundra ecotone. Polar Biology 38:967-974, DOI: 10.1007/s00300-015-1655-6.