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Diversity and trends in distribution of lichens in native and artificial planting in Iskitim (Western Siberia, Russia)

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Abstract

Aim of this work is to assess lichen species richness abundance and distribution in native and artificial plant communities for one of the unexamined small towns within Western Siberian forest-steppe. A total of 156 lichen species have been found within the urban examined and lichen-free zone occupies 10% of town area. Lichen species richness and coverage values in native plant formations decreased heavily from suburbs to living and industrial areas. Shannon entropy decreased the same way and was no more 2,37 even in suburban areas. Crustose lichens had got the largest share in particular plant formations. Fruticose lichens hadn't got any conspicuous position within epiphytic lichen communities. There were no xerophytes in tree formations and mesophytes significantly prevailed. Share of xerophytes was quite high in grass formations. A bark of deciduous tree species was a substrate the most often occupied by lichens both in suburbs and urbanized areas. Composition of dominants and true species in epiphytic lichen communities tended to reduction quite sensitive species. If dominants were tolerant species, their frequency and abundance decreased all the same. The second type of epiphytic lichen communities' transformation is a change of lichen favorite substrate within urbanized plant formations.

Keywords: Lichens, Western Siberia, Human impact, Plant formations.

Introduction

Lichen indicative features and key indicative species vary in different climates, and it's so important to get information about lichen distribution patterns within the urbanized localities of greatest possible number of regions and climates. As for Western Siberia, lichens are almost unstudied both in big and small cities and in native birch and mixed birch-pine lowland forests: there are no even initial data of lichens in the most of these localities. By the beginning of this study, information about lichen species richness, occurrence and distribution was obtained by the author just from 2 big cities and 4 small towns (Romanova 2009, 2011, 2012; Romanova and Sedelnikova, 2010). Currently, data on lichens in most cities and towns within moderate continental climate of Siberian forest-steppe area are completely absent. Aim of this work is to assess lichen species richness and distribution in native and artificial plant communities within one of the completely unexamined small town (Iskitim) in Western Siberian forest-steppe. Findings of the study are contribution both to the general issue of the urban lichens and to the foundation for reliable conclusions of lichen diversity's general patterns.

Habitat description:

Studied area is situated in south-east of Western Siberia (Russia) within forest-steppe zone and are characterized by harsh continental climate. Earth coordinates are 54° 38′ 0″ N, 83° 18′ 0″E; square of the town studied is 29,87 km^2; population in 2011 is 63678 people (Department…, 2012). There are 4 rivers within the town – Berd' River and three it's inflows (Chernaya River, Koinykcha River, Shipunikha River).

Climate characterized by the next features (Regular weather data…, 2014): the duration of sun radiation per year is 2077 hours; number of overcast days is 67; average temperature in July is +19^{o}C; average temperature in January is -19^{o}C; average annual temperature is +0.2^{o}C; maximal annual temperature is +37^{o}C; minimal annual temperature is -51^{o}C; the average daily temperature 0^{o}C is 188 days; frost-free period continues 120 days.

Precipitation total is 330 mm in April-October, 95 mm in November-March, 205 mm in the growing season and 425 mm annual.

The average daily temperature: more, than 5 ^{o}C – 158 days; more, than 10 ^{o}C – 122 days; more, than 15 ^{o}C – 77 days. Above 10 ^{o}C temperature sum – 1920 ^{o}C.
Buildings in Iskitim are both the high-rise houses with centralized heating and low-rise private housing with personal stove heating (more, than half of town area). Within the town, there are more than 100 of industrial companies. Total annual average of atmospheric discharge in 2011 was 12117.52 tons: 4967.529 tons from industrial enterprises, 6492 tons from vehicles and 657.991 tons from personal stove heating (Department …, 2012).

Inside and near the town there are the following plant formations: birch forests and forest outliers, mixed birch-pine forest, alluvial planting along river floodplains, artificial planting with native and introduced tree species (tree lines, parks, gardens in residential environment, planting along streets and autobahns, poplar artificial planting under birch-pine forest canopy), grass formations with native stones on high river-banks and on dumping grounds of limestone open-cut mining.

The following native tree-species have been examined: birch (*Betula pendula* Roth, *B. pubescens* Ehrh.), pine (*Pinus sylvestris* L.), willow (*Salix alba* L., *S. caprea* L.), poplar (*Populus tremula* L., *P. alba* L., *P. nigra* L.), bird cherry tree (*Padus avium* Mill.), rowan (*Sorbus aucuparia* L.), hawthorn (Crataegus sanguinea Pall.) and pea shrubs (Caragana arborescens Lam.). Additions to native, introduced tree-species have also been examined: poplar (*Populus balsamifera* L.), Maakii bird cherry tree (*Padus maackii* (Rupr.) Kom.), maple (*Acer negundo* L., *A. tataricum* L., *A. ginnala* Maxim.), elm tree (*Ulmus laevis* Pall., *U. pumila* L.), ash tree (*Fraxinus excelsior* L.), linden (*Tilia cordata* Mill.), apple-tree (Malus baccata (L.)Borkh.).

Materials and Methods

Lichens have been investigated within all plant formations placed within Iskitim and it's immediate environs. To reveal lichens as fully as possible studied area was divided into 1-km quadrates. All substrates were examined for the presence of lichens; epiphytic lichens were collected from 10 the biggest trees of each species found within quadrate. Lichen-free zone (so-calling "lichen desert") was identified as area where weren't any lichens even as thalli fragments.

Lichen species frequency and abundance (coverage value) were measured for epiphytes only (including crustose) on 20x20 cm plots, which had been based on the side with maximal lichen covering on 2 steam levels: near the steam base and 1,3 m height. Frequency of each species is a percentage of plots, where it was found within square tested. Lichen abundance was assumed as percentage of plot occupied by lichen thalli: for each species and total. Lichen communities were described with true species (frequency>50%), which were dominants (had got the maximal coverage value) or accompanying species. Part of lichen-free trees was estimated in each plant formation studied. Lichen frequency and coverage value have not been investigated on the soil and native stones within grass formations as well as on concrete, decaying and manufactured wood within tree formation. Lichen species richness only was obtained for these substrates. All lichens found have been regimented and analyzed into three humidity groups: mesophytes (adapted to neither a particularly dry nor particularly wet environment), xerophytes (adapted to survive in an environment with extremely low humidity) and xeromesophytes (intermediate group, species adapted to survive in quite dry conditions, but not extremely).

Total of 638 lichen specimens were collected during 2011, worked and deposited at the Cryptogamous Plant Laboratory in Central Siberian Botanical Garden, the Siberian Branch of the Russian Academy of Sciences (Novosibirsk, Russia). Taxonomy follows Mycobank (www.mycobank.org, applying date is 23.09.2015) except for *Caloplaca flavovirescens* (Wulfen) Dalla Torre & Sarnth., *Caloplaca lactea* (A. Massal.) Zahlbr.and *Lepraria incana* (L.) Ach. (http://www.indexfungorum.org, applying date is 23.09.2015).

Calculation

Lichen diversity assessed with Shannon entropy (Shannon and Weaver, 1963):

$$H=-\Sigma p_i \log_2 p_i,$$

where p_i is the proportion of epiphytic lichen abundance in a plot.

Human impact to lichen communities has been evaluated with the geobotanical approach and Index of air pollution tolerance proposed by Trass (author's term is "Poleotolerance Index": Trass 1973; Mudd and Kozlowski, 1975):

$$IP=\sum(a_i c_i)/C_{in};\ i=\text{from 1 to } n,$$

where: n is a species richness, a_i– is an air pollution tolerance value (author's term is "poleotolerance value") of each species, c_i is the coverage value of each species, C_{in} is a total coverage value. IP have been calculated for each plot, where epiphytic lichens had been found. IP values vary from 1 to 10 and increase with addition of air pollution. This method isn't new, but it works quite well after to be adapted to the region. It has been selected from another methods of air quality evaluation and mapping because it allows obtaining information about both lichen community under human impact and susceptibility (a_i) of each species found within area studied. Using IP it needs to be taken into account, air pollution tolerance values (a_i) for some lichen species had been obtained by method's author for Estonia only, and author's range of a_i needn't be used in other regions. So, all lichen taxa found in forest-steppe Western Siberian cities have been shared into 10 poleotolerance values – a_i (Romanova and Sedelnikova, 2010) according to instructions, that had been given with method description (Trass, 1973). IP-values from each plot were averaged within plant formation studied.

Results

A total of 156 lichen species of 29 families and 60 genera have been found within area examined. Lichen-free zone occupies 10% of town area. Data on the distribution of each lichen species and the main characteristics of lichen communities are summarized in Table 1. Independently native or artificial plant communities had the most lichen species richness and abundance in suburban sector versus the same planting in living and industrial districts. There were not lichen-free trees in suburb, but their percentage were up to 100 within urbanized space. Lichen species richness and coverage values in native plant formations decreased heavily (twice and more) from suburbs to living and industrial zones. Shannon entropy decreased the same way and was no more 2.37 even in suburban areas. IP-values were high in all plant formations where epiphytic lichens have been found, but share of sensitive species (a_i=1-3) decreased from suburbs to urbanized localities within both native and artificial planting. Sensitive species desisted be dominant in lichen communities as far as human impact increased (table 1). Lichen abundance was too poor in urban birch forest outliers, in urban birch-pine forest, in urban tree-lines and in gardens of residential areas therefore it's unbelievable to recognize dominant lichen species in these plant formations.

Crustose lichens had got the largest percent in species lists of each several plant formations, except for urban birch forest and out of town birch forest outliers, where share of foliose lichens were a little bit more than crustose ones (Table 2). Fruticose lichens (*Ramalina* and *Evernia* species) found only in plant communities at a significant distance from industrial enterprises and autobahns and had not got any conspicuous position in epiphytic lichen. They survived as a single thalli or thalli fragments only in the most of their localities.

There were no xerophytes in tree formations and mesophytes significantly prevailed over xeromesophytes (Table 2). Other situation could be observed within grass formations: share of xerophytes was quite high and xeromesophytes dominated.

A bark of deciduous tree species was the most preferred substrate for lichens both in suburbs and urbanized areas (Table 3). Lichen species richness was very poor on a bark of coniferous tree species even in native birch-pine forest.

Table 1. Lichen taxa and some characteristics of lichen communities in native and artificial planting in Iskitim

Taxa	Plant formation														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Acarospora cervina f. *cervina* (Ach.) A. Massal.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
A. fuscata (Nyl.) Th. Fr.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
A. oligospora (Nyl.) Arnold	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
A. smaragdula var. *fusca* (de Lesd.) Clauzade & Cl. Roux	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
A. umbilicata Bagl.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Alyxoria varia (Pers.) Ertz & Tehler	+	+	+	+	D	T	–	–	–	+	–	–	–	–	–
Amandinea punctata (Hoffm.) Coppins & Scheid.	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Arthonia apatetica (A. Massal.) Th. Fr.	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–
A. dispersa (Schrad.) Nyl.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A. didyma Körb.	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–
A. exilis (Flörke) Anzi	–	–	–	–	–	–	+	–	–	+	–	–	–	–	–
A. mediella Nyl., Ricerch. Auton.	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–
A. patellulata Nyl.	+	–	–	–	+	–	+	–	–	–	–	–	–	–	–
Arthopyrenia cerasi (Schrad.) A. Massal.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A. grisea (Schleich. ex Schaer.) Körb.	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–
Arthrosporum populorum A. Massal.	+	–	–	+	–	–	+	–	–	–	–	–	–	–	–
Aspicilia calcarea (L.) Körb.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
A. cinerea (L.) Körb.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
A. contorta (Hoffm.) Körb.	–	–	–	–	–	–	+	–	–	–	–	–	–	+	+
A. moenium (Vain.) G. Thor & Timdal	-	-	+	-	-	-	-	-	-	-	+	+	-	+	+
Bacidia laurocerasi (Delise ex Duby) Zahlbr.	+	+	+	–	+	–	+	–	–	+	–	–	–	–	–
B. inundata (Fr.) Körb.	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–
Biatora carneoalbida (Müll. Arg.) Coppins	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
B. ocelliformis (Nyl.) Arnold	–	–	–	–	–	–	+	–	–	–	–	–	+	–	–
B. sphaeroides (Dicks.) Hornem.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B. vernalis (L.) Fr.	–	–	–	–	+	+	–	–	+	–	–	+	–	–	–
Buellia jugorum (Arnold) Arnold	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
B. schaereri De Not.	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–
Caloplaca cerina (Hedw.) Th. Fr.	T	D	T	+	+	+	T	T	+	T	T	T	T	+	+
C. cerinella (Nyl.) Flagey	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. chlorina (Flot.) Sandst.	–	–	–	+	–	–	+	+	–	–	–	–	–	–	–

C. citrina (Hoffm.) Th. Fr.	+	–	–	–	–	–	–	–	–	–	–	–	–	+	–
C. flavorubescens (Huds.) J.R. Laundon	T	D	T	+	D	T	D	T	T	T	+	T	+	+	–
C. flavovirescens (Wulfen) Dalla Torre & Sarnth.	–	–	–	–	–	–	–	–	–	–	–	+	–	+	+
C. haematites (Chaub. ex St.-Amans) Zwackh	+	+	–	+	+	–	+	+	–	+	+	–	–	–	–
C. holocarpa (Hoffm.) A.E. Wade	+	+	+	+	–	–	+	T	+	T	–	T	T	–	–
C. lactea (A. Massal.) Zahlbr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
C. geophila Räsänen	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
C. saxicola (Hoffm.) Nordin	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
C. suspiciosa (Nyl.) H. Magn.	+	+	+	+	–	–	–	–	–	+	–	–	–	–	–
C. vitellinula (Nyl.) H. Olivier	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Candelaria concolor (Dicks.) Arnold	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Candelariella aurella (Hoffm.) Zahlbr.	–	+	+	–	+	–	–	+	+	–	–	–	–	+	+
C. vitellina (Ehrh.) Müll. Arg.	–	+	–	–	–	–	+	–	–	–	–	–	–	+	+
C. xanthostigma (Pers. ex Ach.) Lettau	T	D	T	+	+	+	T	T	T	T	+	T	T	–	–
Chrysothrix candelaris (L.) J.R. Laundon	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cladonia pyxidata (L.) Hoffm.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Cliostomum corrugatum (Ach.) Fr.	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–
Cresporhaphiswienkampii (J. LahmexHazsl.) M.B. Aguirre	+	–	–	–	–	–	–	+	–	+	–	+	+	–	–
Didymella persoonii (A. Massal.) H. Magn.	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–
Eopyrenula leucoplaca (Wallr.) R.C. Harris	–	–	–	–	–	–	–	–	+	+	–	+	+	–	–
Euopsis pulvinata (Schaer.) Vain.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Evernia esorediosa (Müll. Arg.) Du Rietz	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
E. mesomorpha Nyl.	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Flavopunctelia soredica (Nyl.) Hale	D	T	–	+	D	–	+	–	–	–	–	–	–	–	–
Fuscidea mollis (Wahlenb.) V. Wirth & Vezda	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Heterodermia speciosa (Wulfen) Trevis.	+	–	–	–	–	–	–	–	–	+	–	+	–	–	–
Hyperphyscia adglutinata (Flörke) H. Mayrhofer & Poelt	+	+	–	+	+	+	+	T	–	+	–	+	+	–	+
Hypocenomyce scalaris (Ach. ex Lilj.) M. Choisy	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–
Hypogymnia physodes (L.) Nyl.	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Julella fallaciosa (Stizenb. ex Arnold) R.C. Harris	+	–	+	+	–	+	–	–	–	+	–	–	–	–	–
Lecania alexandrae Tomin	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–
L. cyrtellina (Nyl.) Sandst.	+	+	–	+	+	+	+	+	–	+	–	+	+	–	–
L. erysibe (Ach.) Mudd	–	–	–	–	–	–	–	–	–	+	–	–	–	+	+
L. dubitans (Nyl.) A.L. Sm.	–	–	–	–	+	+	+	–	–	+	–	–	–	–	–
L. koerberiana J. Lahm	+	+	+	+	+	+	T	+	–	T	–	+	+	–	–

L. nylanderiana A. Massal.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Lecanora chlarotera Nyl.	+	T	+	+	–	–	–	–	–	–	–	+	+	–	–
L. crenulata(Wahlenb.) Nyl.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
L. dispersa (Pers.) Röhl.	–	–	+	–	–	–	+	–	–	+	–	+	–	+	+
L. frustulosa (Dicks.) Ach.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
L. hagenii (Ach.) Ach.	–	–	–	+	–	–	–	–	–	+	–	+	+	+	–
Lecanora straminella f. *lithophila* Bagl.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
L. muralis (Schreb.) Rabenh.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
L. orae-frigidae R. Sant.	+	–	+	+	+	+	–	–	–	–	–	+	+	–	–
L. populicola (DC.) Duby	+	+	–	–	+	–	T	D	+	+	+	T	T	–	–
L. pruinosa Chaub.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
L. pulicaris (Pers.) Ach.	+	+	–	+	+	–	–	+	–	–	–	+	+	–	–
L. symmicta (Ach.) Ach.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
L. valesiaca (Müll. Arg.) Stizenb.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
L. varia (Hoffm.) Ach.	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–
Lecidea helvola (Körb. ex Hellb.) H. Olivier	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–
L. hypopta Ach.	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–
Lecidella elaeochroma (Ach.) M. Choisy	+	+	–	–	–	–	–	–	–	+	–	–	–	–	–
L. stigmatea (Ach.) Hertel & Leuckert	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Lepraria incana (L.) Ach.	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–
Leptorhaphis atomaria (Ach.) Szatala	+	–	–	–	+	–	+	+	–	+	–	+	–	–	–
L. epidermidis (Ach.) Th. Fr.	+	+	–	+	–	–	–	–	–	–	–	+	–	–	–
L. lucida Körb.	–	+	–	–	–	–	–	+	–	–	–	+	–	–	–
Mattickiolichen triphragmioides (Anzi) Tomas. & Cif.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Melanohalea olivacea (L.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	+	T	–	–	–	–	–	–	–	–	–	–	–	–	–
M. septentrionalis (Lynge) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Melanelixia subargentifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Mycomicrothelia melanospora (Hepp) D. Hawksw.	+	–	–	–	+	+	–	+	+	–	–	+	–	–	–
M. wallrothii (Hepp) D. Hawksw.	–	–	–	–	+	–	+	–	–	–	–	–	–	–	–
Naetrocymbe punctiformis (Pers.) R.C. Harris	–	+	–	–	–	–	–	+	+	+	–	–	–	–	–
N. rhyponta (Ach.) R.C. Harris	+	+	–	–	–	–	–	–	–	+	–	–	–	–	–
Opegrapha niveoatra (Borrer) J.R. Laundon	+	–	–	+	–	–	–	–	–	–	–	+	–	–	–
O. rufescens Pers.	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–

Parmelia sulcata Taylor	+	D	–	–	–	–	–	–	–	–	–	–	–	–	–
P. vagans (Nyl.) Nyl.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Parmeliopsis ambigua (Wulfen) Nyl.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Phaeophyscia ciliata (Hoffm.) Moberg	+	+	+	+	+	+	–	–	–	+	+	+	–	–	–
Ph. denigrata (Hue) Moberg	+	+	+	+	+	+	+	D	D	T	–	+	T	–	+
Ph. hirsuta (Mereschk.) Essl.	+	+	+	+	+	–	+	+	–	+	–	+	–	–	–
Ph. hispidula (Ach.) Essl.	–	+	–	+	+	–	–	+	–	–	–	–	–	–	–
Ph. kairamoi (Vain.) Moberg	–	–	–	–	–	–	+	+	–	–	–	+	–	–	–
Ph. nigricans (Flörke) Moberg	T	D	+	+	+	+	+	+	+	+	+	+	+	+	+
Ph. orbicularis (Neck.) Moberg	D	D	D	T	+	+	D	D	+	D	T	T	T	+	+
Ph.primaria (Poelt) Trass	+	+	–	–	+	–	–	–	–	–	–	–	–	–	–
Physcia adscendens (Fr.) H. Olivier	+	+	+	+	+	–	+	+	–	+	–	+	–	–	–
Ph. aipolia (Ehrh. ex Humb.) Fürnr.	D	T	–	+	+	–	+	–	–	+	–	+	+	+	–
Ph. caesia (Hoffm.) Hampe ex Fürnr.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ph. dubia (Hoffm.) Lettau	+	D	–	+	+	+	+	+	–	+	–	+	+	–	–
Ph. leptalea (Ach.) DC.	+	+	–	+	+	+	–	–	–	+	+	–	–	–	–
Ph. magnussonii Frey	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
Ph. stellaris (L.) Nyl.	+	D	D	+	+	+	D	T	+	T	T	T	T	–	–
Ph. tenella (Scop.) DC.	D	T	+	+	+	+	T	+	–	+	–	+	–	+	–
Ph. tribacia (Ach.) Nyl.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Physciella chloantha (Ach.) Moberg	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Physconia detersa (Nyl.) Poelt	+	–	+	+	+	–	–	+	–	+	–	–	–	–	–
Ph. distorta (With.) J.R. Laundon	+	+	–	+	+	–	–	–	–	–	–	–	–	–	–
Ph. grisea (Lam.) Poelt	+	+	+	+	+	+	+	+	–	+	+	+	+	+	–
Ph. grumosa Kashiw. & Poelt	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ph. perisidiosa (Erichsen) Moberg	–	–	–	–	–	–	+	–	–	–	–	–	–	+	+
Physconia muscigena var. *petraea* Poelt	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
Platismatia glauca (L.) W.L. Culb. & C.F. Culb.	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Porina aenea (Wallr.) Zahlbr.	–	–	–	+	+	–	–	+	–	+	–	+	+	–	–
Protoblastenia rupestris (Scop.) J. Steiner	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Protoparmeliopsis macrocyclos (H. Magn.) Moberg & R. Sant.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Pyrenula laevigata (Pers.) Arnold	+	+	–	+	–	+	–	+	+	+	–	+	+	–	–
Ramalina asahinana Zahlbr.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. dilacerata (Hoffm.) Hoffm.	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–
R. roesleri (Hochst. ex Schaer.) Nyl.	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–

Rhizocarpon umbilicatum (Ramond) Flagey	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Rinodina archaea (Ach.) Arnold	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
R. bischoffii (Hepp) A. Massal.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
R. colobina (Ach.) Th. Fr.	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. exigua (Ach.) Gray	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
R. pyrina (Ach.) Arnold	+	T	+	+	+	–	+	+	+	+	–	+	+	–	–
R. septentrionalis Malme	+	+	–	–	+	–	–	–	–	–	–	–	–	–	–
R. sophodes (Ach.) A. Massal.	+	+	–	+	+	–	+	+	–	+	–	–	–	–	–
Scoliciosporum umbrinum (Ach.) Arnold	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thelenella modesta (Nyl.) Nyl.	–	+	–	–	+	+	+	+	T	+	+	T	T	–	–
Thelidium decipiens (Hepp) Kremp.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
T. minimum (A. Massal. ex Körb.) Arnold	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
Thelocarpon epibolum Nyl.	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–
Verrucaria deversa Vain.	–	–	+	–	–	–	+	+	–	+	–	+	+	+	+
V. viridula (Schrad.) Ach.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
V. nigrescens Pers.	–	–	+	–	–	–	+	–	–	+	–	+	+	+	+
V. umbrinula Nyl.	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
Xanthoria candelaria (L.) Th. Fr.	+	+	T	+	+	+	D	T	+	D	+	D	T	+	+
*X. fallax*Arnold	+	+	+	+	D	T	+	+	–	+	–	+	–	–	–
X. fulva (Hoffm.) Poelt & Petut.	+	+	–	–	+	–	–	–	–	–	–	–	–	–	–
X. parietina (L.) Beltr.	+	+	–	+	–	–	+	–	–	+	–	–	–	–	–
X. ulophyllodes Räsänen	+	+	+	+	+	–	+	+	–	–	+	+	–	–	–
Characteristics of lichen communities:															
Species richness	80	60	32	45	53	28	47	39	19	51	16	47	30	52	27
Coverage value averaged, %	31.82	28.81	16.92	26.26	38.71	29.29	32.41	20.07	4.09	20.29	6.5	7.76	7.27	—	—
Share of lichen-free trees, %	0	0	0	23.3	0	90.0	0	64.5	0	40.9	90.0	47.5	77.1	—	—
Share of sensitive species (a_i=1-3), %	43.2	33.3	6.4	8.9	25.0	10.7	15.0	2.6	5.3	5.9	0	4.5	0	—	—
Shannon entropy	2.17	2.34	1.99	1.54	1.95	0.99	2.37	2.0	1.60	2.19	0.9	1.46	1.68	—	—
IP value	7.68	7.0	7.69	8.90	5.56	6.74	8.07	8.49	7.74	8.32	8.9	8.72	8.79	—	—

Plant formations: 1 – out-of-town birch forest; 2 – out-of-town birch forest outliers; 3 – urban birch forest; 4 – urban birch forest outliers; 5 – out-of-town birch-pine forest; 6 – urban birch-pine forest; 7 – out-of-town alluvial planting along river floodplains; 8 – urban alluvial planting along river floodplains; 9 – poplar artificial planting under urban birch-pine forest canopy; 10 – out-of-town tree-lines; 11 – urban tree-lines; 12 – parks; 13 – gardens in residential environment; 14 – grass formations with native stones on high river-banks, 15 – grass formations on dumping grounds of limestone open-cut mining. Taxa: D – dominant; T – true species (occurrence >50%); + species existed within this plant formation, but was not dominant or true species; – species have not been found within this plant formation. Characteristics of lichen communities: — the values were not estimated

Table 2. Lichen life-forms and humidity groups in native and artificial planting in Iskitim

Plant formation	**Life-forms**						**Humidity groups**					
	crustose		**foliose**		**fruticose**		**mesophytes**		**xeromesophytes**		xerophytes	
	number of species	**%**	**number of species**	**%**	**number of species**	**%**	**number of species**	**%**	**number of species**	**%**	**number of species**	%
Out-of-town birch forest	40	50.0	38	47.5	2	2.5	69	86.3	11	13.8	-	-
Out-of-town birch forest outliers	28	46. 7	30	50.0	2	3.3	50	83.3	10	16.7	-	-
Urban birch forest	15	46.9	17	53.1	-	-	25	78.1	7	21.2	-	-
Urban birch forest outliers	23	51.1	22	48.9	-	-	36	80.0	9	20.0	-	-
Out-of-town birch-pine forest	29	54.7	24	45.3	-	-	46	86.8	7	13.2	-	-
Urban birch-pine forest	15	55.2	13	44.8	-	-	21	75.0	7	24.1	-	-
Out-of-town alluvial planting along river floodplains	23	48.9	22	46.8	2	4.3	42	89.4	5	10.6	-	-
Urban alluvial planting along river floodplains	22	56.4	17	43.6	-	-	31	79.5	8	20.5	-	-
Poplar artificial planting under urban birch-pine forest canopy	13	68.4	6	31.6	0	-	15	78.9	4	21.1	-	-
Out-of-town tree-lines	30	58.8	21	41.2	-	-	40	78,4	11	21.6	-	-
Urban tree-lines	7	43.8	9	56.3	-	-	0	0	13	81.3	3	18.8
Parks	27	57.4	20	42.6	-	-	33	70.2	14	29.8	-	-
Gardens in residential environment	18	60.0	12	40.0	-	-	20	66.7	10	33.3	-	-
Grass formations with native stones on high river-banks	41	78.8	11	21.2	-	-	16	30.8	22	42.3	14	26.9
Grass formations on dumping grounds of limestone open-cut mining	19	70.4	8	29.6	-	-	7	25.9	14	51.9	6	22.2

Table 3. Lichen substrates distribution in native and artificial planting in Iskitim

Plant formation	Deciduous tree bark	Coniferous tree bark	Both manufactured and decaying wood	Soil	Nativerocksand stones	Concrete	Mosses
Out-of-town birch forest	69	-	10	-	-	-	-
Out-of-town birch forest outliers	59	-	23	-	-	-	-
Urban birch forest	24	-	-	-	-	10	-
Urban birch forest outliers	45	-	19	-	-	-	-
Out-of-town birch-pine forest	45	10	6	-	-	-	-
Urban birch-pine forest	27	10	4	-	-	-	-
Out-of-town alluvial planting along river floodplains	47	-	-	-	7	-	-
Urban alluvial planting along river floodplains	39	8	-	-	1	-	-
Poplar artificial planting under urban birch-pine forest canopy	21	-	-	-	-	-	-
Out-of-town tree-lines	40	-	17	-	-	13	-
Urban tree-lines	15	-	-	-	-	1	-
Parks	23	10	-	-	-	2	-
Gardens in residential environment	29	7	-	-	-	-	-
Grass formations with native stones on high river-banks	-	-	-	5	42	-	1
Grass formations on dumping grounds of limestone open-cut mining	-	-	-	-	27	-	-

Discussion

Based on size of lichen-free zone, it could be argued environment of Iskitim is not very suitable for lichens, but it's the best among other Western Siberian cities and towns studied. So lichen-free zones were 35% in Novosibirsk, 17-70% in 4 small towns it's neighborhood (Romanova and Sedelnikova, 2010) and 26,3% in Kemerovo (Romanova, 2012).

According to the species richness and abundance, out of town plant formations (independently of tree species composition) were the less human-impacted. But Shannon entropy was quite low and IP values were a high even in these formations, so no one of them no intact. Lichen species richness and frequency of occurrence within urban native and artificial planting were equally low independently of tree species composition. But lichen abundance was less in artificial planting than in urban native plant formations. Parks and gardens in Iskitim are much smaller native communities, so we could see a forest fragmentation effect that is not suitable for lichens (Svoboda et al., 2010).

Lichen species richness on native stones much reduced from grass formations on river-banks to dumping grounds of limestone open-cut mining. The most likely causes of this situation are both combustion gases from vehicles and the age of substrate. Unlike the stones on river-banks, native stones on dumping grounds are usually located near roads that serve the limestone mining; at the same time age of this substrate was up to 80 years (Department…, 2012).

Nice indicator of plant formation's health is a fruticose lichens diversity (Lehmkuhl, 2004; Lommi, 2010). There are no plant formations with more than 2 fruticose species within and near Iskitim, and fruticose lichens had extremely low coverage values in all their localities. Accordingly, all plant communities within and near Iskitim are disturb with human impact. The same situation could be observed in other small towns studied within south of Western Siberia (Romanova and Sedelnikova, 2010).

Regardless of the human impact and tree species composition, range of epiphytic lichen humidity groups stay unchanged within tree formations of Iskitim as well as in plantings of other studied Western Siberian cities. But published data of epiphytic lichens in cities and towns in European Russia indicate increasing of xerophytes and xeromesophytes within lichen communities as far as human impact grew (Biazrov, 2009; Malysheva, 2003, Muchnik, 2003). What caused by this difference? Why share of xerophytes did not increase with human impact in Western Siberian cities and towns? This question needs to be studied in future.

Poor lichen occurrence on soil, concrete, deadwood and manufactured wood is also indicative to assess of plant formation health. These substrates occurred in all tree formations studied, but they were almost covered with lichens even in humid localities under native forest canopies in suburbs. Perhaps, cause of lichen poorness on artificial substrates is a continental climate in area studied: according to observations of other researchers, lichens occupied soon both artificial substrates and natural stone even in districts with maximal human impact in cities situated within oceanic climate (Malysheva, 2003; Nascimbene et al., 2009; Smith et al., 2010). But lichen species richness on deadwood within native plant communities clearly indicates it's well-being (Humphrey et al., 2002), and poverty of lichens on this substrate, as well as an absent of lichens on the mosses within native plant formations of Iskitim, indicates their damage.

Dominant and true species composition in epiphytic lichen communities tended to reduce of quite sensitive species position (specifically, *Parmeliaceae* species): at first they were no longer true species and then vanished entirely. If dominants were tolerant species (for example this situation could be found in birch forest and tree formations along river flood plains both in and out of town), their occurrence and abundance decreased all the same. The similar situation had been reported for other cities within both continental and oceanic climates (Biazrov, 2009; Castello and Skert, 2005; Geiser and Neitlich, 2007; Jeran et al., 2007; Loppi et al., 2002) and believable it is common trend to all areas urbanized.

It could be observed some species changed their usual substrate within injured plant formations of Iskitim. For example, one of the dominant or true species on pine-bark in native pine forest within and out of town was *Alyxoria varia* (Pers.) Ertz & Tehler that usually prefers to survive on a bark of deciduous trees. During earlier studies of lichens in Western Siberian cities it had been found on birch only, but the same phenomenon had been noticed for 3 other species: *Lecania cyrtellina* (Nyl.) Sandst., *Physcia dubia* (Hoffm.) Lettau and *Ph. stellaris* (L.) Nyl. (Romanova, 2009), which was not or was very rare on pine in native environments and become dominants or true species within impacted native plant formations or within artificial planting.

Conclusion

According to the lichen distribution's trend found, there are no human impact-free plant formations both within and out of the town, but most of them had got high lichen richness. Dimension of native and artificial planting within Iskitim were not enough for surviving of complete lichen communities with sensitive species in its structure.

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