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Lichens and allied fungi of old parks of three museum-reserves in Moscow Region (Russia)

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Abstract: We present the results of lichenological research in the parks of the museum-reserve Abramtsevo, the museum-reserve of A. S. Pushkin and the museum-estate Ostafyevo – Russian Parnassus, for which no previous data were available. The checklist of lichen biota contains 103 species including 98 lichens, a lichenicolous fungus and 4 non-lichenized fungi. 55 species were found in the park of the museum-reserve Abramtsevo, 58 species in the museum-reserve of A. S. Pushkin (estates Vyazemy – 51 and Zakharovo – 29) and 69 species in the museum-estate Ostafyevo – Russian Parnassus. *Lichenochora obscuroides* (Ostafyevo) is new for Central Russia. *Cladonia macilenta*, *Evernia prunastri* and *Usnea hirta* (Ostafyevo) are listed in the Red Data Book of Moscow. *Parmelina tiliacea* (Abramtsevo, Vyazemy), *Ramalina farinacea*, *Usnea dasopoga* and *U. subfloridana* (Abramtsevo) are listed in the Red Data Book of the Moscow Oblast. *Chaenotheca chrysocephala*, *Melanelixia subargentifera*, *Parmelina tiliacea*, *Physconia perisidiosa* and *Ramalina europaea* (Ostafyevo) are proposed for inclusion in the next edition of the Red Data Book of Moscow.

Keywords: lichen biota, lichenicolous fungi, biodiversity, indicator species, Red Data Book, park communities, Central Russia

INTRODUCTION

Old parks in urbanized landscapes are shelters for biodiversity including lichens (Likhacheva, 2010; Liira et al., 2020). In Russia, the parks of the museum-reserves (museum-estates) are usually natural areas having historical and cultural heritage value, which are specially protected at the federal level (Muchnik, 2015). Therefore, they can be considered as promising territories for environmental monitoring in anthropogenically transformed regions. Lichens of the parks of the museum-reserves have repeatedly been objects of research in Central Russia (Malysheva, 1999; Gudovicheva, 2001; Muchnik, 2014; Muchnik, 2015; Gagarina et al., 2020; etc.). However, lichens of the parks of the museums-reserves in the Moscow Region (Moscow and the Moscow Oblast) are poorly studied. In total, there are 14 museums-reserves in the Moscow Region, which include 20 manor parks. Prior to our research, only fragmentary information was available about the lichens of three parks in the city of Moscow, namely the parks Tsaritsyno (Biazrov, 2009), Kolomenskoye and Lefortovo (Pchelkin, 1998; Pchelkin & Pchelkina, 2015). Thirteen species of lichens were found in Tsaritsyno, of which seven species are known by the historical data from the early 20th century. Forty-five species are known from Kolomenskoye, two species of them are listed in the Red Data Book of Moscow: *Graphis scripta* (L.) Ach. and *Protoparmeliopsis muralis* (Schreb.) M. Choisy; two further species are reported from Lefortovo.

Biodiversity exploration in the parks of the museum-reserve (MR) Abramtsevo, the MR of A. S. Pushkin and the museum-estate (ME) Ostafyevo – Russian Parnassus has been started very recently. The published accounts display taxonomic, ecological and sozological analyses, and state assessment of lichen biota (Muchnik et al., 2018; Muchnik & Cherepenina, 2018; Cherepenina & Muchnik, 2019). This paper presents a full lichen checklist of all surveyed parks and a comparative analysis of species richness and lichen diversity.

MATERIAL AND METHODS

The lichen biota of the parks of the MR Abramtsevo, the MR of A. S. Pushkin (estates Vyazemy and Zakharovo) and the ME Ostafyevo - Russian

Parnassus (Fig. 1) was studied in 2016–2018. The surveyed parks are located in the subzone of mixed coniferous-broadleaved forests of the East European Plain in the moderately continental climate zone (Kolosova & Churilova, 2004). *Acer platanoides* L., *Betula* sp., *Picea abies* (L.) H. Karst., *Pinus sylvestris* L., *Populus tremula* L., *Quercus robur* L. and *Tilia cordata* Mill. are typical tree species in coniferous-broadleaved forests and prevail in park plantations. All parks have total area about 32–50 ha and they all originate from the 18th century. The age of some trees exceeds 200 years. According to Kolosova & Churilova (2004), the ME Ostafyevo is located in an area with high degree of anthropogenic impact, and the MRs of A. S. Pushkin and Abramtsevo are situated in areas with moderate degree of anthropogenic impact. However, the MR Abramtsevo is located near a village, while the MR of A. S. Pushkin is situated inside a small town with a greater anthropogenic load.

27 sample plots were examined across all three museum-reserves: plots 1-5 in the MR Abramtsevo, 6-13 in the estate Vyazemy and 14-16 in the estate Zakharovo within the MR of A. S. Pushkin, and 17-27 in the ME Ostafyevo; additional data about the studied localities (geographical coordinates, areas, tree species) are presented in Appendix 1.

Morphology and anatomy of collected vouchers were studied by routine microscopic and laboratory techniques. Some sterile specimens were determined by thin layer chromatography (TLC) (Orange et al., 2001). 1096 identified specimens are deposited in the herbarium of Tsitsin Main Botanical Garden RAS (MHA). The nomenclature follows Nordin et al. (2011). Indicator species of old-growth forest and park communities were selected following Himelbrant & Kuznetsova (2009) and Muchnik (2015a). Protected species are listed following the Red Data Book of Moscow (2011) and Red Data Book of the Moscow Oblast (2018). The Sørensen Index (Sørensen, 1948) was calculated to determine the similarity of lichen biota. The specificity of lichen biota of the surveyed parks (K) was calculated by the formula: $K = (a/b) \times 100$, where a – number of species found only in one of the surveyed parks, b – total number of species found in all surveyed parks. Menhinik Index was calculated to determine the relative indicator of the species richness of lichen biota. Shannon Index of Diversity, which also takes into account the structural aspect, was calculated for a generalized assessment of diversity. Both indices are quite widely used in biodiversity studies as they allow comparisons of samples with different sizes (Magguran, 2004).

RESULTS AND DISCUSSION

The study revealed 103 species: 98 lichens, a lichenicolous fungus and 4 non-lichenized fungi (Table 1). 55 species were found in the park of the MR Abramtsevo, 58 species in the MR of A. S. Pushkin (in estates Vyazemy – 51

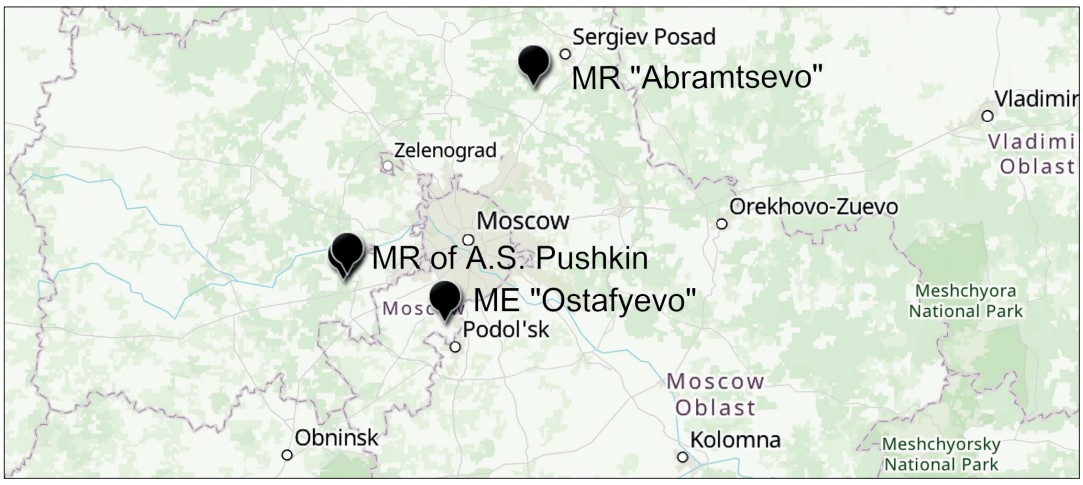

Fig. 1. The locations of the studied parks of the museum-reserves in the Moscow Region.

and Zakharovo – 29) and 69 species in the ME Ostafyevo – Russian Parnassus. The lichen diversity in the surveyed parks is higher than in the manor parks of the neighboring Smolensk Region. Studies of that Region reveal the highest diversity of 41 species in the Natural Monument Dugino (36 ha) while the other manors had 7–39 species and lacked protection value (Gagarina et al., 2020). Apparently, the federal protection of the museums-reserve's parks in Moscow region has a positive effect on the lichen biodiversity.

Comments on the species

The lichenicolous fungus *Lichenochora obscuroides* is new for Central Russia. Its known distribution in European Russia: Kaliningrad, Leningrad, Samara Regions and Republic of Bashkortostan (Tsurykau & Korchikov, 2017). However, it is likely to be widespread but undercollected as the host, *Phaeophyscia orbicularis*, is very common within the study area.

Candelaria concolor was previously reported as *Candelaria pacifica* M. Westb. & Arup. (Muchnik & Cherepenina, 2018), but later re-identified by A. Tsurykau. *Ramalina europaea* from MR Abramtsevo (point 2) was previously reported as *Ramalina pollinaria* (Westr.) Ach. (Muchnik et al., 2018), but was later re-identified by A. Tsurykau, as *Ramalina europaea* has recently been described by a combination of morphological and genetic characteristics (Gasparyan et al., 2017). *Xanthomendoza fallax* was previously reported as *Xanthomendoza huculica* (S.Y. Kondr.) Diederich (Cherepenina & Muchnik, 2019), which is currently considered as a synonym of *X. fallax* (Lindblom et al, 2019).

Analysis of the lichen biota

Candelariella efflorescens, *Hypogymnia physodes*, *Lecania fuscella*, *Lecanora symmicta*, *Parmelia sulcata*, *Phaeophyscia orbicularis*, *Physcia adscendens*, *P. aipolia*, *Physconia enteroxantha* and *Xanthoria parietina* form the core of lichen biota in the studied parks. In our definition, the "core of lichen biota" is identical to the concept of "core of bryoflora" (Maslovsky, 1990) and is considered from the point of view of the species occurrence. The core species are most widespread, have a stable position in the community and are able to withstand significant environmental fluctuations.

Cladonia macilenta, *Evernia prunastri* and *Usnea hirta* (Ostafyevo) are listed in the Red Data Book of Moscow (2011). *Parmelina tiliacea* (Abramtsevo, Vyazemy), *Ramalina farinacea*, *Usnea dasopoga* and *U. subfloridana* (Abramtsevo) are listed in the Red Data Book of the Moscow Oblast (2018). Also, *Hypogymnia tubulosa* (Abramtsevo, Zakharovo) is listed in the Appendix of the Red Data Book of the Moscow Oblast as a rare and vulnerable species that needs constant monitoring. Other rare and interesting records for park communities include *Arthonia punctiformis*, *Arthopyrenia analepta*, *Biatora helvola*, *Chaenotheca chrysocephala* (Ostafyevo), *C. trichialis* (Abramtsevo, Vyazemy, Ostafyevo), *Lecidea erythrophaea* (Vyazemy), *Parmeliopsis ambigua* (Abramtsevo, Zakharovo), *Pycnora sorophora* (Vyazemy). These species have forest ecology and are more characteristic for zonal forest communities.

Furthermore, *Alyxoria varia* (Ostafyevo), *Caloplaca obscurella* (Zakharovo), *Catinaria atropurpurea* (Vyazemy), *Melanelixia subargentifera* (Ostafyevo), *Parmelina tiliacea* (Vyazemy, Ostafyevo) and *Physconia perisidiosa* (Abramtsevo, Ostafyevo) are indicators of biologically valuable forest and park landscapes in the subzone of mixed coniferous-broadleaved forests (Muchnik, 2015a). Within the subzone, these species inhabit only old-growth forest and park communities, hence we consider them as indicators of old-aged forest and park communities.

According to the specificity values (Table 2), each park includes a notable proportion of species not found in the other parks, contributing differently to the lichen biota of the region. As a result, all studied park communities are valuable biotopes for lichens and should be conserved as habitats of rare lichen species, including lichens typical for forest ecology, indicator species and red-listed species. However, the lichen biota of park of the ME Ostafyevo has the highest number of unique species due to higher number of preserved old-growth trees (especially *Ulmus glabra* Mill.), creating additional micro-habitats for lichens.

The parks of the MR of A. S. Pushkin and the ME Ostafyevo are most similar considering lichen biota, according to Sørensen Index values (Table 3). These parks have greater similarity of planted

Table 1. List of recorded species in the parks of three museum-reserves in Moscow region. The following symbols are used: # – lichenicolous fungi; + – allied non-lichenized fungi; * indicator species of old-aged forest and park communities; ! – the species is in the Red Data Book of Moscow; !! – the species is in the Red Data Book of the Moscow Oblast; new species for Central Russia is in **bold**.

Taxon	Study plots within the museum-reserves			Substrata and notes
	Abramtsevo	A. S. Pushkin	Ostafyevo	
**Alyxoria varia* (Pers.) Ertz &Tehler			19	bark of old *Ulmus* sp.
Amandinea punctata (Hoffm.) Coppins & Scheid.	2	6–9, 11	18–20, 23, 25	bark of old *Betula* sp., *Larix sibirica* Ledeb., *Malus* sp., old *Pinus sylvestris*, old *Quercus robur*, *Tilia cordata*
Anisomeridium polypori (Ellis & Everh.) M. E. Barr		10		bark of *Acer platanoides*
Arthonia punctiformis Ach.			25	bark of old *Betula* sp.
Arthopyrenia analepta (Ach.) A. Massal			23	bark of old *Acer platanoides*
Athallia holocarpa (Hoffm.) Arup et al.			17	treated wood
Athallia pyracea (Ach.) Arup et al.		7, 9, 13, 14	17, 27	bark of *Acer platanoides*, old *Betula* sp., *Fraxinus* sp., *Populus* sp., *Populus tremula*, *Salix* sp., branches of deciduous trees
Bacidina chloroticula (Nyl.) Vězda & Poelt		9		rotted wood; det. G. P. Urbanavichus
Biatora globulosa (Flörke) Fr.	2, 4		19, 24	bark of *Quercus robur*, *Tilia cordata*
Biatora helvola Körb. ex Hellb.			17	branch of *Betula* sp.
Buellia griseovirens (Turner & Borrer ex Sm.) Almb.		8	18, 25	bark of *Betula* sp., old *Pinus sylvestris*, rotted wood; TLC: atranorin, norstictic acid
Caloplaca cerina (Hedw.) Th. Fr.		7, 9, 15	23, 27	bark of *Acer platanoides*, *Malus* sp., *Populus tremula*, old *Salix* sp.
**Caloplaca obscurella* (J. Lahm ex Körb.) Th. Fr.		15		on bark of old *Pyrus* sp.; det. A. G. Paukov
Candelaria concolor (Dicks.) Stein		12		bark of old *Larix sibirica*
Candelariella efflorescens R. C. Harris & W. R. Buck	2	6, 7, 9–15	17–27	bark of deciduous trees, bark and branch of *Pinus sylvestris*, treated wood
Candelariella vitellina (Hoffm.) Müll. Arg.			18, 20, 23	bark of *Malus* sp., *Syringa* sp., branches of *Tilia cordata*
Catillaria nigroclavata (Nyl.) Schuler		9, 14	17, 18, 25, 27	bark of old *Betula* sp., old *Salix* sp., *Tilia cordata*, branches of *Pinus sylvestris*, *Tilia cordata*, treated wood
**Catinaria atropurpurea* (Schaer.) Vězda & Poelt		8		rotted wood
Chaenotheca chrysocephala (Turner ex Ach.) Th. Fr.			19	bark of old *Ulmus* sp.
Chaenotheca ferruginea (Turner ex Sm.) Mig.	2, 4, 5		18, 19, 25	bark of old *Picea abies*, *Pinus sylvestris*, old *Tilia cordata*
*Chaenotheca trichialis (*Ach.) Th. Fr.	2	9	18, 19	bark of old *Picea abies*, old *Tilia cordata*
Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.	1, 2, 4	14–16	17, 19, 20, 22, 24, 25, 27	bark of *Betula* sp., *Quercus robur*, *Tilia cordata*
Cladonia coniocraea (Flörke) Spreng.	1, 2, 4, 5	7, 10, 12, 14, 16	1 7 – 2 0 , 22–25, 27	bark of *Betula* sp., old *Quercus robur*, *Tilia cordata*, rotted wood
Cladonia digitata (L.) Hoffm.	2, 4		19, 22	bark of *Betula* sp., *Tilia cordata*

Table 1. (continued)

Taxon	Study plots within the museum-reserves			Substrata and notes
	Abramtsevo	A. S. Pushkin	Ostafyevo	
Cladonia fimbriata (L.) Fr.	1, 4	7, 12, 16	17–20, 22, 24–27	bark of *Betula* sp., old *Pinus sylvestris*, old *Quercus robur*, old *Tilia cordata*, rotted wood
! *Cladonia macilenta* Hoffm.	4		19, 25	bark of old *Betula* sp., old *Quercus robur*
Evernia mesomorpha Nyl.	5			bark of *Betula* sp.
! *Evernia prunastri* (L.) Ach.	1, 4		18, 20	bark of *Betula* sp., *Tilia cordata*
Fuscidea arboricola Coppins & Tønsberg	2			bark of *Quercus robur*, *Tilia cordata*
Fuscidea pusilla Tønsberg			27	bark of old *Betula* sp.; TLC: divaricatic acid
Hypocenomyce scalaris (Ach.) M. Choisy	1, 2, 4		24, 25	bark of *Betula* sp., old *Picea abies*, old *Pinus sylvestris*, old *Tilia cordata*, rotted wood
Hypogymnia physodes (L.) Nyl.	1–5	8, 11, 14–16	17–20, 24, 25, 27	bark and branches of deciduous and coniferous trees
Hypogymnia tubulosa (Schaer.) Hav.	1, 4	15		on bark of *Betula* sp., old *Pyrus* sp.
+ *Julella fallaciosa* (Stizenb. ex Arnold) R. C. Harris			17–19, 24, 25	bark of *Betula* sp.
Lecania cyrtella (Ach.) Th. Fr.	1, 4	7, 9	21, 27	bark of *Fraxinus* sp., *Populus tremula*, *Salix* sp., *Tilia cordata*
Lecania cyrtellina (Nyl.) Sandst.	3, 4			bark of *Acer platanoides*, *Populus tremula*
Lecania fuscella (Schaer.) A. Massal.	3, 5	7, 9, 11, 14, 15	18, 21, 26, 27	bark of deciduous trees, branches of *Betula* sp.
Lecania koerberiana J. Lahm		9, 14		bark of old *Betula* sp., *Salix* sp.
Lecania naegelii (Hepp) Diederich & van den Boom			21, 24, 27	bark of *Populus tremula*, *Prunus padus* L., *Salix* sp., *Tilia cordata*
Lecanora albellula (Nyl.) Th. Fr.		7–10	24	bark of old *Betula* sp., old *Larix sibirica*, old *Pinus sylvestris*
Lecanora allophana Nyl.	4, 5			bark of *Quercus robur*, *Tilia cordata*
Lecanora carpinea (L.) Vain.	5	11, 13		bark of *Acer platanoides*, *Populus tremula*, *Tilia cordata*
Lecanora chlarotera Nyl.		14		bark of *Populus tremula*
Lecanora circumborealis Brodo & Vitik.	3, 4			bark of *Quercus robur*
Lecanora leptyrodes (Nyl.) G. B. F. Nilsson	3			bark of *Acer platanoides*
Lecanora populicola (DC.) Duby		13	22	bark of *Acer tataricum* L., *Populus* sp.
Lecanora pulicaris (Pers.) Ach.	5	12, 14	25	bark of old *Betula* sp., *Tilia cordata*
Lecanora saligna (Schrad.) Zahlbr.			25	bark of old *Betula* sp.
Lecanora symmicta (Ach.) Ach.	1, 3–5	9, 11–15	17–19, 22, 25, 27	bark and branches of deciduous and coniferous trees
Lecidea erythrophaea Flörke ex Sommerf.		8		rotted wood
Lecidella elaeochroma (Ach.) M. Choisy f. *soralifera* (Erichsen) D. Hawksw.		7		bark of *Quercus robur*; TLC: arthothelin
Lecidella flavosorediata (Vězda) Hertel & Leuckert			17, 27	bark of *Betula* sp., old *Tilia cordata*; TLC: arthothelin, granulosin
Lepraria elobata Tønsberg	1, 2, 4	14	18, 19, 23–26	bark of old *Betula* sp., old *Quercus robur*, *Tilia cordata*, rotted wood

Table 1. (continued)

Taxon	Study plots within the museum-reserves			Substrata and notes
	Abramtsevo	A. S. Pushkin	Ostafyevo	
Lepraria finkii (B. de Lesd.) R. C. Harris			18, 19, 24, 27	bark of old *Betula* sp., *Pinus sylvestris*, old *Tilia cordata*, old *Ulmus* sp.
Lepraria incana (L.) Ach.	2		18, 20, 24	bark of old *Betula* sp., old *Quercus robur*, old *Tilia cordata*; TLC: divaricatic acid, zeorin
+ *Leptorhaphis epidermidis* (Ach.) Th. Fr.	1	7	18, 25	bark of *Betula* sp.
# ***Lichenochora obscuroides*** (Linds.) Triebel & Rambold (Fig. 2)			23	thallus of *Phaeophyscia orbicularis* growing on bark of old *Acer platanoides*; det. A. Tsurykau
Melanelixia glabratula (Lamy) Sandler & Arup	2, 4	6		bark of old *Quercus robur*, *Tilia cordata*
**Melanelixia subargentifera* (Nyl.) O. Blanco et al.			17, 18, 20, 23	bark of old *Acer platanoides*, *Malus* sp., *Tilia cordata*
Melanelixia subaurifera (Nyl.) O. Blanco et al.	4			bark of *Betula* sp.
Melanohalea exasperata (De Not.) O. Blanco et al.	1			bark of old *Quercus robur*
Melanohalea exasperatula (Nyl.) O. Blanco et al.	1	6, 7, 11, 15	17–20	bark and branches of deciduous trees, bark of *Picea abies*, treated wood
Melanohalea olivacea (L.) O. Blanco et al.	1, 5			bark of *Betula* sp., branch of deciduous trees
Micarea nitschkeana (J. Lahm ex Rabenh.) Harm.			25	bark of old *Pinus sylvestris*
+ *Mycomicrothelia confusa* D. Hawksw.	2		18, 20, 23–27	bark of *Tilia cordata*
+ *Mycomicrothelia wallrothii* (Hepp) D. Hawksw.		13	27	bark of *Betula* sp., *Populus tremula*
Myriolecis hagenii (Ach.) Śliwa et al.		7, 9, 13	17, 22	bark of *Acer platanoides*, *Acer tataricum*, *Fraxinus* sp., old *Salix* sp., deciduous tree, treated wood
Myriolecis persimilis (Th. Fr.) Śliwa et al.	5			bark of *Tilia cordata*
Myriolecis sambuci (Pers.) Clem.		11		bark of *Alnus* sp.
Parmelia sulcata Taylor	1, 3–5	6, 7, 9–16	17–25, 27	bark and branches of deciduous trees and coniferous trees
*!! *Parmelina tiliacea* (Hoffm.) Hale		6	18, 20	bark of old *Betula* sp., old *Quercus robur*, *Tilia cordata*
Parmeliopsis ambigua (Wulfen) Nyl.	1, 4	14		bark of *Betula* sp., old *Quercus robur*
Phaeophyscia nigricans (Flörke) Moberg		9, 13, 14	17, 18, 20, 22, 23, 27	bark of deciduous trees, rotted wood
Phaeophyscia orbicularis (Neck.) Moberg: var *orbicularis*	4, 5	7, 9–16	17–20, 22, 23, 25–27	bark and branches of deciduous trees and coniferous trees, rotted and treated wood
var. *hueiana* (Harm.) Clauzade & Cl. Roux			27	bark of *Populus tremula*
Phlyctis argena (Spreng.) Flot.	1, 2	7, 9	18, 20, 24	bark of old *Acer platanoides*, old *Betula* sp., *Tilia cordata*
Physcia adscendens H. Olivier	1, 4	6, 7, 9–16	17–27	bark and branches of deciduous trees and coniferous trees, treated wood
Physcia aipolia (Ehrh. ex Humb.) Fürnr.	1, 4	7, 9, 10, 12–16	17–19, 21–24, 27	bark and branches of deciduous trees, bark of *Picea abies*, treated wood

Table 1. (continued)

Taxon	Study plots within the museum-reserves			Substrata and notes
	Abramtsevo	A. S. Pushkin	Ostafyevo	
Physcia caesia (Hoffm.) Fürnr.		13		bark of old *Populus* sp.
Physcia dubia (Hoffm.) Lettau		6, 7, 10–12, 16	17–23, 27	bark of *Betula* sp., old *Larix sibirica*, *Picea abies*, old *Pinus sylvestris*, *Salix* sp., *Tilia cordata*
Physcia stellaris (L.) Nyl.	1	7, 16	17, 18, 22, 25	bark of *Acer platanoides*, *Tilia cordata*, branches of *Betula* sp., *Pinus sylvestris*, *Quercus robur*, *Tilia cordata*, deciduous trees, treated wood
Physcia tenella (Scop.) DC.	4	6, 11, 12	18, 19, 22, 24	bark of *Betula* sp., old *Pinus sylvestris*, *Populus tremula*, old *Quercus robur*, old *Salix* sp., *Tilia cordata*, treated wood
Physcia tribacia (Ach.) Nyl.		6, 10, 12, 13	22, 25	bark of *Betula* sp., old *Larix sibirica*, old *Quercus robur*, old *Tilia cordata*, branch of *Pinus sylvestris*
Physconia detersa (Nyl.) Poelt		7, 9, 11, 15	17–20, 22, 24, 27	bark of deciduous trees, bark of *Pinus sylvestris* coniferous trees, treated wood
Physconia distorta (With.) J. R. Laundon	1, 4		17, 18, 23	bark of *Populus tremula*, *Quercus robur*, old *Tilia cordata*, *Ulmus* sp.
Physconia enteroxantha (Nyl.) Poelt	1, 2	6, 7, 9, 10, 15	17–27	bark and branches of deciduous trees
Physconia cf. *grisea* (Lam.) Poelt		12		bark of *Thuja occidentalis* L.
**Physconia perisidiosa* (Erichsen) Moberg	1, 2		17	bark of *Betula* sp., *Tilia cordata*
Polycauliona candelaria (L.) Frödén et al.		7		bark of old *Larix sibirica*
Polycauliona polycarpa (Hoffm.) Frödén et al.		6, 7	17, 20	bark of old *Larix sibirica*, *Salix* sp., old *Pinus sylvestris*, branches of *Betula* sp.
Pycnora praestabilis (Nyl.) Hafellner			24	bark of old *Pinus sylvestris*
Pycnora sorophora (Vain.) Hafellner		8		bark of old *Pinus sylvestris*
Ramalina europaea Gasparyan et al.	2		18, 19, 22	bark of old *Tilia cordata*
!! *Ramalina farinacea* (L.) Ach.	1, 2			bark of *Tilia cordata*
Rinodina exigua (Ach.) Gray	1			branch of *Quercus robur*
Rinodina pyrina (Ach.) Arnold		13	17, 18, 27	bark of *Acer platanoides*, old *Tilia cordata*, branches of *Betula* sp., *Tilia cordata*
Scoliciosporum sarothamni (Vain.) Vězda	2	7, 11	17, 18	bark of *Salix* sp., *Sorbus aucuparia* L., *Tilia cordata*, branches of *Betula* sp., *Tilia cordata*; TLC: gyrophoric acid
!! *Usnea dasopoga* (Ach.) Nyl.	1			bark of *Tilia cordata*
! *Usnea hirta* (L.) Weber ex F. H. Wigg.			18	bark of old *Tilia cordata*
!! *Usnea subfloridana* Stirt.	4			bark of *Betula* sp.
Violella fucata (Stirt.) T. Sprib.	4			bark of *Betula* sp., old *Quercus robur*
Vulpicida pinastri (Scop.) J.-E. Mattsson & M. J. Lai	1, 4	14, 16		bark of *Betula* sp.
Xanthomendoza fallax (Hepp) Søchting et al.			20	bark of *Ulmus* sp.
Xanthoria parietina (L.) Th. Fr.	1, 4	5, 7, 9–16	17–27	bark and branches of deciduous trees and coniferous trees, treated wood

Table 2. The specificity of the lichen biota in the surveyed parks

The park	Number of species found only in one of the surveyed parks	Total number of species found in all surveyed parks	The specificity
Museum-reserve Abramtsevo	15	103	14.6
Museum-reserve of A. S. Pushkin	14	103	13.6
Museum-estate Ostafyevo	19	103	18.4

Table 3. Similarity matrix of the lichen biota in the surveyed parks indicating Sørensen Index values (in bold) and the number of joint species for pairs of parks

The park	Museum-reserve Abramtsevo	Museum-reserve of A.S. Pushkin	Museum-estate Ostafyevo
Museum-reserve Abramtsevo	-	**0.51**	**0.56**
Museum-reserve of A. S. Pushkin	29	-	**0.61**
Museum-estate Ostafyevo	35	39	-

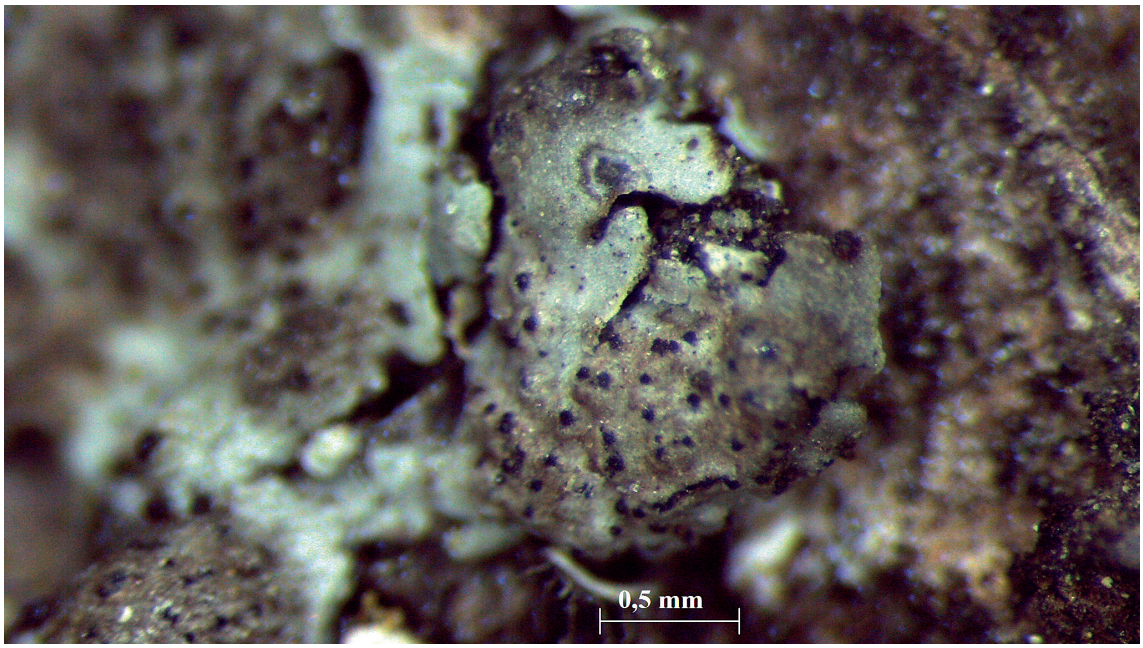

Fig. 2. *Lichenochora obscuroides* (Linds.) Triebel & Rambold: caps of perithecia on the lobes of *Phaeophyscia orbicularis*.

trees, as well as a higher anthropogenic impact, compared to the park of the MR Abramtsevo.

Menhinik Index and Shannon Index of Diversity values showed that the relative indicators of the species richness and diversity of the lichen biota in the park of the MR Abramtsevo were higher than in the other parks (Table 4). These indices probably reflect the fact that the Abramtsevo park is located in a rural area with moderate degree of anthropogenic impact (Kolosova & Churilova, 2004), while the parks of the MR of A. S Pushkin and the ME Ostafyevo are located within urban areas with a significant anthropogenic impact.

We plan to use the Menhinik Index and Shannon Index of Diversity as relative indicators of species

Table 4. Menhinik Index and Shannon Index of Diversity values of the lichen biota in the surveyed parks

The park	Menhinik Index	Shannon Index of Diversity
Museum-reserve Abramtsevo	4.57	1.60
Museum-reserve of A. S. Pushkin	2.96	1.41
Museum-estate Ostafyevo	2.90	1.53

richness and diversity in comparative analysis in further studies of the park lichen biota of the museum-reserves in the Moscow Region.

Suggestions to include new species into the Red Data Book of Moscow

Since 2012, the territory of the city of Moscow has greatly increased due to the accession of the Novomoskovsky and Troitsky administrative districts. As a result, the lists of species included in the Red Data Book of Moscow (2011) are largely outdated.

Within this study, *Chaenotheca chrysocephala*, *Melanelixia subargentifera*, *Parmelina tiliacea*, *Physconia perisidiosa* and *Ramalina europaea* were found in the park of the ME Ostafyevo - Russian Parnassus and should be recommended for the next edition of the Red Data Book of Moscow.

Chaenotheca chrysocephala, like most of the calicioid lichens and fungi, is highly sensitive to environmental alterations of anthropogenic nature (Tibell, 1999). Previously, the species was singly noted in the early 20th century on the territory now occupied by Moscow (Elenkin, 1906–1911). *C. chrysocephala* is scattered in the Moscow Oblast (Golubkova, 1966; Biazrov, 1993; Pchelkin, 2005; Notov, 2010; etc.).

Melanelixia subargentifera and *Parmelina tiliacea* are indicators of mature broad-leaved forests and old parks in the Northwest of European Russia (Himelbrant & Kuznetsova, 2009). These species retain indicator properties in Central Russia and are considered as indicators of biologically valuable broadleaved forest and park landscapes in the subzone of mixed coniferous-broadleaved forests (Muchnik, 2015a). *Melanelixia subargentifera* was previously recorded on the territory of Moscow within its new borders with no exact locality and date of discovery (Biazrov, 2012). To date, in the Moscow Oblast it has been revealed within specially protected natural areas Prioksko-Terrasny Nature Biosphere Reserve (Pchelkin, 2005) and Zavidovo National Park (Notov, 2010). The few findings of *Parmelina tiliacea* in Moscow are from the last century (Elenkin, 1906–1911; Biazrov, 1996, Pchelkin, 1998). In the Moscow Oblast, the species is rare and listed in the Red Data Book of the Moscow Oblast (2018) with category 2 – Threatened species.

Physconia perisidiosa is also considered as indicator of biologically valuable forest and park landscapes in the subzone of mixed coniferous-broadleaved forests of Central Russia (Muchnik, 2015a). The species is extremely rare in the region; it has been singly recorded in Moscow (Muchnik, 2016) and the Moscow Oblast (Muchnik et al., 2018).

Ramalina europaea has been described very recently (Gasparyan et al., 2017). To update the data on the distribution of *Ramalina* species in the Moscow Region, it is necessary to revise all available material for this genus in MW and LE herbaria. All species of the genus known in Moscow Region are sensitive to anthropogenic impact and confined to areas of well-preserved forest and park communities, and therefore listed in the Red Data Book of Moscow (2011) and Red Data Book of the Moscow Oblast (2018).

All the mentioned species need protection on the territory of the city of Moscow due to their rare occurrence and special requirements for the ecological niche, i. e. forest or park communities with the presence of old broadleaved trees.

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Appendix 1. Description of studied localities in the surveyed parks

No.	Geographical coordinates, habitat	Date
Museum-reserve Abramtsevo (area 50 ha)		
1	56°14.060'N, 37°58.010'E, *Betula* sp., *Picea abies*, *Quercus robur*, *Tilia cordata* around the Upper pond	22.06.2016
2	56°14.103'N, 37°58.109'E, alleys of *Tilia cordata*, with old *Picea abies*, *Quercus robur*, *Sorbus aucuparia*, behind the manor house, slope to the river Vorya	22.06.2016
3	56°14.188'N, 37°58.119'E, *Acer platanoides*, *Quercus robur* along the bank of the river Vorya	22.06.2016
4	56°14.201'N, 37°58.343'E, *Betula* sp., old *Pinus sylvestris*, *Populus tremula*, *Quercus robur*, *Tilia cordata* along the bank of the river Vorya	10.08.2016
5	56°14.122'N, 37°58.238'E, *Betula* sp., *Pinus sylvestris*, *Populus tremula*, *Tilia cordata* around the Lower pond, near the automobile road	10.08.2016
Museum-reserve of A. S. Pushkin (area 32 ha)		
Estate Vyazemy		
6	55°37.671'N, 36°59.473'E, old *Larix sibirica*, *Tilia cordata* near the entrance to the park near the church	23.08.2017
7	55°37.692'N, 36°59.400'E, *Acer platanoides*, old *Betula* sp., *Fraxinus* sp., old *Larix sibirica*, old *Populus* sp., *Quercus robur*, *Salix* sp., *Tilia cordata* near the dam on the Vyazemka river	23.08.2017 30.08.2017
8	55°37.744'N, 36°59.583'E, old *Pinus sylvestris* east of the dam on the Vyazemka river, opposite the automobile road.	23.08.2017
9	55°37.766'N, 36°59.575'E, *Betula* sp., *Larix sibirica*, *Quercus robur*, *Rhamnus* sp., *Salix* sp., old *Tilia cordata*, *Ulmus* sp. near the automobile road in the area of the Godunovsky ravine	30.08.2017
10	55°37.664'N, 36°59.426'E, *Acer platanoides*, old *Betula* sp., old *Larix sibirica*, *Picea abies*, *Syringa* sp., *Tilia cordata* around the Church of the Transfiguration (the Life-Giving Trinity)	30.08.2017
11	55°37.663'N, 36°59.511'E, regular park with *Alnus* sp., *Larix sibirica*, old *Quercus robur*, *Tilia cordata*	09.09.2017
12	55°37.646'N, 36°59.407'E, *Frangula alnus* Mill., old *Larix sibirica*, old *Quercus robur*, old *Salix* sp., *Thuja occidentalis*, *Tilia cordata* around the stable yard	09.09.2017
13	55°37.652'N, 36°59.459'E, large field with *Acer platanoides*, *Betula* sp., *Malus* sp., *Populus* sp., *Rhamnus* sp., *Salix* sp., *Sorbus aucuparia*, old *Tilia cordata*	09.09.2017
Estate Zakharovo		
14	55°38.806'N, 36°58.260'E, park with *Acer negundo L.*, old *Betula* sp., *Populus tremula*, *Tilia cordata*, *Ulmus* sp.	15.09.2017
15	55°38.804'N, 36°58.224'E, fruit grove of *Malus* sp., old *Pyrus* sp., with old *Betula* sp., *Rhamnus* sp.	07.10.2017
16	55°38.682'N, 36°58.213'E, old *Betula* sp., *Salix* sp., *Tilia cordata* near the manor pond	07.10.2017
Museum-estate Ostafyevo - Russian Parnassus (area 40 ha)		
17	55°29.703'N, 37°30.166'E, *Acer platanoides*, *Betula* sp., *Salix* sp., old *Tilia cordata* in front of the main house, near the Big pond	17.06.2018 19.06.2018
18	55°29.816'N, 37°30.109'E, behind the main house, row of *Tilia cordata* «Russian Parnassus», with *Betula* sp., old *Pinus sylvestris*, old *Quercus robur*, *Salix* sp. near the Big pond	17.06.2018 19.06.2018
19	55°29.794'N, 37°29.923'E, old *Betula* sp., *Pinus sylvestris*, old *Tilia cordata*, old *Ulmus* sp. to the left of the Field of Mars and behind it	19.06.2018 23.06.2018 27.06.2018
20	55°29.725'N, 37°30.055'E *Acer platanoides*, *Betula* sp., *Picea abies*, old *Pinus sylvestris*, old *Populus* sp., old *Quercus robur*, *Sorbus aucuparia*, *Syringa* sp., *Tilia cordata*, *Ulmus* sp. in front of the main house	23.06.2018
21	55°29.708'N, 37°30.107'E floodplain of the Lobuchi river with *Acer platanoides*, *Prunus padus*, *Salix* sp.	23.06.2018
22	55°29.715'N, 37°30.019'E, *Acer platanoides*, *Acer tataricum*, *Betula* sp., *Malus* sp., *Sorbus aucuparia*, old *Tilia cordata* around the cabinet of medals	23.06.2018
23	55°29.668'N, 37°30.143'E old *Acer platanoides*, old *Betula* sp., *Malus* sp., old *Quercus robur*, old *Tilia cordata*, *Ulmus* sp. near the building of the former cloth factory	27.06.2018
24	55°29.892'N, 37°29.836'E, coniferous grove of old *Pinus sylvestris*, with old *Betula* sp., *Tilia cordata*	29.06.2018
25	55°29.996'N, 37°29.629'E, Karamzin grove of old *Betula* sp., with old *Pinus sylvestris*, old *Tilia cordata*	29.06.2018
26	55°29.902'N, 37°29.855'E, *Acer platanoides*, old *Betula* sp., old *Tilia cordata* along the bank of the Big pond, Dorsky stream, behind the arbor «Temple of Apollo»	29.06.2018
27	55°29.947'N, 37°29.939'E, *Acer platanoides*, old *Betula* sp., *Populus tremula*, *Salix* sp., old *Tilia cordata* on the right bank of the Big pond	03.07.2018