LICHENS — ЛИШАЙНИКИ

Are lichens coming back? Strelninsky Bereg Protected Area (St. Petersburg, Russia)

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Abstract. The total revealed lichen diversity of Strelninsky Bereg Protected Area includes 130 species, 123 of them are lichenized, four are lichenicolous, and three are non-lichenized saprobic fungi. The lichen biota of Strelninsky Bereg is quite rich, despite extremely small size of the area. The lichen *Lecania olivacella* is new to Russia. *Bacidina pycnidiata*, *Fellhanera bouteillei*, and *Lecidella subviridis* are new to North-Western European Russia. Nine lichen species reported from Strelninsky Bereg are red-listed in St. Petersburg. The reappearance of *Leptogium saturninum*, which was not recorded in St. Petersburg more than last 90 years, could reflect a decline of atmospheric pollution in the city suburbs. Successful occasional reintroduction of foliose lichens *Flavoparmelia caperata*, *Hypotrachyna revoluta*, and *Punctelia jeckeri* could be possible as a result of modern climate change in the region of St. Petersburg and in the World.

Keywords: lichen biota, new records, protected species, modern climate change, North-West European Russia.

Лишайники возвращаются? Памятник природы Стрельнинский берег (Санкт-Петербург, Россия)

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Резюме. Выявленное разнообразие лихенобиоты памятника природы «Стрельнинский берег» насчитывает 130 видов, в том числе 123 вида лишайников, четыре вида лихенофильных и три вида нелихенизированных сапротрофных грибов. Лихенобиота памятника природы достаточно богата, несмотря на незначительную его площадь. Лишайник *Lecania olivacella* обнаружен впервые в России, а *Bacidina pycnidiata*, *Fellhanera bouteillei* и *Lecidella subviridis* — на Северо-Западе европейской части России. Девять видов лишайников, обнаруженных на территории Стрельнинского берега, занесены в Красную книгу Санкт-Петербурга. Находка лишайника *Leptogium saturninum*, который не регистрировали в черте Санкт-Петербурга более чем 90 лет, может свидетельствовать о снижении уровня атмосферного загрязнения в пригородах. Успешная непреднамеренная реинтродукция комплекса листоватых лишайников *Flavoparmelia caperata*, *Hypotrachyna revoluta* и *Punctelia jeckeri*

https://doi.org/10.31111/nsnr/2023.57.1.55
Accepted: 14 March 2023 Published: 2 April 2023

стала возможна в результате современного изменения климата в Санкт-Петербурге и в мире в целом.

Ключевые слова: лихенобиота, новые находки, охраняемые виды, современное изменение климата, Северо-Запад Европейской России.

The network of the protected areas of St. Petersburg nowadays counts 16 territories with a total area of ca. 65 km^2 (Osobo..., 2012–2022). The lichen diversity in most of them has been investigated properly (see, e. g., Atlas..., 2016; Stepanchikova *et al.*, 2020). Noteworthy that a huge part of the contemporary lichen biota of St. Petersburg, ca. 90%, is known from the protected areas (Himelbrant *et al.*, 2017). Although St. Petersburg is a city with the most studied lichen diversity in Russia (Krasnaya..., 2018; Stepanchikova *et al.*, 2020), the investigations on the protected areas still can bring new discoveries.

Nowadays Strelninsky Bereg is a one of the smallest (0.4 km^2) protected areas in St. Petersburg. It is situated in Strelna in the easternmost part of the Petrodvorets District just on the shore of the Nevskaya Bay, Gulf of Finland (Fig. 1). Strelninsky Bereg is declared to protect original landscape, plant communities, and biodiversity of the southern shore of the Nevskaya Bay. In addition, small shoreline territory East of Strelninsky Bereg was investigated as proposed for inclusion in the protected area (Fig. 2).

Relief of Strelninsky Bereg is generally uniform and is represented by low and flat accumulative terrace of ancient Littorina Sea with low and flattened coastal bars, with elevations up to 1.5 m a. s. l. Most part of the territory is covered with modern turf and in some places with sandy sediments. The vegetation is represented mainly by black alder forests [*Alnus glutinosa* (L.) Gaertn.], willow stands (*Salix fragilis* L.), and willow thickets (*S. cinerea* L., *S. myrsinifolia* Salisb., *S. pentandra* L.). All these types of vegetation are swampy with tall grasses [*Filipendula ulmaria* (L.) Maxim., *Urtica dioica* L., *Geum rivale* L., *Dactylis glomerata* L., *Athyrium filix-femina* (L.) Roth, etc.]. Reed beds [*Phragmites australis* (Cav.) Trin. ex Steud.] are another type of dominant plant communities situated on the seashore. Most drained parts earlier were occupied by gardens and now are overgrown by young deciduous stands with birch (*Betula pendula* Roth and *B. pubescens* Ehrh.), aspen (*Populus tremula* L.), and gray alder [*Alnus incana* (L.) Moench], sometimes with undergrowth (*Prunus padus* L., rarely *Acer platanoides* L.). Of special interest are small planted groups of spruces [*Picea abies* (L.) H. Karst. and *P. glauca* (Moench) Voss.] on bulk areas. Almost the entire study area was used as agricultural in different periods of XIX and XX centuries, but at least over the last four decades typical shoreline tree and shrub vegetation is gradually recovering (Strelninsky..., 2005).

Strelninsky Bereg Protected Area at first sight is not extremely interesting for lichenological investigations due to its small square, uniform lowland landscape, and trivial vegetation. However, it deserves special attention due to the presence of wet black alder forests which are typical natural communities on the shores of the Gulf of Finland (Strelninsky..., 2005).

Fig. 1. The location of the study area in the limits of St. Petersburg.

The first data on lichens of Strelna were published at the end of the 18th century by Grigory F. Sobolewski, who reported five taxa under the generic names "*Lepra*" and "*Lichen*" from the localities "Strelinae" and "circa Strelinae" (Sobolewski, 1799, 1802). According to the modern taxonomy, these taxa belong to four species: *Anaptychia ciliaris*, *Placynthium nigrum* (Huds.) Gray, *Stereocaulon paschale* (L.) Hoffm., and *Vulpicida juniperinus* (L.) J.-E. Mattsson et M. J. Lai. The fate and place of storage of the Sobolewski's collections is still unclear, probably all specimens were lost (Kolchinsky *et al*., 2004). However, later some of these species were found in the same area by other specialists. A specimen of *Anaptychia ciliaris* collected in Strelna in the beginning of 20th century is stored in the lichen herbarium of the Komarov Botanical Institute of the Russian Academy of Science (LE L-10608, 30 V 1926, N. M. Kartashova), and a specimen of *Ramalina baltica* Lettau — in the lichen herbarium of the Museum

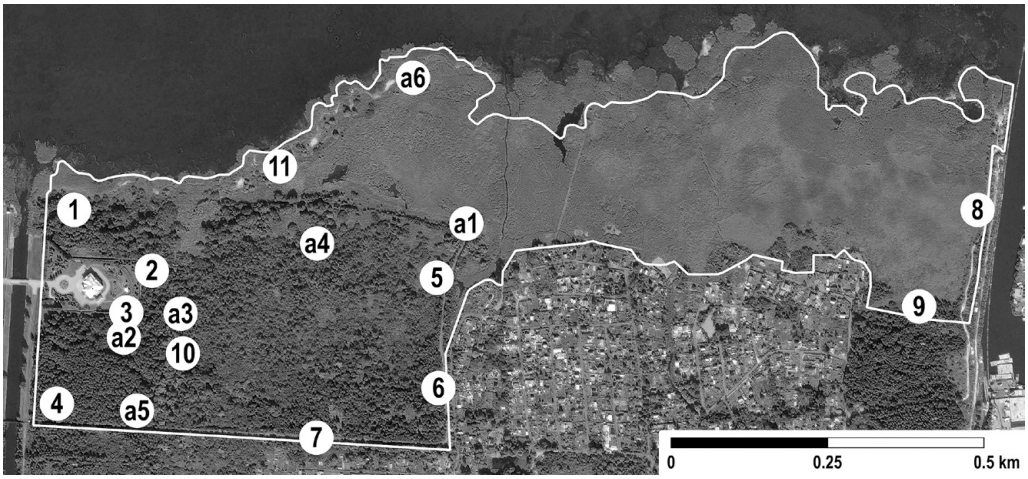


Fig. 2. Map of the study area, with the location of sampling areas (indicated with numbers 1–11) and additional collection points (indicated with a1–a6).

of Natural History of the Uppsala University (UPS s. n., 9 VII 1931, K. A. Rassadina). Unfortunately, the exact localities for all cited specimens were not indicated, so it is impossible to estimate whether these materials originate from the modern territory of the protected area. Remarkable record of *Flavoparmelia caperata* was published for Strelna in the first edition of the Red Data Book of nature of St. Petersburg (Krasnaya..., 2004), but there are no data on the source of this record and place of storage of the specimen. In addition, Malysheva (1994) reported 21 and 19 common and widespread species for Konstantinovsky and Orlovsky parks in Strelna, respectively. First special investigation of Strelninsky Bereg Protected Area was conducted in June and September 2004 by Olga A. Kataeva, who reported 41 species (Kataeva, 2005). Some specimens in the frame of this work were collected by Lyubov E. Kurbatova. Our current paper is devoted to unexpected results of our recent study of lichens and allied fungi of Strelninsky Bereg Protected Area and its vicinities proposed for inclusion in the protected area.

Material and Methods

The specimens were collected by D. E. Himelbrant (DH) and I. S. Stepanchikova (IS) in May 2022. Altogether 17 localities were investigated (Fig. 2): 11 standard sample areas (SA) (20 × 20 m, otherwise in natural boundaries of the community), where the lichen diversity on each substrate was described as detailed as possible, and six additional plots, where only most interesting substrates and species were recorded. Geographical coordinates are given in the coordinate system WGS 84. Photos were made by IS using digital camera Olympus Tough 5.

Chromatography was performed by IS according to the standard techniques of high performance thin-layer chromatography using solvent systems A, B, and C (Orange

et al., 2001). The specimen of *Bacidina pycnidiata* was DNA-analyzed. DNA was extracted by V. V. Pankova with magnetic beads-based protocol using "Fitosorb" kit by Syntol. Internal transcribed spacer region (ITS) of the nuclear ribosomal gene was amplified and sequenced using the primer ITS1F (Gardes, Bruns, 1993). The NCBI (GenBank) accession number is provided in the species list.

The nomenclature of taxa generally follows recently published checklists for Scandinavia (Westberg *et al*., 2021) and Germany (Printzen *et al*., 2022); the genera of the family Gyalectaceae are understood according to the Lichen Flora of Russia (Gagarina, 2017). The recently collected lichen specimens, as well as the specimens deposited in LE, were identified by DH, IS, and E. S. Kuznetsova (EK). Most important records are confirmed by specimens kept in lichen herbarium of Komarov Botanical Institute (LE, the numbers are provided in the text), other material is deposited in the herbarium of the Department of Botany, St. Petersburg State University (LECB, s. n.).

Sampling locations (Fig. 2)

Standard sample areas. Saint Petersburg, Petrodvorets District, Strelna, NE to Konstantinovsky Palace, Strelninsky Bereg Protected Area: 1 — 59°51′43.5″N, 30°04′51.0″E, old-growth willow stand (*Salix fragilis*) with tall grasses, 5 V 2022, *Himelbrant, Stepanchikova Streln-1*; 2 — 59°51′40.2″N, 30°04′58.8″E, black alder forest with tall grasses, with bird cherry, 5 V 2022, *Himelbrant, Stepanchikova Streln-2*; 3 — 59°51′37.9″N, 30°04′55.7″E, white spruce (*Picea glauca*) planted stand ca. 35 years old on a meadow, 5 V 2022, *Himelbrant, Stepanchikova Streln-3*; 4 — 59°51′33.5″N, 30°04′48.7″E, black alder forest with tall grasses, with rowan and birch, 5 V 2022, *Himelbrant, Stepanchikova Streln-4*; 5 — 59°51′39.4″N, 30°05′28.0″E, willow thickets with tall grasses, 5 V 2022, *Himelbrant, Stepanchikova Streln-5*; 6 — 59°51′33.7″N, 30°05′27.9″E, young birch and aspen stand on the place of gardens, 5 V 2022, *Himelbrant, Stepanchikova Streln-6*; 7 — 59°51′31.4″N, 30°05′15.2″E, spruce alley along the road, 5 V 2022, *Himelbrant, Stepanchikova Streln-7*; 10 — 59°51′35.9″N, 30°05′01.8″E, old-growth swampy willow stand (*Salix fragilis*) with tall grasses, 25 V 2022, *Himelbrant, Stepanchikova Streln-10*; 11 — 59°51′45.4″N, 30°05′12.3″E, old-growth willows (*Salix fragilis*) on seashore, 25 V 2022, *Himelbrant, Stepanchikova Streln-11*; **Krasnoselsky District, E to Strelna, NE to Konstantinovsky Palace, territory proposed for the inclusion in Strelninsky Bereg Protected Area:** 8 — 59°51′41.7″N, 30°06′24.7″E, sea buckthorn and willow thickets along the track, 5 V 2022, *Himelbrant, Stepanchikova Streln-8*; 9 — 59°51′37.2″N, 30°06′17.5″E, willow thickets on the seashore, 5 V 2022, *Himelbrant, Stepanchikova Streln-9*.

Additional collection points. Saint Petersburg, Petrodvorets District, Strelna, NE to Konstantinovsky Palace, Protected Area Strelninsky Bereg: a1 — 59°51′42.2″N, 30°05′31.3″E, granite boulder on seashore, 5 V 2022, *Himelbrant, Stepanchikova Streln-ad1*; a2 — 59°51′36.8″N, 30°04′55.8″E, black alder in swampy black alder stand with tall grasses, 25 V 2022, *Himelbrant, Stepanchikova Streln-ad2*; a3 — 59°51′38.0″N, 30°05′01.7″E, black alder in gray alder stand with tall grasses, 25 V 2022, *Himelbrant, Stepanchikova Streln-ad3*; a4 — 59°51′41.4″N, 30°05′15.9″E, black alder stand with tall grasses, with willows (*Salix fragilis*), 25 V 2022, *Himelbrant, Stepanchikova Streln-ad4*; a5 — 59°51′33.0″N, 30°04′56.9″E, swampy black alder stand with tall grasses, 25 V 2022, *Himelbrant, Stepanchikova Streln-ad5*; a6 — 59°51′49.8″N, 30°05′26.2″E, concrete constructions on the seashore, 25 V 2022, *Himelbrant, Stepanchikova Streln-ad6*.

Protected Area Strelninsky Bereg (Kataeva, 2005): shore of Finnish Gulf in Strelna, [59°51′N, 30°05′E], 24 VI and 17 IX 2004, *Kataeva* or *Kurbatova*.

Results

In the annotated species list presented below the following symbols and abbreviations are used: **#** — lichenicolous and algicolous fungi, **+** — non-lichenized saprobic fungi, ***** — species new to St. Petersburg, **R** — species protected by the Red Data Book of St. Petersburg (Krasnaya..., 2018), **s** — habitat specialist, and **i** — indicator species (Vyyavlenie..., 2009), LR — Leningrad Region, SPb — St. Petersburg. Lichen substances are given for HPTLC-analyzed specimens. For the species already reported from Strelninsky Bereg (Kataeva, 2005), the references are given. For the species not known before from SPb and LR, information on their presence in Baltic and Scandinavian countries, as well as nearest localities in European Russia, is provided.

Acarospora moenium (Vain.) Räsänen — on concrete; a6.

Amandinea punctata (Hoffm.) Coppins et Scheid. — on bark of *Betula* sp., *Picea glauca*, and *Salix* spp.; 3, 4, 6, 9–11.

RAnaptychia ciliaris (L.) Körb. — on bark of *Picea glauca*; 3.

Anisomeridium polypori (Ellis et Everh.) M. E. Barr — on bark of *Alnus glutinosa* and *Salix fragilis*; 10, a4.

R, iArthonia helvola (Nyl.) Nyl. — on bark of *Alnus glutinosa*; 2, a2, a3, a5.

A. ruana A. Massal. — on bark of *Acer platanoides*, *Alnus glutinosa*, and *Prunus padus*; 2, 4.

Athallia cerinelloides (Erichsen) Arup et al. — on bark of *Ulmus* sp. in the garden, 17 IX 2004, *Kurbatova*, LE L-3800 (sub *Phaeophyscia orbicularis*).

A. holocarpa (Hoffm.) Arup et al. — on concrete; a6.

A. pyracea (Ach.) Arup et al. — on bark of *Populus tremula* and *Salix fragilis*; 1, 6, 10. On bark of *Betula* sp. and *Salix mirsinifolia* Salisb. in willow thickets [Kataeva, 2005, as *Caloplaca holocarpa* (Hoffm. ex. Ach.) A. E. Wade, LE L-3804].

#Athelia arachnoidea (Berk.) Jülich — on thalli of *Scoliciosporum* spp. and green algae growing on bark of *Salix* sp. and *Picea abies*; 2, 5, 7.

Bacidia arceutina (Ach.) Arnold — on bark of *Salix fragilis*; 10.

Bacidina arnoldiana (Körb.) V. Wirth et Vězda — on concrete; 6.

B. inundata (Fr.) Vězda — on granite boulder and on concrete; 6, a1.

***B. pycnidiata** (Czarnota et Coppins) Czarnota et Guz.-Krzem. — on bark of *Alnus glutinosa*; 2 (LE L-21828; GenBank accession number: OQ238791). New to North-Western European Russia. In European Russia the nearest locality is known in the Orel Region (Muchnik, 2016). Distribution in Fennoscandia and Baltic countries: Norway, Finland (Westberg *et al.*, 2021), Lithuania (Motiejūnaitė, 2017), and Estonia (Randlane *et al.*, 2021).

The species is distinguished by having abundant whitish long-necked pycnidia, similar to *Fellhanera subtilis* (Vězda) Diederich et Sérus., on finely granular to slightly coralloid thallus, which resembles thallus of *Bacidina modesta* (Zwackh ex Vain.) S. Ekman (Czarnota, Coppins, 2006).

Biatora efflorescens (Hedl.) Räsänen — on bark of *Acer platanoides* and *Salix fragilis*; 4, 10.

Buellia griseovirens (Turner et Borrer ex Sm.) Almb. — on bark of *Alnus glutinosa* and *Salix* sp.; 2, 9, a4.

B. schaereri De Not. — on bark of *Alnus glutinosa*; 2.

Caloplaca cerina (Hedw.) Th. Fr. — on bark of *Populus tremula* and *Salix fragilis*; 6, 11.

Candelariella aurella (Hoffm.) Zahlbr. — on concrete; a6.

C. efflorescens R. C. Harris et W. R. Buck — on bark of *Alnus glutinosa*, *Betula* sp., *Picea glauca*, *Prunus padus*, and *Salix* spp.; 1–3, 5, 6, 10, 11. On bark of *Ulmus* sp. near the garden, 17 IX 2004, *Kurbatova*, LE L-3797 (sub *Parmelia sulcata*).

C. lutella (Vain.) Räsänen — on bark of *Salix* sp.; 9. On bark of *S. mirsinifolia* in willow thickets, 17 IX 2004, Kurbatova, LE L-3807 (sub *Myriolecis hagenii*).

C. reflexa (Nyl.) Lettau — on bark of *Picea glauca* (branches); 3.

C. vitellina (Hoffm.) Müll. Arg. — on bark of *Hippophaë rhamnoides* and *Salix* spp., on granite; 1, 5, 6, 8–11. On bark of *Salix mirsinifolia* in willow thickets, 17 IX 2004, *Kurbatova*, LE L-3804 (sub *Athallia pyracea*).

C. xanthostigma (Ach.) Lettau — on bark of *Salix* spp.; 5, 9, 10. The specimen published by Kataeva (2005) as *Candelariella xanthostigma* (LE L-3804) refers to *C. vitellina*.

Catillaria nigroclavata (Nyl.) Schuler — on bark of *Salix* sp.; 5.

Catinaria atropurpurea (Schaer.) Vězda et Poelt — on wood of *Salix fragilis*; 1.

Cetraria sepincola (Ehrh.) Ach. — on bark of *Alnus glutinosa*; 2. On bark of *A. glutinosa* in black alder forest near the brook (Kataeva, 2005, LE L-3769).

[R, i]Chaenotheca brachypoda (Ach.) Tibell — on bark of *Alnus glutinosa* and *Salix fragilis*; 10, a4.

C. furfuracea (L.) Tibell — on bark of *Alnus glutinosa* and *Salix fragilis*; 2, 10.

[R, i]C. hispidula (Ach.) Zahlbr. — on bark of *Alnus glutinosa*; 2.

C. trichialis (Ach.) Th. Fr. — on bark of *Alnus glutinosa* and *Salix fragilis*; 2, 4, 10.

Cladonia chlorophaea (Flörke ex Sommerf.) Spreng. — on bark of *Alnus glutinosa* and *Salix fragilis*; 2, 10. On soil in the meadow (Kataeva, 2005, LE L-3780). Specimens contain fumarprotocetraric acid complex and fatty acid.

C. coniocraea (Flörke) Spreng. — on bark of *Alnus glutinosa* and *Salix fragilis*; 2, 10.

C. fimbriata (L.) Fr. — on bark of *Alnus glutinosa*; 2. On bark of *Salix* sp. in black alder forest with willow (Kataeva, 2005, LE L-3779). The specimen LE L-3779 contains fumarprotocetraric acid complex.

Evernia prunastri (L.) Ach. — on bark of *Alnus glutinosa*, *Picea glauca*, *Prunus padus*, and *Salix* spp.; 2, 3, 5, 10, 11, a4. On bark of *Prunus padus* on the glade and on bark of old *Salix* sp. in black alder forest (Kataeva, 2005).

***Fellhanera bouteillei** (Desm.) Vězda (Fig. 3A) — abundant on twigs and needles of *Picea glauca*; 3 (LE L-21829). New to North-Western European Russia. Nearest localities in European Russia known from Kaliningrad (Himelbrant *et al*., 2022) and Moscow (Golubkova, 1959) regions. Distribution in Fennoscandia and Baltic countries: Norway, Sweden, Finland (Westberg *et al*., 2021), Lithuania (Motiejūnaitė, 2017), and Estonia (Randlane *et al*., 2021).

Crustose lichen, characterized by entirely sorediate thallus, pinkish apothecia, and 1-septate ascospores (Cannon *et al*., 2022).

[R]Flavoparmelia caperata (L.) Hale (Fig. 3B) — well developed on bark of *Picea glauca* (branches); 3 (LE L-21834).

Graphis scripta (L.) Ach. — on bark of *Prunus padus*; 2.

#Heterocephalacria physciacearum (Diederich) Millanes et Wedin — on thallus of *Physcia aipolia* growing on bark of *Salix* sp.; 5.

Hypocenomyce scalaris (Ach.) M. Choisy — on bark of *Alnus glutinosa*; 2.

Hypogymnia physodes (L.) Nyl. — on bark of *Alnus glutinosa*, *Betula* sp., *Picea glauca*, *Prunus padus*, and *Salix* spp.; 2–6, 10. On bark of various deciduous trees in different habitats [Kataeva, 2005, LE L-3785 (sub *Tuckermannopsis chlorophylla*)].

Hypogymnia tubulosa (Schaer.) Hav. — on bark of *Alnus glutinosa*, *Betula* sp., *Picea glauca*, and *Salix* spp.; 2–6, 10. On bark of *Prunus padus* on the glade [Kataeva, 2005, as *Hypogymnia tubulosa* f. *farinosa* (Hillm.) Rassad., LE L-3810].

[R, s]Hypotrachyna revoluta (Flörke) Hale (Fig. 3C) — well developed on bark of *Picea glauca* (branches); 3 (LE L-21830).

#Illosporiopsis christiansenii (B. L. Brady et D. Hawksw.) D. Hawksw. — on thalli of *Physcia* spp. growing on bark of *Salix* spp.; 1, 5, 9, 10.

Lecania cyrtella (Ach.) Th. Fr. — on bark of *Acer platanoides*, *Betula* sp., *Populus tremula*, and *Salix* spp.; 1, 4, 6, 8–11. The specimen published by Kataeva (2005) as *Lecania cyrtella* (LE L-3805) refers to *Lecanora albellula*.

L. cyrtellina (Nyl.) Sandst. — on fruit body of polypore growing on old *Salix* sp.; 5.

L. dubitans (Nyl.) A. L. Sm. — on bark of *Salix fragilis*; 1.

L. naegelii (Hepp) Diederich et van den Boom — on bark of *Acer platanoides*, *Alnus glutinosa*, *Picea glauca*, *Populus tremula*, *Prunus padus*, and *Salix* spp.; 1–6, 8–11. On bark of *Salix* sp. in swampy willow thickets, 24 VI 2004, *Kataeva*, LE L-3773 (as *Lecania fuscella*).

***L. olivacella** (Nyl.) Zahlbr. (Fig. 3D) — on rusty iron; 6 (LE L-21831). New to Russia. Distribution in Fennoscandia and Baltic countries: Norway and Sweden (Westberg *et al*., 2021). The rare but widespread in Europe species; also known from Austria, France, Great Britain, Italy, and Spain (Atienza, Segarra, 1999; Nimis *et al*., 2018; Cannon *et al*., 2021).

This normally saxicolous crustose lichen is characterized by persistent thalline margin of apothecia with a rich photobiont layer, flat to moderately convex disc, 1-septate ascospores, and areolate to nearly squamulose thallus with no pruina (Cannon *et al*., 2021).

Lecanora aitema (Ach.) Hepp — on bark of *Alnus glutinosa*, *Picea glauca*, and *Salix fragilis*; 1, 3, 4, 10, 11.

L. albellula (Nyl.) Th. Fr. — on bark of *Alnus glutinosa* and *Salix* sp.; 2, 4, 9. On bark of *Salix* spp. in willow thickets, 24 VI 2004, *Kataeva*, LE L-3785 (sub *Tuckermannopsis chlorophylla*); on bark of *Alnus incana* in gray alder stand, 24 VI 2004, *Kataeva*, LE L-3786 (sub *Rinodina septentrionalis*); on bark of *Alnus glutinosa* in black alder forest, 24 VI 2004, *Kataeva*, LE L-3793 (as *Lecanora saligna*); on bark of *Salix fragilis*, 17 IX 2004, *Kurbatova*, LE L-3805 (as *Lecania cyrtella*, sub *Polycauliona polycarpa*).

L. allophana Nyl. — on bark of *Populus tremula* and *Salix fragilis*; 6, 10, 11. The specimen published by Kataeva (2005) as *Lecanora allophana* (LE L-3791) refers to *L. chlarotera*.

L. argentata (Ach.) Malme — on bark of *Salix fragilis*; 1.

L. carpinea (L.) Vain. — on bark of *Alnus glutinosa*, *Betula* sp., *Populus tremula*, *Prunus padus*, *Salix* spp., and *Sorbus aucuparia*; 1, 2, 4–6, 8–11. On bark of *Salix* sp. in willow thickets (Kataeva, 2005, LE L-3795); same substrate and biotope, 17 IX 2004, *Kataeva*, L-3809 (as *Lecanora leptyrodes*).

L. chlarotera Nyl. — on bark of *Acer platanoides*, *Prunus padus*, *Salix* spp., and *Sorbus aucuparia*; 1, 2, 4, 8, 9. On bark of *Prunus padus* on the glade, 24 VI 2004, *Kataeva*, LE L-3791 (as *Lecanora allophana*) and *Salix* sp. in swampy willow thickets, 24 VI 2004, *Kataeva*, LE L-3794 (as *Lecanora populicola*).

L. pulicaris (Pers.) Ach. — on bark of *Alnus glutinosa*, *Betula* sp., and *Picea* spp.; 2–4, 6, 7.

L. symmicta (Ach.) Ach. — on bark of *Alnus glutinosa*, *Betula* sp., *Picea* spp., *Prunus padus*, and *Salix* spp.; 1–7, 9–11, a4. On bark of *Alnus* spp., *Prunus padus*, and *Salix* spp. in different habitats [Kataeva, 2005, LE L-3786 (sub *Rinodina septentrionalis*), L-3805, L-3808 (sub *Polycauliona polycarpa*)].

L. umbrina (Ach.) A. Massal. — on bark of *Acer platanoides*, *Alnus glutinosa*, *Betula* sp., *Hippophaë rhamnoides*, *Picea abies*, *Prunus padus*, and *Salix* spp.; 1, 2, 4–11.

L. varia (Hoffm.) Ach. — on bark of *Salix fragilis*; 1.

Lecidea nylanderi (Anzi) Th. Fr. — on bark of *Alnus glutinosa*; 2.

Lecidella elaeochroma (Ach.) M. Choisy — on bark of *Picea glauca*, *Populus tremula*, *Prunus padus*, and *Salix* spp.; 1–3, 5, 6, 9, 11.

L. euphorea (Flörke) Hertel — on bark of *Populus tremula*; 6.

L. flavosorediata (Vězda) Hertel et Leuckert — on bark of *Alnus glutinosa*; a5.

***L. subviridis Tønsberg** — on bark of *Alnus glutinosa*; 2 (LE L-21833). The specimen contains atranorin, thiophanic acid, cf. arthothelin, cf. expallens-unknown. New to North-Western European Russia. In European Russia the species is known also from the Kaliningrad Region (Himelbrant *et al*., 2022). Distribution in Fennoscandia and Baltic countries: Norway, Sweden (Westberg *et al*., 2021), Latvia (Motiejūnaitė *et al*., 2016), Lithuania (Motiejūnaitė, 2017), and Estonia (Randlane *et al*., 2021).

The species is characterized by thin, sometimes almost leprose, pale yellow-green thallus, and specific secondary metabolites (Zduńczyk, Kukwa 2014).

Lepraria elobata Tønsberg — on bark of *Alnus glutinosa*; 2.

L. incana (L.) Ach. — on bark of *Alnus glutinosa* and *Salix fragilis*; 2, 10. The specimen published by Kataeva (2005) from bark of *Alnus glutinosa*, willow thickets, 24 VI 2004, *Kataeva* (LE L-3784), is undeterminable (poor material).

R, i Leptogium saturninum (Dicks.) Nyl. (Fig. 3E) — small thallus (ca. 1 cm in diam.) on bark of very old *Salix* sp. (Fig. 3F); 5.

Leptorhaphis atomaria (Ach.) Szatala — on bark of *Populus tremula*; 6.

Melanelixia glabratula (Lamy) Sandler et Arup — on bark of *Prunus padus*; 2.

M. subaurifera (Nyl.) O. Blanco et al. — on bark of *Alnus glutinosa*, *Betula* sp., *Hippophaë rhamnoides*, *Picea glauca*, *Prunus padus*, and *Salix* spp.; 2, 3, 5, 6, 8–11, a4.

Melanohalea exasperata (De Not.) O. Blanco et al. — on bark of *Alnus glutinosa* and *Salix* spp.; 2, 5, 9, 11.

M. exasperatula (Nyl.) O. Blanco et al. — on bark of *Alnus glutinosa*, *Picea* spp., *Prunus padus*, and *Salix* spp.; 2–5, 7, 10, 11. On bark of *Alnus incana*, *Prunus padus*, and *Salix* sp. in different habitats [Kataeva, 2005, as *Melanelia exasperatula* (Nyl.) Essl., LE L-3775].

M. olivacea (L.) O. Blanco et al. — on bark of *Alnus glutinosa*, *Betula* sp., and *Salix* sp.; 2, 4–6.

Mycobilimbia epixanthoides (Nyl.) Vitik. et al. — on mosses growing on bark of *Alnus glutinosa*; 2.

+Mycocalicium subtile (Pers.) Szatala — on wood of *Alnus glutinosa*; a3.

Myriolecis dispersa (Pers.) Śliwa et al. — on concrete; 6, a6.

M. hagenii (Ach.) Śliwa et al. — on bark of *Alnus glutinosa* and *Salix* spp.; 1, 4, 5, 9–11. On bark of *Betula* sp., *Prunus padus*, and *Salix* sp. [Kataeva, 2005, as *Lecanora hagenii* (Ach.) Ach., LE L-3807]; on bark of *Alnus incana* in gray alder stand, 24 VI 2004, *Kataeva*, LE L-3786 (sub *Rinodina septentrionalis*).

M. sambuci (Pers.) Clem. — on bark of *Ulmus* sp. in the garden, 17 IX 2004, *Kurbatova*, LE L-3800 (sub *Phaeophyscia orbicularis*).

M. semipallida (H. Magn.) Śliwa et al. — on concrete; a6.

Naetrocymbe punctiformis (Pers.) R. C. Harris — on bark of *Alnus glutinosa* and *Salix* sp.; 4, 5.

+Naevia punctiformis (Ach.) A. Massal. — on bark of *Alnus glutinosa* and *Salix* sp.; 4, 5.

Pachyphiale fagicola (Hepp) Zwackh — on bark of *Salix* sp.; 5.

Parmelia sulcata Taylor — on bark of *Alnus glutinosa*, *Betula* sp., *Picea* spp., *Populus tremula*, and *Salix* spp., on treated wood; 1–7, 9–11, a4. On bark of various deciduous trees in different habitats [Kataeva, 2005, LE L-3797, L-3785 (sub *Tuckermannopsis chlorophylla*)].

Parmeliopsis ambigua (Wulfen) Nyl. — on bark of *Alnus glutinosa*; 2, a4.

Peltigera didactyla (With.) J. R. Laundon — on clayey soil on the shore of the Gulf of Finland (Kataeva, 2005, LE L-3776).

P. neopolydactyla (Gyeln.) Gyeln. — on bark of *Salix fragilis*; 10.

P. praetextata (Flörke ex Sommerf.) Zopf — on bark of *Salix fragilis* and on mosses growing on granite boulder; 6, 10.

Phaeophyscia nigricans (Flörke) Moberg — on bark of *Populus tremula* and *Salix* spp., on wood of *Salix fragilis*; 1, 5, 6, 9, 11.

P. orbicularis (Neck.) Moberg — on bark of *Alnus glutinosa*, *Betula* sp., *Hippophaë rhamnoides*, *Picea abies*, *Populus tremula*, *Prunus padus*, and *Salix* spp., on wood of *Salix fragilis*, and on concrete; 1, 4, 5–11, a6. On bark of *Ulmus* sp. near the gardens (Kataeva, 2005, LE L-3800).

P. sciastra (Ach.) Moberg — on granite; a1.

Phlyctis argena (Spreng.) Flot. — on bark of *Alnus glutinosa*, *Picea glauca*, *Prunus padus*, and *Salix* spp.; 2, 3, 9, 10.

Physcia adscendens H. Olivier — on bark of *Alnus glutinosa*, *Hippophaë rhamnoides*, *Picea* spp., *Prunus padus*, and *Salix* spp., on wood of *Salix fragilis*; 1–3, 5, 7–11. On bark of *Salix* sp. in swampy willow thickets (Kataeva, 2005, LE L-3781).

P. aipolia (Ehrh. ex Humb.) Fürnr. — on bark of *Alnus glutinosa*, *Betula* sp., and *Salix* spp.; 1, 2, 4–6, 8–11. On bark of *S. mirsinifolia* in willow thickets, 17 IX 2004, *Kurbatova*, LE L-3807 (sub *Myriolecis hagenii*).

P. alnophila (Vain.) Loht. et al. — on bark of *Alnus glutinosa* and *Salix* spp.; 1, 2, 5, 9, 11.

P. caesia (Hoffm.) Fürnr. — on granite; 6.

P. dubia (Hoffm.) Lettau — on bark of *Betula* sp.; 6. On bark of *Salix* sp. in swampy willow thickets, 24 VI 2004, *Kataeva*, LE L-3781 (sub *Physcia adscendens*); on bark of *Ulmus* sp. in the garden, 17 IX 2004, *Kurbatova*, LE L-3800 (sub *Phaeophyscia orbicularis*).

P. stellaris (L.) Nyl. — on bark of *Alnus glutinosa*, *Hippophaë rhamnoides*, and *Salix* spp.; 2, 4, 5, 8, 9, 11. On bark of *Salix* sp. and *Ulmus* sp. in different habitats (Kataeva, 2005, LE L-3798).

P. tenella (Scop.) DC. — on bark of *Alnus glutinosa*, *Betula* sp., *Hippophaë rhamnoides*, *Picea* spp., and *Salix* spp., on treated wood; 1–11. On bark of various deciduous trees in different habitats [Kataeva, 2005, LE L-7807, L-3781 (sub *Physcia adscendens*)].

Physconia detersa (Nyl.) Poelt — on bark of *Salix fragilis*; 10.

P. distorta (With.) J. R. Laundon — on bark of *Picea glauca* and *Salix fragilis*; 3, 10, 11.

P. enteroxantha (Nyl.) Poelt — on bark of *Betula* sp.; 6.

Placynthiella dasaea (Stirt.) Tønsberg — on wood of *Alnus glutinosa* and *Salix fragilis*; 11, a4.

Platismatia glauca (L.) W. L. Culb. et C. F. Culb. — on bark of *Alnus glutinosa* and *Salix fragilis*; 10, a4. On bark of *Alnus glutinosa* in black alder forest and *Salix* sp. in swampy willow thickets (Kataeva, 2005, LE L-3782).

Polycauliona candelaria (L.) Frödén et al. — on bark of *Salix* sp.; 5.

P. polycarpa (Hoffm.) Frödén et al. — on bark of *Alnus glutinosa*, *Betula* sp., *Hippophaë rhamnoides*, *Picea abies*, *Prunus padus*, and *Salix* spp., on treated wood; 1, 2, 4–11. On bark of various deciduous trees in different habitats [Kataeva, 2005, LE L-3797 (sub *Parmelia sulcata*)

and L-3804 (sub *Athallia pyracea*)]; on bark of *Salix* sp. in willow thickets, 17 IX 2004, *Kurbatova*, LE L-3805 [as *Caloplaca lobulata* (Flörke) Hellb.].

Pseudevernia furfuracea (L.) Zopf — on bark of *Alnus glutinosa* and *Prunus padus*; 2, a4.

Pseudoschismatomma rufescens (Pers.) Ertz et Tehler — on bark of *Salix fragilis*; 1.

[R, s]Punctelia jeckeri (Roum.) Kalb (Fig. 3G) — well developed on bark of *Picea glauca* branches (Fig. 3H); 3 (LE L-21832).

Ramalina farinacea (L.) Ach. — on bark of *Alnus glutinosa*, *Picea glauca*, *Prunus padus*, and *Salix* spp.; 1–3, 9–11. On bark of old *Salix* sp. in black alder forest (Kataeva, 2005, LE L-3770); on bark of *Salix* sp. in swampy willow thickets, 24 VI 2004, *Kataeva*, LE L-3778 (as *Ramalina pollinaria*).

R. fraxinea (L.) Ach. — on bark of *Prunus padus*; a4.

Rinodina exigua (Ach.) Gray — on bark of *Alnus glutinosa* on the shore of the Gulf of Finland (Kataeva, 2005), on bark of *Salix fragilis* in willow thickets, 17 IX 2004, *Kurbatova*, LE L-3805 (sub *Polycauliona polycarpa*). The specimen published by Kataeva (2005) as *Rinodina exigua* (LE L-3801) refers to *R. septentrionalis*.

R. pyrina (Ach.) Arnold — on bark of *Hippophaë rhamnoides* and *Salix* spp.; 1, 8, 9, 11.

R. septentrionalis Malme — on bark of *Salix* sp.; 5, 8. On bark of *Alnus incana* (Kataeva, 2005, LE L-3786); on bark of *Salix* sp. in swampy willow thickets, 24 VI 2004, *Kataeva*, LE L-3788 (as *Rinodina laevigata*); on bark of *Salix mirsinifolia* in willow thickets, 17 IX 2004, *Kurbatova*, LE L-3801 (as *Rinodina exigua*) and L-3808 (sub *Lecanora symmicta*).

Ropalospora viridis (Tønsberg) Tønsberg — on bark of *Alnus glutinosa* and *Prunus padus*; 2.

Scoliciosporum chlorococcum (Graewe ex Stenh.) Vězda — on bark of *Populus tremula* and *Salix* sp.; 5, 6, 9. On bark of *Alnus incana*, 24 VI 2004, *Kataeva*, LE L-3772 [as *Bacidia subincompta* (Nyl.) Arnold].

S. sarothamni (Vain.) Vězda — on bark of *Alnus glutinosa*, *Betula* sp., *Hippophaë rhamnoides*, *Picea* spp., *Populus tremula*, *Prunus padus*, and *Salix* spp., on wood of *S. fragilis*; 1–11. On bark of *Ulmus* sp. in a garden, 17 IX 2004, *Kataeva*, LE L-3797 (sub *Parmelia sulcata*); on bark of *Salix* sp. in willow thickets, 17 IX 2004, *Kataeva*, LE L-3806 (as *Scoliciosporum umbrinum*); same substrate and biotope, 24 VI 2004, *Kataeva*, LE L-3785 (sub *Tuckermannopsis chlorophylla*); on bark of *Padus avium* in open place, 24 VI 2004, *Kataeva*, LE L-3771 (as *Scoliciosporum umbrinum*).

[R]Scytinium subtile (Schrad.) Otálora et al. — on bark of *Salix fragilis*; 10.

Steinia geophana (Nyl.) Stein — on clayey soil on the shore of the Gulf of Finland, 24 VI 2004, *Kataeva*, LE L-3777 [as *Mycobilimbia hypnorum* (Lib.) Kalb et Hafellner].

+Stenocybe pullatula (Ach.) Stein — on bark of *Alnus glutinosa*; 2, 4.

Strangospora pinicola (A. Massal.) Körb. — on bark of *Alnus incana*, 6 VIII 2004, *Kataeva*, LE L-2069 (as *Strangospora deplanata*).

Thelenella pertusariella (Nyl.) Vain. — on bark of *Prunus padus*; 1.

Toniniopsis separabilis (Nyl.) Gerasimova et A. Beck — on bark of *Acer platanoides* and *Salix fragilis*; 1, 4. The specimen published by Kataeva (2005) as *Bacidia subincompta* (Nyl.) Arnold (LE L-3772) refers to *Scoliciosporum chlorococcum*.

#Tremella lichenicola Diederich — on thallus of *Violella fucata* growing on bark of *Alnus glutinosa*; 2.

Tuckermannopsis chlorophylla (Willd. ex Humb.) HaLE — on bark of *Alnus glutinosa*, *Picea glauca*, *Prunus padus*, and *Salix* sp.; 2, 3, 5, a4. On bark of *Alnus glutinosa* in black alder forest and *Salix* sp. in swampy willow thickets [Kataeva, 2005, as *Cetraria chlorophylla* (Willd.) Vain., LE L-3785].

Usnea hirta (L.) F. H. Wigg. — on bark of *Salix* sp.; 5.

U. subfloridana Stirt. — on bark of *Prunus padus* and *Salix* sp.; 5, a4.

Verrucaria muralis Ach. — on concrete; 6.

Violella fucata (Stirt.) T. Sprib. — on bark of *Alnus glutinosa*; 2.

Vulpicida pinastri (Scop.) J.-E. Mattsson et M. J. Lai — on bark of *Alnus glutinosa*, *Picea glauca*, and *Prunus padus*; 2, 3, a4. On bark of various deciduous trees in different habitats (Kataeva, 2005, LE L-3783).

Xanthoria parietina (L.) Th. Fr. — on bark of *Alnus glutinosa*, *Betula* sp., *Hippophaë rhamnoides*, *Picea* spp., *Populus tremula*, *Prunus padus*, and *Salix* spp., on wood of *S. fragilis*; 1–11. On bark of various deciduous trees in different habitats (Kataeva, 2005, LE L-3802).

Taxa excluded from lichen flora of Strelninsky Bereg Protected Area

Calogaya lobulata (Flörke) Arup et al. — reported by Kataeva (2005) as *Caloplaca lobulata* (Flörke) Hellb., the specimen belongs to *Polycauliona polycarpa* (LE L-3805).

Lecania fuscella (Schaer.) A. Massal. — reported by Kataeva (2005), the specimen belongs to *L. naegelii* (LE L-3773).

Lecanora intumescens (Rebent.) Rabenh. — reported by Kataeva (2005), the specimen LE L-3792 is poorly developed for correct identification, but does not belong to *L. intumescens*.

L. leptyrodes (Nyl.) Degel. — reported by Kataeva (2005), the specimen belongs to *L. carpinea* (LE L-3809).

L. populicola (DC.) Duby — reported by Kataeva (2005), the specimen belongs to *L. chlarotera* (LE L-3794).

L. saligna (Schrad.) Zahlbr. — reported by Kataeva (2005), the specimen belongs to *L. albellula* (LE L-3793).

Bryobilimbia hypnorum (Lib.) Fryday et al. — reported by Kataeva (2005) as *Mycobilimbia hypnorum* (Lib.) Kalb et Hafellner, the specimen belongs to *Steinia geophana* (LE L-3777).

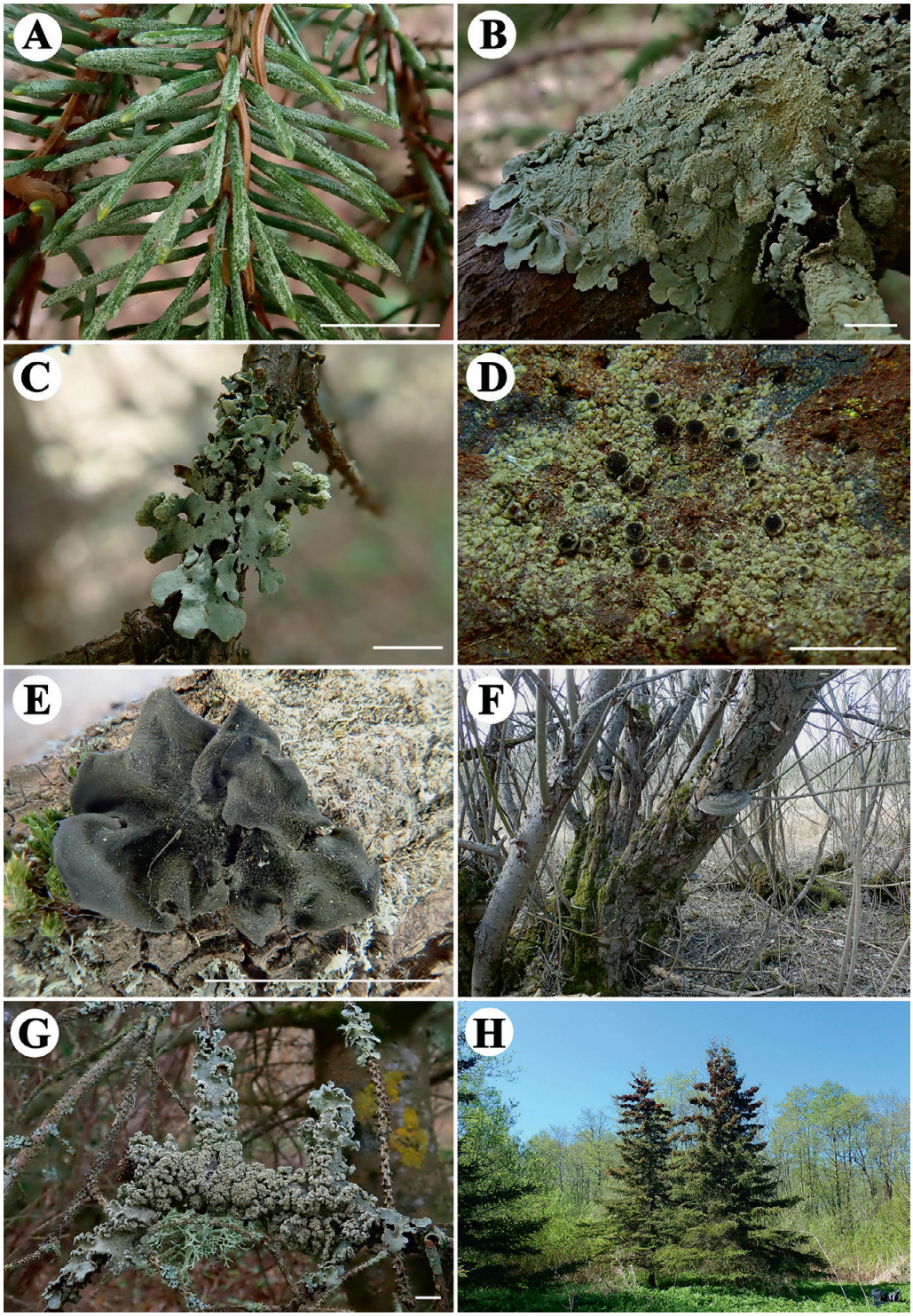
Ramalina pollinaria (Westr.) Ach. — reported by Kataeva (2005), the specimen belongs to *R. farinacea* (LE L-3778).

Rinodina laevigata (Ach.) Malme — reported by Kataeva (2005), the specimen belongs to *R. septentrionalis* (LE L-3788).

Scoliciosporum umbrinum (Ach.) Arnold — reported by Kataeva (2005), the specimens belong to *S. sarothamni* (LE L-3771, L-3806).

Strangospora deplanata (Almq.) Clauzade et Cl. Roux — reported by Kataeva (2005), the specimen belongs to *S. pinicola* (LE L-2069).

Fig. 3. The lichens of Strelninsky Bereg and their habitats.
A — *Fellhanera bouteillei* on needles of *Picea glauca* (LE L-21829); B — *Flavoparmelia caperata* on twig of *Picea glauca* (LE L-21834); C — *Hypotrachyna revoluta* on twig of *Picea glauca* (LE L-21830); D — *Lecania olivacella* on rusty iron (LE L-21831); E — *Leptogium saturninum* on bark of old *Salix* sp. (field record, SA 5); F — Habitat of *Leptogium saturninum*: old willow tree in thickets (SA 5); G — *Punctelia jeckeri* on twig of *Picea glauca* (LE L-21832); H — *Picea glauca* trees on a meadow. Scale bars: A–C, E, G — 1 cm; D — 1 mm.


A
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Discussion

The total revealed lichen diversity of Strelninsky Bereg Protected Area includes 130 species, 123 of them are lichenized, four are lichenicolous, and three are non-lichenized saprobic fungi. The lichen biota of Strelninsky Bereg is quite rich, despite extremely small size of the area, and is richer than a number of compatible small territories within the city limits (Himelbrant *et al.*, 2007; Atlas..., 2016; Stepanchikova *et al.*, 2020; unpublished authors' data). For example, the list of lichens and allied fungi of Petrovsky Pond Protected Area (ca. 0.03 km^2) counts 30 species only, Elagin Island Protected Area (ca. 1 km^2) — 87 species, Piskarevsky Park (ca. 1.2 km^2) — 91 species, Polezhaevsky Park (ca. 1.5 km^2) — 108 species, Dubki Park (0.6 km^2) — 117 species, proposed protected area Gagarka (ca. 0.3 km^2) — 121 species. Obviously, the diversity of lichens and allied fungi depends not only on the size of the area, but more on the diversity and condition of substrates and biotopes, as well as on the position of the area within the city.

In the result of the revision of the herbarium specimens in LE, we accepted the reports of 25 lichen species out of 41 which were published (Kataeva, 2005). Moreover, some additional species were identified in herbarium specimens. Altogether, 39 species were correctly published or collected before our study.

In May 2022, we found 124 species in Strelninsky Bereg. In course of this inventory, we did not record only six species which existed here in 2004: *Athallia cerinelloides*, *Myriolecis sambuci*, *Peltigera didactyla*, *Rinodina exigua*, *Steinia geophana*, and *Strangospora pinicola*. They all are widely distributed in the Leningrad Region and St. Petersburg, but are small-sized and normally not abundant, so they could be just overlooked.

Most common species registered in all 11 SA were *Physcia tenella*, *Scoliciosporum sarothamni*, and *Xanthoria parietina*; *Lecania naegelii*, *Lecanora symmicta*, *L. umbrina*, *Parmelia sulcata*, and *Polycauliona polycarpa* found in 10 SA. Controversially, 51 species were found in our investigation in only one SA or additional plot.

An average amount of species per SA was 33.1±3.7, with minimum 12 (young shadowy spruce alley, SA 7), and maximum 56 (black alder forest with bird cherry, SA 2). This average number is similar with territories along the northern shore of the Gulf of Finland within St. Petersburg, where an average is 33.3±1.3 (Stepanchikova *et al.*, 2020), but significantly lower than in more remote territories of the Leningrad Region or even St. Petersburg with very rich lichen diversity. For example, in the proposed protected area Motornoe-Zaostrovje (LR) an average amount of species per standard SA was 58.6±3.1 (Stepanchikova *et al.*, 2022), in Konevets Island (LR) — 47.7±2.6 (Himelbrant *et al.*, 2018), in proposed protected area Pukhtolova Gora (SPb) — 49.7±5.5 (Stepanchikova *et al.*, 2021), and in the valley of the Smorodinka River (LR) — 42.9±4.0 (Stepanchikova *et al.*, 2013).

Altogether 78 species (60.0% of the lichen biota revealed in 2022) were recorded in communities dominated by willows, of them 60 species (46.2%) inhabited old-growth willow stands of *Salix fragilis* and *S. myrsinifolia*, and 51 species (39.2%) were found in

willow thickets. Black alder forests which are typical natural communities of the study area were also comparatively rich in lichens: 73 species (56.2%) were recorded there. In young birch and aspen stand (SA 6), 37 species (28.5%) were recorded. Planted spruces (alley and single trees) brought to the lichen biota 32 species (24.6%). Concrete constructions and granite boulders were very poor in lichens (8 species altogether).

The majority of lichens in Strelninsky Bereg Protected Area were epiphytic (104 species, 80.0% of the lichen biota revealed in 2022), which is typical for the region. The richest phorophytes were *Salix* spp. (71 species) and *Alnus glutinosa* (58 species). Other phorophytes are arranged below in descending order of the number of species: *Picea glauca* and *Prunus padus* (28 species each), *Betula* sp. (20 species), *Populus tremula* (15 species), *Hippophaë rhamnoides* and *Picea abies* (11 species each), *Acer platanoides* (7 species), and *Sorbus aucuparia* (2 species). Very few species were found on stones (12 species, 9.2%), wood (11 species, 8.5%). Lichenicolous fungi were represented by 4 species. Some species were recorded also on mosses, iron, fruit bodies of polypores, and epiphytic algae. Terricolous lichens were not observed during the last investigation, though several species were recorded before by Kataeva (2005).

We found four species, previously unknown in St. Petersburg and the Leningrad Region: *Lecania olivacella*, which is also new to Russia, *Bacidina pycnidiata*, *Fellhanera bouteillei*, and *Lecidella subviridis*, new to North-Western European Russia. However, these new records were important, but not the main result of the study, which brought us additionally two "discoveries".

One "discovery" concerns a species which had not been recorded in St. Petersburg for a long time: surprisingly, we found a small thallus of *Leptogium saturninum* on bark of very old willow tree in swampy willow thickets with tall grasses (SA 5; Fig. 3E, 3F). This corticolous cyanolichen is one of indicator species of biologically valuable forests in North-Western European Russia (Vyyavlenie..., 2009). The species was listed in the Red Data Book of St. Petersburg as regionally extinct (Krasnaya..., 2018); its last collections within St. Petersburg were made in 1927 by M. M. Gollerbakh in Dudergof (LE L-10634) and Pavlovsk (Rassadina, 1930; LE L-10635). Moreover, the nearest known actual localities in the Leningrad Region are remote from the city: near Mattia (Kingisepp District) 67 km from St. Petersburg, Lisinskoe (Tosno District) 28 km from St. Petersburg, and Orekhovo (Priozersk District) 34 km from St. Petersburg (unpublished authors' data). *Leptogium saturninum* as a cyanolichen known as very sensitive to atmospheric pollution (Richardson, Cameron, 2004), so its reappearance could reflect a decline of pollution in the city suburbs. It is not a unique case within the limits of St. Petersburg — single finds of the other sensitive species, such as *Acolium inquinans* (Sm.) A. Massal., *Nephroma parile* (Ach.) Ach., *Schismatomma pericleum* (Ach.) Branth et Rostr., *Sclerophora pallida* (Pers.) Y. J. Yao et Spooner, *Scytinium teretiusculum* (Wallr.) Otálora et al., are known from Oranienbaum Park in Lomonosov, as well as *Sclerophora coniophaea* (Norman) J. Mattsson et Middelb. from Dubki Park in Sestroretsk (Krasnaya..., 2018).

Another "discovery" of our investigation was an unusual lichen community on branches, twigs, and needles of planted *Picea glauca* (SA 3; Fig. 3H). This community included 28 species, most interesting of them were *Fellhanera bouteillei* (already mentioned above as new for the region), *Flavoparmelia caperata*, *Hypotrachyna revoluta*, and *Punctelia jeckeri*. Three last foliose species were known from St. Petersburg in 1920^{s} and early 1930^{s} from old parks of the Petrodvorets District, faced to the Gulf of Finland (LE; Rassadina, 1930; Minyaev, 1936; Krasnaya..., 2018), but were not registered there later despite intensive investigations. The four species mentioned are currently known as suboceanic; around Baltic Sea, they are distributed mainly in the southwest and west, with eastern parts of their ranges lying in Lithuania, Kaliningrad Region of Russia, and Sweden (Fałtynowicz, Kossowska, 2016; Motiejūnaitė, 2017; Himelbrant *et al*., 2020, 2022; Westberg *et al*., 2021; Printzen *et al*., 2022). During the previous lichen inventory in 2004, none of these species was found in Strelninsky Bereg (Kataeva, 2005), as well as *Picea glauca* was not recorded there in course of the comprehensive complex inventory (Strelninsky..., 2005). Considering this, the trees of *Picea glauca* were planted not more than 18 years ago (though at least ten years ago or more, given their twisted shape). The age of the spruces now is about 35 years. Obviously, when the trees were brought from the Kaliningrad Region or some European country, their epiphytic lichens came together with phorophytes, and then survived. Surprisingly, all four "alien" lichen species did not decline, on the contrary, they actively colonized young branches. However, they were absent in the neighboring willow thickets and black alder stands, probably due to lack of favorable substrate. In our opinion, long-term successful surviving of four introduced lichen species usually occurring in the European regions with milder climate could be a possible result of modern climate change in the region of St. Petersburg and in the World. This is in a good concordance with the historical fact of early 20th century warming (1920-s and 1930-s) (Hegerl *et al*., 2018), when *Flavoparmelia caperata*, *Hypotrachyna revoluta*, and *Punctelia jeckeri* were registered in parks of the Petrodvorets District of St. Petersburg. During next decades with colder climate these species were not recorded in the region. Based on this data, we report here a successful occasional reintroduction of lichen species as the first recordable change in the regional lichen diversity due to modern climate change. The lower level of atmospheric pollution in St. Petersburg in last decades might be the other reason for the species to come back. However, at least *Flavoparmelia caperata* and *Punctelia jeckeri* are not highly sensitive to air quality, e. g., they occur on bark of trees growing along highways in the Kaliningrad Region (Himelbrant *et al*., 2020, 2022).

Altogether, nine lichen species red-listed in St. Petersburg (Krasnaya..., 2018) were found in the study area: *Anaptychia ciliaris*, *Arthonia helvola*, *Chaenotheca brachypoda*, *C. hispidula*, *Flavoparmelia caperata*, *Hypotrachyna revoluta*, *Leptogium saturninum*, *Punctelia jeckeri*, and *Scytinium subtile*. The lichens *Arthonia helvola*, *Chaenotheca brachypoda*, *C. hispidula*, and *Leptogium saturninum* are indicator species, whereas *Hypotrachyna revoluta* and *Punctelia jeckeri* are habitat specialists

of biologically valuable forests in North-Western European Russia (Vyyavlenie..., 2009). The red-listed and indicator species were found on bark of old trees of *Alnus glutinosa* and *Salix* spp. in swampy or very wet habitats, except for the reintroduced species discussed before.

The lichen biota of Strelninsky Bereg Protected Area seems to be quite rich, including a number of red-listed and indicator species. However, the most interesting part of lichen diversity is represented by the successfully reintroduced species and the species coming back to St. Petersburg, which makes the territory extremely valuable for the monitoring studies of the lichen diversity in the future and reflects the processes taking place in the regional biota.

Acknowledgments

The authors are grateful to the Directorate of Nature Protected Areas of St. Petersburg, as well as to V. N. Khramtsov and E. A. Volkova (Komarov Botanical Institute of RAS, St. Petersburg) for support in organization of field studies. We thank G. A. Isachenko (St. Petersburg State University) for consultations on regional climate changes. The laboratory and herbarium studies were supported by the Ministry of Science and Higher Education of the Russian Federation under Agreement No. 075-15-2021-1056. Authors are grateful to anonymous reviewers for valuable comments and corrections.

References / Литература

Atienza V., Segarra J. G. 1999. A first approximation checklist of the lichens of the Valencian Community. *Flora Mediterranea* 9: 231–268.

Atlas osobo okhranyaemykh prirodnykh territorii Sankt-Peterburga [Atlas of the Protected Areas of St. Petersburg]. 2016. St. Petersburg: 176 p. [*Атлас особо охраняемых природных территорий Санкт-Петербурга*. 2016. СПб.: 176 с.].

Cannon P., Ekman S., Kistenich S., LaGreca S., Printzen C., Timdal E., Aptroot A., Coppins B., Fletcher A., Sanderson N., Simkin J. 2021. Lecanorales: Ramalinaceae, including the genera *Bacidia*, *Bacidina*, *Bellicidia*, *Biatora*, *Bibbya*, *Bilimbia*, *Cliostomum*, *Kiliasia*, *Lecania*, *Megalaria*, *Mycobilimbia*, *Phyllopsora*, *Ramalina*, *Scutula*, *Thalloidima*, *Toninia*, *Toniniopsis* and *Tylothallia*. *Revisions of British and Irish lichens* 11: 1–82.

Cannon P., Orange A., Aptroot A., Sanderson N., Coppins B., Simkin J. 2022. Lecanorales: Pilocarpaceae, including the genera *Aquacidia*, *Byssoloma*, *Fellhanera*, *Fellhaneropsis*, *Leimonis* and *Micarea*. *Revisions of British and Irish lichens* 27: 1–48.

Czarnota P., Coppins B. J. 2006. A new *Bacidia* with long-necked pycnidia from Central Europe. *The Lichenologist* 38(5): 407–410. https://doi.org/10.1017/S0024282906005986

Fałtynowicz W., Kossowska M. 2016. The lichens of Poland. A fourth checklist. *Acta Botanica Silesiaca Monographiae* 8: 3–122.

Gagarina L. V. 2017. Family Gyalectaceae. *Flora lishainikov Rossii: rod Protoparmelia, semeistva Coenogoniaceae, Gyalectaceae i Umbilicariaceae* [The lichen flora of Russia: the genus *Protoparmelia*, families Coenogoniaceae, Gyalectaceae and Umbilicariaceae]. Moscow, St. Petersburg: p. 31–65. [Гагарина Л. В. 2017. Семейство Gyalectaceae. *Флора лишайников России: род Protoparmelia, семейства Coenogoniaceae, Gyalectaceae и Umbilicariaceae*. М., СПб.: 31–65].

Gardes M., Bruns T. D. 1993. ITS primers with enhanced specificity for basidiomycetes — application to the identification of mycorrhizae and rusts. *Molecular Ecology* 2: 113–118. https://doi.org/10.1111/j.1365-294X.1993.tb00005.x

Golubkova N. S. 1959. Outline the lichen flora of the Moscow Region and adjacent districts. *Botanicheskii zhurnal* 44(2): 153–161. [Голубкова Н. С. 1959. Очерк флоры лишайников Московской области и смежных районов. *Ботанический журнал* 44(2): 153–161].

Hegerl G. C., Brönnimann S., Schurer A., Cowan T. 2018. The early 20th century warming: anomalies, causes, and consequences. *WIREs Climate Change* 9(4): e522. https://doi.org/10.1002/wcc.522

Himelbrant D. E., Kuznetsova E. S., Stepanchikova I. S. 2017. The lichens of the Protected Areas of St. Petersburg. *Environment of St. Petersburg* 3: 48–49. [Гимельбрант Д. Е., Кузнецова Е. С., Степанчикова И. С. 2017. Лишайники особо охраняемых природных территорий Санкт-Петербурга. *Окружающая среда Санкт-Петербурга* 3: 48–49].

Himelbrant D. E., Stepanchikova I. S., Kuznetsova E. S., Motiejūnaitė J., Konoreva L. A. 2018. Konevets Island (Leningrad Region, Russia) — a historical refuge of lichen diversity in Lake Ladoga. *Folia Cryptogamica Estonica* 55: 51–78. https://doi.org/10.12697/fce.2018.55.07

Himelbrant D., Stepanchikova I., Korolev K., Motiejūnaitė J., Petrenko D. 2020. Forty species of lichens, lichenicolous and calicioid fungi new for the Kaliningrad region (former Ostpreußen) with additional noteworthy records. *Herzogia* 33(1): 38–60. https://doi.org/10.13158/heia.33.1.2020.34

Himelbrant D., Stepanchikova I., Andreev M., Korolev K., Chesnokov S., Konoreva L., Petrenko D. 2022. New and noteworthy lichenized and lichen associated fungi from the Kaliningrad region (former Ostpreußen). *Herzogia* 35(2): 475–493. https://doi.org/10.13158/heia.35.2.2022.475

Himelbrant D. E., Stepanchikova I. S., Kuznetsova E. S., Konoreva L. A. 2007. Lichens. *Priroda Elagina ostrova* [Nature of Elagin Island]. St. Petersburg: 60–67. [Гимельбрант Д. Е., Степанчикова И. С., Кузнецова Е. С., Конорева Л. А. 2007. Лишайники. *Природа Елагина острова*. СПб.: 60–67].

Kolchinsky E. I., Sytin A. K., Smagin G. I. 2004. *Estestvennaya istoriya v Rossii (Ocherki razvitiya estestvoznaniya v Rossii v XVIII veke)* [Natural History in Russia (Papers on development of Natural History in Russia in XVIII)]. St. Petersburg: 242 p. [Колчинский Е. И., Сытин А. К., Смагин Г. И. *Естественная история России (Очерки развития естествознания в России в XVIII веке)*. 2004. СПб.: 242 с.].

Kataeva O. A. 2005. Lichens. *Strelninsky Bereg — kompleksnyi pamyatnik prirody* [Strelninskiy coast — Complex Natural Reserve]. St. Petersburg: 27–30. [Катаева О. А. 2005. Лишайники. *Стрельнинский берег — комплексный памятник природы*. СПб.: 27–30].

Krasnaya kniga prirody Sankt-Peterburga [Red Data Book of nature of St. Petersburg]. 2004. St. Petersburg: 416 p. [*Красная книга природы Санкт-Петербурга*. 2004. СПб.: 416 с.].

Krasnaya kniga Sankt-Peterburga [Red Data Book of St. Petersburg]. 2018. St. Petersburg: 568 p. [*Красная книга Санкт-Петербурга*. 2018. СПб.: 568 с.].

Malysheva N. V. 1994. The lichens of historical parks in the environs of St. Petersburg. *Botanicheskii zhurnal* 79(11): 29–35.

Minyaev N. A. 1936. New lichen records to the vicinities of Leningrad. *Trudy Botanicheskogo instituta Akademii nauk SSSR. Seriya II. Sporovye rasteniya* 3: 603–623. [Миняев Н. А. Новые лишайники для флоры окрестностей Ленинграда. *Труды Ботанического института Академии наук СССР. Серия II. Споровые растения* 3: 603–623].

Motiejūnaitė J. 2017. Supplemented checklist of lichens and allied fungi of Lithuania. *Botanica Lithuanica* 23(2): 89–106. https://doi.org/10.1515/botlit-2017-0011

Motiejūnaitė J., Chesnokov S. V., Czarnota P., Gagarina L. V., Frolov I., Himelbrant D., Konoreva L. A., Kubiak D., Kukwa M., Moisejevs R., Stepanchikova I., Suija A., Tagirdzhanova G., Thell A., Tsurykau A. 2016. Ninety-one species of lichens and allied fungi new to Latvia with a list of additional records from Kurzeme. *Herzogia* 29(1): 143–163. https://doi.org/10.13158/heia.29.1.2016.143

Muchnik E. E. 2016. Conspectus of the lichen biota of Orel Region (Central Russia). *Fitoraznoobrazie Vostochnoi Evropy* 10(3): 6–28. [Мучник Е. Э. Конспект лихенобиоты Орловской области (Центральная Россия). *Фиторазнообразие Восточной Европы* 10(3): 6–28].

Nimis P. L., Hafellner J., Roux C., Clerc P., Mayrhofer H., Martellos S., Bilovitz P. O. 2018. The lichens of the Alps — an annotated checklist. *MycoKeys* 31: 1–634. https://doi.org/10.3897/mycokeys.31.23568

Orange A., James P. W., White F. J. 2001. *Microchemical methods for the identification of lichens*. London: 101 p.

Osobo okhranyaemye prirodnye territorii. [Особо охраняемые природные территории]. 2012–2022. https://oopt.spb.ru/protected_areas/ (Date of access: 10 XI 2022).

Printzen C., von Brackel W., Bültmann H., Cezanne R., Dolnik C., Dornes P., Eckstein J., Eichler M., John V., Killmann D., Nimis P. L., Otte V., Schiefelbein U., Schultz M., Stordeur R., Teuber D., Thüs H. 2022. Lichens, lichenicolous and allied fungi of Germany — a revised checklist. *Herzogia* 35(1): 193–393. https://doi.org/10.13158/heia.35.1.2022.193

Rassadina K. A. 1930. About lichens of former Petergofsky County of the Leningrad Province. *Trudy Botanicheskogo muzeya Akademii nauk SSSR* 22: 223–271. [Рассадина К. А. О лишайниках б. Петергофского уезда Ленинградской губернии. *Труды Ботанического музея Академии Наук СССР* 22: 223–271].

Randlane T., Saag A., Suija A. 2021. Lichenized, lichenicolous and allied fungi of Estonia. Ver. December 31, 2021. http://esamba.bo.bg.ut.ee/checklist/est/home.php (Date of access: 6 XII 2022).

Richardson D. H. S., Cameron R. P. 2004. Cyanolichens: their response to pollution and possible management strategies for their conservation in Northeastern North America. *Northeastern Naturalist* 11(1): 1–22. https://doi.org/10.1656/1092-6194(2004)011[0001:CTRTPA]2.0.CO;2

Sobolewski G. 1799. *Flora Petropolitana*. Petropoli: 354 p.

Sobolewski G. 1802. *Sanktpeterburgskaya flora. Chast' II* [Flora of St. Petersburg. Part II]. St. Petersburg: 424 p. [Соболевский Г. 1802. *Санктпетербургская флора. Часть 2*. СПб.: 424 с.].

Stepanchikova I. S., Tagirdzhanova G. M., Himelbrant D. E. 2013. The lichens and allied fungi of the Smorodinka River valley (Leningrad Region). *Novosti sistematiki nizshikh rastenii* 47: 262–278. https://doi.org/10.31111/nsnr/2013.47.262

Stepanchikova I. S., Himelbrant D. E., Kuznetsova E. S., Motiejūnaitė J., Chesnokov S. V., Konoreva L. A., Gagarina L. V. 2020. The lichens of the northern shore of the Gulf of Finland in the limits of St. Petersburg, Russia — diversity on the edge of megapolis. *Folia Cryptogamica Estonica* 57: 101–132. https://doi.org/10.12697/fce.2020.57.11

Stepanchikova I. S., Himelbrant D. E., Kuznetsova E. S., Chesnokov S. V., Konoreva L. A., Pankova V. V. 2021. The lichens of Pukhtolova Gora (St. Petersburg, Russia). *Folia Cryptogamica Estonica* 58: 73–86. https://doi.org/10.12697/fce.2021.58.10

Stepanchikova I. S., Himelbrant D. E., Chesnokov S. V., Konoreva L. A., Timofeeva E. A. 2022. Modern and historical lichen biota of Karelian Isthmus: the case of Motornoe-Zaostrovje proposed protected area (Leningrad Region, Russia). *Novosti sistematiki nizshikh rastenii* 56(2): 371–404. https://doi.org/10.31111/nsnr/2022.56.2.371

Strelninsky Bereg — kompleksnyi pamyatnik prirody [Strelninskiy coast — Complex Natural Reserve]. 2005. St. Petersburg: 56 p. [*Стрельнинский берег — комплексный памятник природы*. 2005. СПб.: 56 с.].

Vyyavlenie i obsledovanie biologicheski tsennykh lesov na Severo-Zapade Evropeiskoi chasti Rossii. T. 2. Posobie po opredeleniyu vidov, ispol'zuemykh pri obsledovanii na urovne vydelov [Survey of biologically valuable forests in North-Western European Russia. Vol. 2. Identification manual of species to be used during survey at stand level]. 2009. St. Petersburg: 258 p. [*Выявление и обследование биологически ценных лесов на Северо-Западе Европейской части России. Т. 2. Пособие по определению видов, используемых при обследовании на уровне выделов*. 2009. СПб.: 258 с.].

Westberg M., Moberg R., Myrdal M., Nordin A., Ekman S. 2021. *Santesson's Checklist of Fennoscandian Lichen-forming and Lichenicolous Fungi*. Uppsala: 933 p.

Zduńczyk A., Kukwa M. 2014. A revision of sorediate crustose lichens containing usnic acid and chlorinated xanthones in Poland. *Herzogia* 27(1): 13–40. https://doi.org/10.13158/heia.27.1.2014.13