The condition of the epiphytic lichens of dark coniferous forest in the area of the outbreak of ips sexdentatus boern on the Maly Abakan site of Khakassky nature reserve

Olga Larina[1*], *Evgenia* Makeeva[1,2]

[1]Khakas State University named after N.F. Katanov, 655000 Abakan, Russia
[2] Khakassky State Nature Reserve, 655017, Abakan, Russia

Abstract. The study presents data on the condition of the thalli of epiphytic lichens, their occurrence and projective cover on the sample plots located in the area of the outbreak of Ips sexdentatus Boern on the Maly Abakan site of Khakassky Nature Reserve.

1 Introduction

The Maly Abakan site of Khakassky State Nature Reserve is situated in the Tashtyp district of the Republic of Khakassia. In the territory, three main types of the landscape can be identified: the Alpine high-mountain landscape, the massive high-mountain landscape and the mid-mountain erosive landscape [2]. The study was conducted in the mountainous taiga vegetation belt represented by dark coniferous forest. The Siberian nut pine and the fir are the main trees of this forest.

Lichens represent one of the significant components of the forest communities. The species composition and the living forms of epiphytic lichens are closely connected with certain environmental factors and naturally vary as the environmental conditions change. For example, density and extension of the canopies of the trees described is one of such factors [1, 9-10].

For several decades, the reserve scientists have been investigating the impact of the bark beetle *Ips sexdentatus* Boern., which results in mass drying out of the trees [3-5].

2 Materials and methods

In 2019, we conducted a study of the species composition of the epiphytic lichens on the Maly Abakan site of Khakassky State Nature Reserve in the areas most infested by *Ips sexdentatus* [9-10]. Four permanent sample plots were selected (sized 20x20 m), located on two sites: near Nizhny post (further referred to as 'Nizhny' site and near the mouth of the Otkyl River ('Otkyl' site). Two sample plots were flawless (with trees not infested by the bark beetles), and two sample plots contained trees infested by the pest. On each site under

* Corresponding author: o_a_zyryanova@mail.ru

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (http://creativecommons.org/licenses/by/4.0/).

study, 10 phorophytic trees selected belonged to *Pinus sibirica* Du Tour, and 5 – *Abies sibirica* Ledeb. [9-10]. Each tree was divided into zones: the lower part of the tree trunk, the trunk and the canopy. From all the sides, the projective cover of epiphytic lichens was determined for each tree using the method of line intersects [8]. The lichen thalli were studied on the intersection with the measuring tape (with millimeter graduation), applied horizontally to the tree trunk at a certain height (0.6 m; 0.9 m; 1.2 m; 1.5 m). The sum of the lengths of the thallus parts of lichens of a certain species divided by the length of the entire horizontal section was taken into consideration. The linear projective cover (PC) for the domineering species of epiphytic lichens was calculated as an integral value (average for all the trees and for all the heights).

3 Results and discussion

For two plots under study, 46 species of epiphytic lichens were identified, referring to 24 genera and 13 families. The small species variability of the epiphytic lichens in the dark coniferous forest may be caused to the high degree of canopy density in the territory under study (0.7-0.8) and by the other factors (the height and age of the phorophytic tree).

The total number of the identified lichen species on *Pinus* (on all the plots) was 34, and that on *Abies* was 32. Depending on the number of the infested phorophytes, the epiphytic lichens found on the plots could be divided into two groups: stenotopes – species found only on one phorophyte (26 species), and olygotopes – species found on *Pinus* and *Abies* (22 species).

The following species were found only on *Abies*: *Alectoria sarmentosa*, *Bryoria capillaris*, *B. furcellata*, *B. fuscescens*, *B. tortuosa*, *Cladonia bacilliformis*, *C. squamosa*, *Evernia mesomorpha*, *Lecanora carpinea*, *Lecidea albofuscescens*, *Ramalina pollinaria*, *Usnea hirta;* only on *Pinus*: *Bacidia circumspecta*, *Bryoria nadvornikiana*, *B. simplicior*, *Cetrelia cetrarioides*, *Cladonia fimbriata*, *C. rei*, *Evernia esorediosa*, *Hypogymnia bitteri*, *Lecania cyrtella*, *Melanelia exasperata*, *Mycobilimbia hypnorum*, *Nephromopsis laureri*, *Physcia adscendens*, *P. tenella*.

The most commonly occurring species found on the examined phorophytes of the Nizhny site were the following: *Usnea glabrescens* (found on 70.0% of the examined trees), *Hypogymnia vittata* (65.0%), *H. physodes* and *Platismatia glauca* (по 45.0%), *Usnea dasopoga* (35.0%), *Chaenotheca ferruginea* and *Parmelia sulcata* (30.0%); those found on the phorophytes of the Otkyl site were: *Chaenotheca ferruginea* (65.0%), *Hypogymnia vittata* (45.0 %), *Usnea dasopoga* (35.0%), and *U. glabrescens* (30.0%).

Thus, foliose epiphytic lichens occur most widely in the said territories.

On all the sample plots, the species *Hypogymnia vittata* is common. This epiphytic lichen has become well-adapted to the conditions of the locality under study. The occurrence and projective cover of the other types of epiphytic lichens are much lower.

Consider the composition of the domineering species of the epiphytic lichens and variation of their linear projective cover (PC) on the flawless sample plots and on the infested plots under study (Table 1).

Nizhny site: *Pinus sibirica*.

Sample plot N_d. The domineering species graded by the reduction of the projective cover: *Pertusaria flavida*, *Chaenotheca ferruginea*, *Hypogymnia vittata*, *H. physodes*, *Tuckemanopsis chlorophylla*, *Vulpicida pinastri*, *Usnea glabrescens* (табл. 1).

Sample plot N_f. The domineering species: *Hypogymnia vittata*, *Platismatia glauca*, *Cladonia fimbriata*, *Hypogymnia bitteri*, *H. physodes*, *Tuckemanopsis chlorophylla*, *Cladonia coniocraea*, *Parmelia squarrosa*, *Ramalina dilacerate*, *Mycobilimbia hypnorum*, *Usnea dasopoga*, *U. glabrescens.*

Nizhny site: *Abies sibirica*.

Sample plot N_d. The domineering species: *Chaenotheca ferruginea, Hypogymnia vittata, Pertusaria amara, Usnea glabrescens, Platismatia glauca, Pertusaria flavida, Lobaria pulmonaria, Hypogymnia physodes.*
Sample plot N_f. The domineering species: *Hypogymnia physodes, H. vittata, Parmelia sulcata, Usnea glabrescens, Platismatia glauca, Lobaria pulmonaria, Pertusaria amara, Alectoria sarmentosa*.
Otkyl site: *Pinus sibirica*.
Sample plot O_d. The domineering species: *Hypogymnia vittata, Usnea glabrescens, U. dasopoga.*
Sample plot O_f. The domineering species: *Chaenotheca ferruginea, Hypogymnia vittata, Usnea dasopoga, Vulpicida pinastri, Platismatia glauca.*
Otkyl site: *Abies sibirica*.
Sample plot O_d. The domineering species: *Chaenotheca ferruginea, Lobaria pulmonaria, Hypogymnia vittata, Parmelia sulcata, Usnea dasopoga*
Sample plot O_f. The domineering species: *Chaenotheca ferruginea, Hypogymnia vittata, Lobaria pulmonaria, Lecidea turgidula, Usnea glabrescens, Hypogymnia physodes, Lecanora carpinea, Vulpicida pinastri.*

Table 1. Linear projective cover of the domineering species of epiphytic lichens on the flawless and infested plots, %

Species	Nizhny plot				Otkyl plot			
	Pinus sibirica		*Abies sibirica*		*Pinus sibirica*		*Abies sibirica*	
	N_d	N_f	N_d	N_f	O_d	O_f	O_d	O_f
Alectoria sarmentosa				0,3				
Chaenotheca ferruginea	4.48		34.4		16.6	9.7	29.8	15.3
Cladonia coniocraea		0.2						
Cladonia fimbriata		0.9						
Hypogymnia bitteri		0.8						
Hypogymnia physodes	0.9	0.8	0.3	4.6				0.5
Hypogymnia vittata	3.5	1.9	9.4	4.1	1.0	3.7	2.2	6.1
Lecanora carpinea								0.4
Lecidea turgidula								3.2
Lobaria pulmonaria			0.5	2.6			2.7	3.2
Mycobilimbia hypnorum		0.1						
Parmelia squarrosa		0.2						
Parmelia sulcata				3.5			2.2	
Pertusaria amara			8.7	1.1				

Pertusaria flavida	4.6		0.7					
Platismatia glauca		1.5	1.4	1.2		0.4		
Ramalina dilacerate		0.2						
Tuckemanopsis chlorophylla	0.8	0.5						
Usnea dasopoga		0.1			0,1	1.2	0.3	
Usnea glabrescens	0.2	0.,1	3.1	3.0	0,2			2.8
Vulpicida pinastri	0.5					0.6		0.3

* d – a site with damaged trees, f – a site without damage.

There is no clear regularity in the increase or decrease of the projected cover of lichens on the flawless and damaged sites in terms of the complex of the range of species. For instance, on the Nizhny site, the PC of *Hypogymnia vittata* (both on the Siberian nut pine and on the firs) was greater on the damaged plots with infested trees, while the inverse dependence was observed on the Otkyl site. In the damaged area of the Nizhny site, the increase of the average PC of certain lichen species was observed: *Hypogymnia vittata, H. physodes, Tuckemanopsis chlorophylla, Usnea glabrescens*. However, the total variety of the domineering species was found to be greater on the flawless sample plot.

The degree of the projective cover of the species *Chaenotheca ferruginea* rises in the damaged areas. The degree of the projective cover of such a species as *Lobaria pulmonaria* rises on the sample plots. This is definitely related to the fact that the thallus of this species is sensitive to the smallest fluctuations of atmospheric pollution, to fires, felling of the trees, and other limiting factors, but, in case these factors are absent, the species regenerates.

On the plots with infested phorophytes, the thallus of *Lobaria pulmonaria* turned dark brown, indicating its destruction. It is to be pointed out that the damaged thalli of epiphytic lichens were found also for *Hypogymnia physodes, Parmelia sulcata* and for single plants of *Platismatia glauca*. The damage was related to the presence of necroses on the thalli, manifested in the change of the color of the thallus (from gray to reddish-brown) and in the destruction of soralia (soredia).

Among the rare species (listed in the Red Books of the Russian Federation and of the Republic of Khakassia, respectively), the following species were found on the plots in question: *Lobaria pulmonaria* and *Nephromopsis laureri* (Kremp.) Kurok. [6,7]. The population of *Nephromopsis laureri* is in a stable condition, whereas that of *Lobaria pulmonaria* is suppressed.

4 Conclusion

In terms of the projective cover, foliose and fruticose lichens were found to prevail on the sample plots. The projective cover of crustose lichens rose on the sites infested by the bark beetle. Currently the influence of the bark beetle on the morphology of epiphytic lichens has been noted (the damage of lichen thalli), indicating the suppressed vital function of lichens on the infested territories.

Acknowledgements. This work was supported by the RFFI grant 18-44-190004 (Russian Foundation for Basic Research) r_a Assessment of the state of pine forests of the Republic of Khakassia in the place of localization of the breeding outbreak of Ips sexdentatus (by the example of the Maly Abakan site, Khakassky Nature Reserve)

References

1. Methods of studying of forest communities (NIIHimiya SPbSU, St. Petersburg, 2002)
2. Khakassky Reserve: a scientific publication (Journalist, Abakan, 2001)
3. I. L. Maymanakova, Scientific research of reserves and national parks of Southern Siberia, **1** (2011)
4. I. L. Maymanakova, Scientific research of reserves and national parks of Southern Siberia, **4** (2014)
5. I. L. Isaeva, Achievements of modern natural sciences, **12 (1)** (2018)
6. The Red Book of the Russian Federation: plants and fungi (KMK Society of Scientific Publications, Moscow, 2008)
7. The Red Book of the Republic of Khakassia. Rare and endangered species of plants (Novosibirsk, 2012)
8. A. V. Pchelkin, V. B. Slepov, The use of algae and lichens in environmental monitoring and bioindication studies (MGSUN, Moscow, 2004)
9. O. A. Zyryanova, E. G. Makeeva, The species composition of the epiphytic lichens of the Siberian pine and fir forest on the Maly Abakan site of Khakassky Nature Reserve (SB RAS Press, Novosibirsk, 2019)
10. E. Makeeva, O. Zyryanova, Epiphytic lichens of the dark coniferous forest within the outbreak of Ips sexdentatus Boern. in the Maly Abakan site of the Khakassky Nature Reserve (CSBG SB RAS, Novosibirsk, 2019)