Rate of recovery of lichen-dominated tundra vegetation after overgrazing at the Yamal Peninsula

Short Communication

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Abstract

Lichens are the most sensitive part of vegetation cover to reindeer grazing. In this study we analyse success of restoration rate of lichen-rich tundra vegetation after ceasing the grazing stress at the Yamal Peninsula. On experimental plots we compare the main parameters of lichen mat (species diversity, total cover, thalii height, biomass, recovery rate) on grazed pastures and fanced sites after 13 years after of its isolation. Our results demonstrate that after intensive overgrazing the lichen species diversity and synusiases structure change very slowly. The rate of the biomass increase of lichens for this period has made 3.8 g m^{-2} $year^{-1}$ that makes 3.6% from mass in the year. But this rate is two times lowers than in highly productive lichen communities.

Key words: lichen tundra, reindeer pastures, restoration, lichen growth, Yamal

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Introduction

Within last several decades, terrestrial ecosystems of the Yamal Peninsula have been subjected to the impact of domestic reindeer. It is well established that the reindeer husbandry was extensively developed in the traditional nomadic way during the past century and especially recently (see *e.g.* Golovatin et al. 2012). Generally, nomadic reindeer husbandry is the primary cause of the observed degradation of higher plants and lichens cover forming tundra ecosystems of the Yamal Peninsula. Dramatic negative changes in both productivity and standing biomass characteristics of vegetation cover indicate the impossibility of keeping on this way of land use under the present industrial and climatic situation in the region. Recent evidence form the Yamal Peninsula supports the idea that atmospheric warming seems to be not a sufficient factor for restoration of vegetation cover in tundra ecosystem of the

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Yamal Peninsula when extensive grazing continues. Recently, number of reindeer is estimated 350 000 individuals at the Yamal Peninsula and rapid changes to vegetation cover vegetation are evidenced (Ektova et Ermokhina 2012). If number of reindeer individuals increases in future (exponential growth is expected in worst scenarion) more dangerous changes in natural ecosystems might be expected in the region. The present situation requires significant corrections in ethno-cultural and economical policy in the region. Vegetation of the Yamal Peninsula has been changing rapidly thanks to several interacting factors like *e.g.* rapid industrial development and changes (Kumpula et al. 2011, 2012) in land-use policy both affecting vegetation cover characteristics (Walker et al. 2009, 2011). Self-recovery after technogenic and natural disturbances in the central part of the Yamal Peninsula may help to restore original vegetation characteristics to a certain extent (Khitun 1997), however, this is likely only in small-scale areas with limited extent of disturbances.

Terrestrial ecosystems of the Yamal Peninsula were subjected to the impact of domestic reindeer for several decades: the reindeer husbandry was extensively developed in the traditional nomadic way during the past century and especially recently. In several studies (*e.g.* Kryazhimskiy et al. 2011, 2012), the ecosystem dynamics was analyzed by means of computer simulations using a model describing lichens production by classical Verhulst's S-shaped growth equation in order to predict lichen productivity under global warming scenario. In these studies, it was shown that that nomadic reindeer husbandry is the primary cause of the observed degradation of vegetative and lichens covering the Yamal Peninsula. Gaio-Oliveira et al. (2006) brought similar conclusion for scandinavian tundra.

Recovery rate of lichen cover in tundra regions with reindeer population is in focus of many reseachers conducting loggterm studied in Arctic regions. Dependency between reindeer density and lichen (*Cladonia* spp.) ranges in the Finnish semidomesticated reindeer management area was studied by Kumpula et al. (2000). Using a model and data from the 90-ies, they reported that average lichen biomass on lichen ranges in the Finnish reindeer management districts was 13.0% of this optimum, and the average lichen production was 36% of the possible maximum annual yield. They concluded that the Finnish lichen ranges would have to remain ungrazed for an average of 18 years to recover to maximum production levels. Similarly, Morozova et Ektova (2010, 2012) reported recovery rates for lichen-dominated tundra of the Yamal Peninsula. In this paper a detailed information on the changes in lichen growth is given.

Material and Methods

The lichen-rich tundra communities on the Yamal Peninsula (North of Western Siberia, Russia) are overexploited by reindeer grazing and trampling (Magomedova et al. 2006, Golovatin et al. 2010). In 1993-1995, in the northern subarctic tundra subzone on Yamal, 5 pairs of experimental plots (5 x 5 m) were established with the aim to evaluate restoration rate of lichen-rich tundra vegetation after ceasing the grazing stress in grass-dwarf shrub-lichen-moss tundra. Each plot of every pair was isolated from the pasture by a metal fence. During the period of monitoring the detailed description of species composition, ground cove, frequency, structure of synusiae and above ground productivity was regularly registered at the small

plots (20 x 50 cm), 12 times for each (Magomedova et Morozova 1997). The first collecting of data was made in 2006, *i.e*. after 12-13 years from isolation of experimental plots. In the fenced territory (RE - enclose) in comparison with grazed pastures (RN - not enclose) visible changes in the species composition and synusiae structure of lichens were obtained.

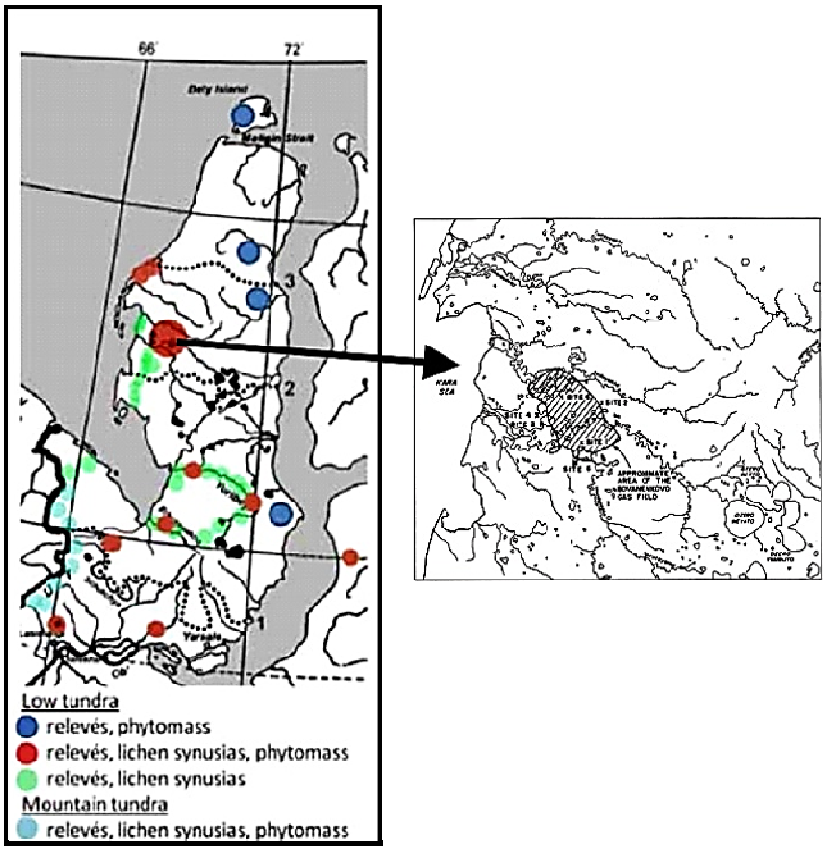

Fig. 1. In total for Yamal Peninsula taken from Ermokhina 2013; and Location of monitoring plots for enclosed experiment.

Results and Discussion

Species diversity

The number and species composition of lichens is very dynamical, strongly depends from patchiness of vegetative cover and micro habitats. As a whole the species diversity on all encloses plots was higher than under impact of reindeer grazing. The tendency of an increase in the number of constant species was outlined. In this group species, which frequence above 50%, on enclose plots the tendency to occurrence increasing of reindeer lichens species and foliose lichens is to be observed. On the grazing sites, the opposite trend decrease in frequency of fodder species and increase of crustose lichens is looked through.

Vegetation cover
For 12-13 years after removal of grazing pressure the total cover of lichens has not changed. However, it is possible to note some changes in structure of a lichen cover. Some morphological type of lichens (fruticose-furcated, filiform, subulate, foliose, their ferquencies in lichen cover, respectively) were revealed. Fruticose-lociniated and crustose morphotypes have considerably lowered in numbers and cover arear. As a whole for tundra under the influence reindeer grazing for 12 years there was a significant decrease in the cover of fruticose-lociniated and filiform lichens and on the other hand, the cover of subulate and crustose species has increased.

Lichen stand height
At the time of monitoring plots establishment, the lichen stands were reduced by grazing to a thin layer of fractured lichens and the general height of fruticose species (*Cladina* ssp.) everywhere was 0.5-1.5-2 cm, on the average 1.25 cm (Magomedova et Morozova 1997). For 13 years of recovery the increase in podetium height of fruticose lichens on the enclosed plots is revealed in comparison with the data for 1993-1994 years and the areas under reindeer grazing pressure. For the last period the general height of lichens has increased to 3-5 cm. The height of lichens on not enclosed plots for the last period remained without change.

Lichen mass
Its volume and biomass depended on the height of thalii, density of the lichen cover and the total area occupied by lichens (Andreev 1954). On the enclosed plots a significant increase in a cover of three morphotypes of fruticose lichens and increases in height of podetium the growth in total mass from 40-65 to 80-155 g m^{-2} is revealed too. The necromass of lichens is about 25% from the total mass. On the plots under impact of reindeer grazing some changes of lichen mass is not discovered.

Recovery rate
Using techniques of simulation modeling and based on the data of thalii height and lichen mass change for thirteen years was calculated an average recovery rate of lichens. So in grass-dwarf shrub-lichen-moss tundra in the subzone of Northern Subarctic tundra at the Yamal Peninsula the average rate of increment of fruticose lichens in the first 12-13 years after removal of reindeer grazing has made 1.3 mm $year^{-1}$. The rate of the biomass increase of lichens for this period has made 3.8 g m^{-2} $year^{-1}$ that makes 3.6% from mass in the year.

Concluding remarks

Our results suggest differently directed processes of changes in lichen mat on sites under the influence of intensive grazing and pastures fanced from reindeer. The first demonstrated total degradation of lichens, on the other hand fenced plots on the background of slow recovery not only alters the species composition, but both persent of cover and height of lichens, proportion between the morphological types. There is a very slow recovery of forage species (*Cladonia arbuscula, C. rangiferina, C. cornuta, Flavocetraria cucullata* and others). But the rate of lichen growth did not reach the parameters which are typical for tundra zone of Yamal Peninsula and other part of Arctic. The productive and recovery potential of lichen mat after 13 years without

impact of reindeer grazing are very low and dependes not only from growth rate of lichen but also from the structure of lichen layer (thickness of mat and present cover of fruticose species). In average the growth rate of forage lichen species for the tundra zone is estimated by the following values: *C. arbuscula* – 4.1-6.7 mm year^{-1}; *C. rangiferina* – 4.7-8.1 mm year^{-1} (Andreev 1954). Our results demonstrated that the recovery rate of *Cladonia* lichen at Yamal Peninsula in 2.5-4.5 times lower than these values as under reindeer grazing and on anced plots. So in our opinion for the recovery these lichen tundras for normal zonal status will need at least 60-80 years.

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