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Climatic Changes and Evidence from Plants and Animals Responses: The Data which could be Associated with Climatic Changes in the Extreme North of Europe

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ABSTRACT

Climatic changes in the northern hemisphere have been documented in Fennoscandia accompanied by an earlier and a longer growing season there. In Murmansk Region the actual shifts in the timing of the growing season found more pronounced in oceanic and mountainous parts. It was predicted that such climatic trends could influence the retreat of the tundra zone and changes in the forest line. In order to investigate climatic changes markers, the following studies have been conducted: 1) an assessment of population trends of certain species with a relatively southern distribution in the target region along with climatic variables, 2) an evaluation of ecology and fitness of the regional populations with similar characteristics within its main range, 3) a review of new records of plants and animals north of the Arctic Circle, 4) an analysis of dispersal patterns and possible migration routes of new registered species. From our research we project a success of studies on water plants along the Baltic Sea/the White Sea path and complementary climatic studies. A new international data base on new records of plants and animals in Europe and in the world is required.

Keywords: *climatic change, warming, growing season, Murmansk Region, range expansion, first records, migration routes, the Baltic Sea/the White Sea.*

INTRODUCTION

Climatic changes in the northern hemisphere - first observed in Central Europe - have been expanded further to Fennoscandia (Fig. 1), an area with a heterogeneous Atlantic-Arctic climatic (Førland *et al.*, 2009; Stainforth *et al.*, 2013; Aalto *et al*., 2016). In the last two decades they resulted in an earlier and a longer growing season there (Schwartz *et al.* 2006; Karlsen *et al.*, 2007). In Murmansk Region (66-70° N) the actual shifts in the timing of the growing season found more pronounced in oceanic and mountainous parts. It was predicted that such climatic trends could cause losses of tundra biodiversity and enrichment of the northern taiga by southern species (Blinova and Chmielewski, 2015).

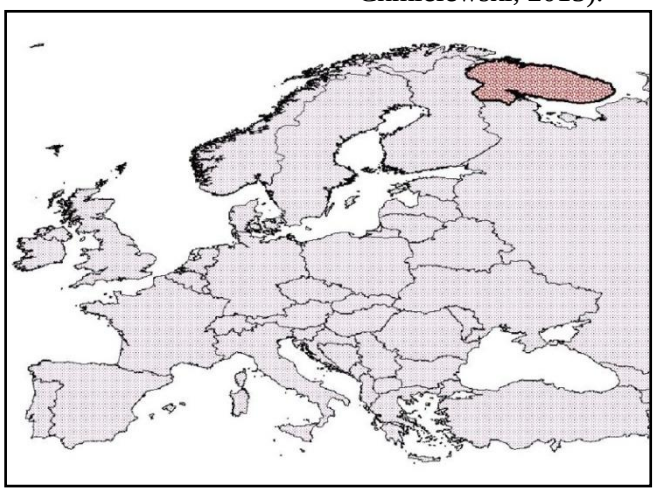

Fig1. *Location of NE Fennoscandia (Murmansk Region) on the map of Europe*

Material and Methods

Murmansk Region (66-70° N, Fig. 1) is situated in the Atlantic-Arctic climatic zone of the temperate belt, and climatically the region is very heterogeneous. Two latitudinal vegetation zones can be distinguished - tundra and taiga - which are congruent with climate (Fig. 2). A review of new records (since 2010) of plants and animals north of the Arctic Circle have been done in order to investigate whether these data could be associated with recent climatic changes. The latest species records of the distribution area are analyzed along with their outpost records and dates of their discovery. The ecology and fitness of the regional populations are compared with similar characteristics within its main range. Species‘ dispersal and possible migration routes have been studied. Long-term studies on the monitoring of certain species with a relatively southern distribution in Region and in Europe (e.g. the southern species from Orchidaceae) have been conducted. Trends of population size and climatic variables are compared.

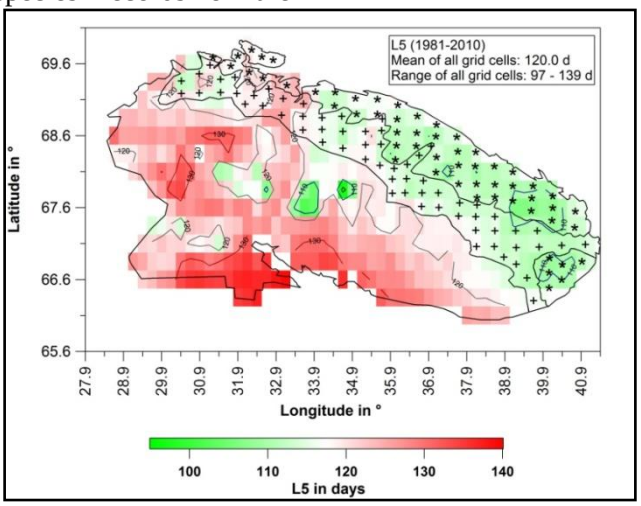

Fig2. *Length of the thermal growing season (L5) in Murmansk Region together with vegetation zones: asterisks indicate tundra, plus signs indicate tundra-taiga ecotone (mountain birch forest) and north taiga forest (without specific markers), Fig. from Blinova and Chmielewski (2015).*

Result and Discussion

Summary of Previous Climatic Studies

The average annual air temperature in Murmansk Region has been ranged from -0.32 °C to -2.3 °C in various studies over the last 50 years (Blinova and Chmielewski 2015; Marshall *et al.*, 2016). Shifts in the timing of the growing season and its mean prolongation by 18.5 days/62a are demonstrated for Murmansk Region (1951-2012), wherein the actual length of the growing season reached 120 days on average, onset on 30 May and ending on 27 September (Blinova and Chmielewski, 2015). Contradicting trends in the duration of the snow cover season occurred between 2000 and 2016: a) at different stations within the Mts Unit, b) at different altitudes (decreased at higher altitudes and increased in valleys and plains) (Vignols *et al.*, 2019). Precipitation tendency stayed very variable in the Arctic Fennoscandia (Førland *et al.*, 2009; Aalto *et al.*, 2016; Marshall *et al.*, 2018).

A Review of Cases from Plants & Animal New Records North of the Arctic Circle

The northernmost records among plants and animals (invertebrates) are linked to both climatic and other (rare species ecology, rare species consortium, regional gaps in exploration) causes (Blinova and Mironov, 2012; Romanov and Blinova, 2015). In Murmansk Region some data have been obtained which could be associated with trends in climatic warming (Fig. 3). The species with a more southern distribution and mostly with restricted areas in NE Fennoscandia (e.g. Orchidaceae) had positive responses to the climatic warming with a larger population size and the number of generative individuals in population (Blinova and Chmielewski, 2008). Water plants and animals, close water flows, prevailed among new and first records (Fig. 4, 5, 6), made in the region recently in 2006-2019 years (Blinova and Koistinen, 2013; Blinova and Gregor, 2016; Blinova, 2019). Sea ways could be the main dispersal routes for these species.

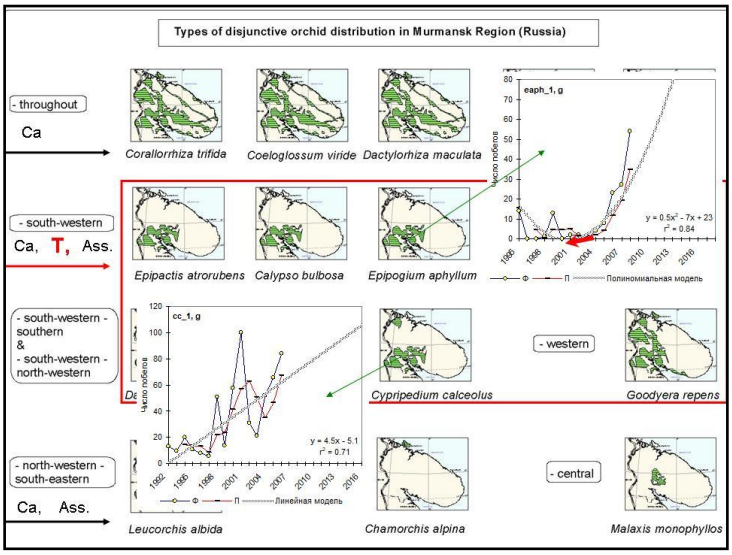

Fig3. *Types of orchid distribution and some examples of the increase of the population size in some plant species (Orchidaceae) which had temperature-dependent type (T) in Murmansk Region and limited mainly in the SE area*

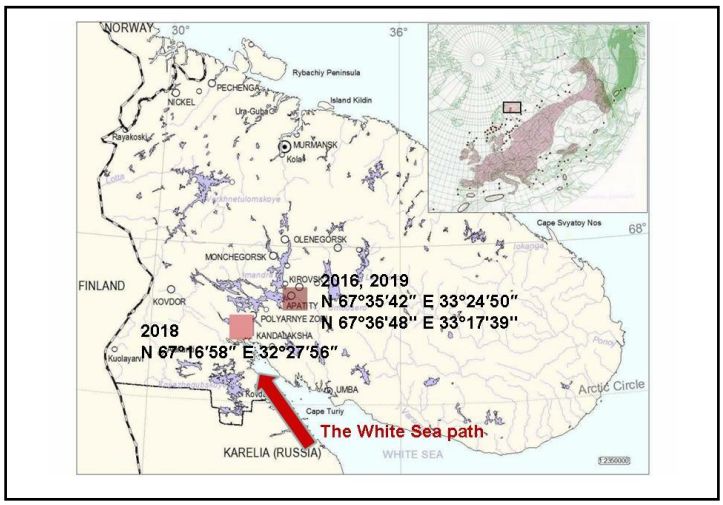

Fig4. *The new localities of Veronica beccabunga near the town of Apatity and in the Kandalaksha District (Murmansk Region). The nearest recorded sites of V. beccabunga are 250–300 km to the south-west and to the south of the Apatity' population in Finland and Karelia. The migration of populations to the outposts of their distribution area goes through the White Sea path*

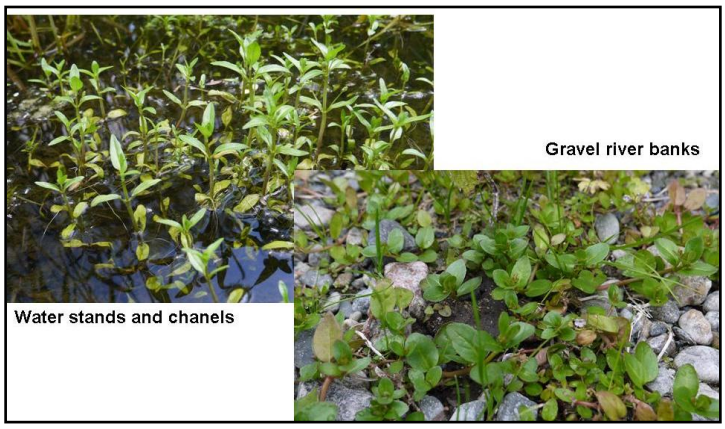

Fig5. *Ecological variability of stands with Veronica beccabunga (Plantaginaceae) in Murmansk Region. Populations occur in wide range of coastal habitats (water stands and channels, gravel river banks), their individuals have strong fitness expressed by intensive vegetative multiplication and seed rain. Individuals show traits of r-strategy*

Fig6. *Large land snail Arianta arbustorum (Helicidae) is an alien species in Murmansk Region. In 2019 it is found on the coast of River Belaya in surroundings of the town of Apatity. This record is linked to climatic changes because of 1) the extraordinary big shell (not characteristic for other land snails here because of a short summer and regional calcium-deficient soils), 2) common distribution far to the south from Murmansk Region - in Central and Atlantic Europe, 3) an extended regional study of this group.*

Conclusion

The studies on water plants along the the Baltic Sea/the White Sea path, could be considered very perspective along with climatic studies. A data base on new records of plants and animals in Europe, at least with information on region and species (family) and publication details will enhance the actual interpretation of climatic changes.

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