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Mycolichenological portrait of alder forest: alpha diversity revealed in 1ha plot in the Samursky National Park (Republic of Dagestan, Russia)

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Abstract
Aim. Xylobiont fungi and lichens determine the sustainability of forest ecosystems, but their species richness and taxonomic diversity depend on the forest type and the degree of its disturbance. Alder forests, characterised by a specific set of ecological conditions, represent poorly studied habitats in terms of myco- and lichenobiota. The aim of this work was to determine the species composition of aphyllophoroid fungi and epiphytic lichens on a 1 ha sample plot in a lowland floodplain forest dominated by *Alnus glutinosa* in the Delta Samura area of the Samursky National Park.
The authors collected basidiomata of lignicolous fungi and lichen specimens on a sample plot of 1 ha during field studies. The surveyed forest area is represented by a community dominated by *Alnus glutinosa* and lianas. The material was identified using light microscopy techniques and a standard set of chemical reactions.
Thirty-three species of aphyllophoroid fungi (Basidiomycota) and 53 species of lichens and allied fungi (Ascomycota) were identified. Among them, 16 species (48 %) of aphyllophoroid fungi were recorded for the first time for the Samursky National Park, including six species revealed for the first time for the Republic of Dagestan, of which three species (*Donkia pulcherrima*, *Phanerochaete cumulodentata* and *Sertulicium granuliferum*) were new to the Northern Caucasus. Lichen species *Arthothelium ruanum*, *Bacidia arceutina* and *Graphis pulverulenta* are listed for the first time for the Republic of Dagestan. At the same time, 21 species of lichenized fungi were recorded for the first time on *Alnus glutinosa* within the region.
The taxonomical structure of aphyllophoroid fungi revealed reflects the spring period of basidiomata-based field study. The predominance of corticioid fungi and revealing hydnoid species among morphological groups may be indicative of the generally wetter habitats of alder forests in comparison to other forest types distributed in the studied area. Most of species were recorded on dead wood of *Alnus glutinosa* as the main forest-forming tree. At the same time, each of other substrates (*Carpinus betulus* and *Corylus avellana*) turned out to be the habitat of species new to the region. The group of fungal species developing on large-scale substrate units, represented by fallen trunks, was the most prevalent and is to be considered as more vulnarable in a case of anthropogenical habitat disturbance. The majority of epiphytic lichens discovered on alder are not specific to this woody substrate, except for single findings. These species belong to epiphytes inhabiting the Samur forest, the core of the lichenobiota of which is composed of thermophilous lichens of lowland deciduous forests. In our opinion, the relict character of the forest, which is an isolated and rather small forest massif with relatively homogeneous climatic conditions, causes a high similarity between the species composition of lichens revealed in the surveyed sample plot with *Alnus glutinosa* and previously studied plots dominated by *Carpinus betulus*, *Populus alba*, and *Quercus robur*.

Key Words
Ascomycota, Basidiomycota, black alder forest, East Caucasus, epiphytic lichens, inventory, protected nature area, polypores, corticioid fungi, xylobionts, *Donkia pulcherrima*.

Миколихенологический портрет ольхового леса: альфа-разнообразие, выявленное на лесном участке площадью 1 га в национальном парке «Самурский» (Республика Дагестан, Россия)

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Резюме

Цель. Ксилобионтные грибы и лишайники определяют устойчивость лесных экосистем, однако их видовое богатство и таксономическое разнообразие зависит от типа леса и степени его нарушенности. Ольховые леса, характеризующиеся специфическим набором экологических условий, представляют собой малоизученные местообитания в отношении мико- и лихенобиоты. Целью данной работы являлось выявление видового состава афиллофороидных грибов и эпифитных лишайников на 1 га пробной площади в низменном пойменном лесу с доминированием *Alnus glutinosa* на территории кластера «Дельта Самура» национального парка «Самурский».

В ходе полевых исследований сбор плодовых тел грибов и образцов лишайников проводился авторами на пробной площади 1 га. Обследованный участок леса представлен сообществом с преобладанием *Alnus glutinosa* и лианами. Материал был идентифицирован с использованем методов световой микроскопии и стандартного набора химических реакций.

Выявлено 33 вида афиллофороидных грибов (Basidiomycota) и 53 вида лишайников и близких к ним нелихенизированных грибов (Ascomycota). Среди них 16 видов (48 %) афиллофороидных грибов отмечены впервые для территории национального парка «Самурский», в том числе шесть видов указываются впервые для Республики Дагестан, из них три вида (*Donkia pulcherrima*, *Phanerochaete cumulodentata* и *Sertulicium granuliferum*) оказались новыми для Северного Кавказа. Виды лишайников *Arthothelium ruanum*, *Bacidia arceutina* и *Graphis pulverulenta* впервые приводятся для Республики Дагестан. В то же время, 21 вид лихенизированных грибов впервые отмечены на *Alnus glutinosa* в пределах региона.

Выявленная таксономическая структура афиллофороидных грибов отражает специфику полевых исследований, проведенных в весенний период. Преобладание среди морфологических групп кортициоидных грибов и обнаружение видов с шиповатым гименофором может свидетельствовать о более влажных условиях черноольшаника по сравнению с другими типами леса, распространенными на исследуемой территории. Большинство видов отмечено на валежной древесине *Alnus glutinosa* как основной лесообразующей породы. В то же время, каждый из других древесных субстратов (*Carpinus betulus* и *Corylus avellana*) оказался местообитанием новых для региона видов. Группа видов грибов, развивающихся на крупных субстратных единицах, представленных валежными стволами, была преобладающей и может рассматриваться как наиболее уязвимая в случае антропогенного нарушения среды обитания. Большинство эпифитных лишайников, выявленных на ольхе, не являются специфичными для данного древесного субстрата, за исключением единичных находок. Эти виды относятся к эпифитам, обитающим в Самурском лесу, ядро лихенобиоты которого составляют теплолюбивые лишайники низменных лиственных лесов. На наш взгляд, реликтовый характер леса, представляющий собой изолированный и довольно небольшой лесной массив с относительно однородными климатическими условиями, обуславливает высокое сходство видового состава лишайников, выявленных на обследованной пробной площади с *Alnus glutinosa* и ранее изученных участков с доминированием *Carpinus betulus*, *Populus alba*, *Quercus robur*.

Ключевые слова
Аскомицеты, базидиомицеты, черноольшаник, Восточный Кавказ, эпифитные лишайники, инвентаризация, особо охраняемая природная территория, трутовики, кортициоидные грибы, ксилобионты, *Donkia pulcherrima*.

INTRODUCTION

Xylobiont fungi and lichens determine the sustainability of forest ecosystems, being an integral part of nutrient and energy cycles. These organisms play a crucial role as source of nutrition and dwelling for various groups of heterotrophic organisms, such as insects, molluscs, birds, etc. At the same time, species richness and taxonomic diversity of xylobiont fungi and lichens highly depend on the forest structure and the degree of its disturbance. In this regard, protected natural areas, especially nature reserves and national parks, are worthy of special attention.

The Samursky National Park is a unique habitat for many groups of organisms, including Hyrcanian elements, Tertiary relicts and rare species of vascular plants. This study is a continuation of our researches on alpha diversity of aphyllophoroid fungi and epiphytic lichens inhabits the Samur forest [1].

Alder forests, characterized by a specific set of ecological conditions, represent poorly studied habitats in terms of myco- and lichenobiota. The aim of this work is to determine the species composition of aphyllophoroid fungi and epiphytic lichens on a 1 ha sample plot in a lowland floodplain forest dominated by *Alnus glutinosa* in the Delta Samura area of the Samursky National Park.

MATERIALS AND METHODS

The specimens of aphyllophoroid fungi and epiphytic lichens (include lichenicolous and non-lichenized saprophytic fungi) were collected from 1-ha plot in the Samursky National Park (Fig. 1) during three days in May 2024. Detailed characterization of investigated plot is described below.

Figure 1. Location of the studied sample plot
Рисунок 1. Местоположение изученной пробной площади

All variety of woody substrates was studied – dry and fallen branches, deadwood, logs, snags, stumps, fallen and standing trunks, etc. Macromorphological and microscopical studies of specimens were carried out by light microscopy technique using routine spot-tests for lichens (KOH, hypochlorite, paraphenylenediamine and UV light) and the standard set of chemicals (5 % KOH, Melzer's reagent, 0.1 % Cotton Blue) for aphyllophoroid fungi. The specimens are deposited in the herbaria of the Mountain Botanical Garden of the Dagestan Federal Research Centre of the RAS (DAG) and the Komarov Botanical Institute of the RAS (LE).

Investigated plot

Russia, Eastern Caucasus, Republic of Dagestan, Magaramkentsky district, Samursky National Park ("Delta Samura" area), 41.85043° N, 48.50897° E, alt. 6 m below the sea level, 07.05.2024–09.05.2024. One-ha plot in the black alder forest (Fig. 2). Dominated tree species: *Alnus glutinosa* (*Carpinus betulus* sporadically). Tree canopy density – 90 %. The second tree layer: *Acer campestre*, *Crataegus pentagyna*, *Ulmus laevis*. Undergrowth: *Cornus mas*, *Mespilus germanica*, *Prunus divaricata.* Lianas: *Hedera pastuchowii*, *Pereploca graeca*, *Smilax excelsa*, *Vitis silvestris*. Herbal layer: *Solenanthus biebersteinii*. Covering of the herbal layer – 95 %. Average height and diameter of dominated trees: *Alnus glutinosa* – 15–17 m, 50–60 cm. General relief is flat with pronounced micro-relief (depressions).

Figure 2. Studied forest plot dominated by *Alnus glutinosa*
Рисунок 2. Изученный участок леса с доминированием *Alnus glutinosa*

RESULTS AND DISCUSSION

In total, 33 species of aphyllophoroid fungi (Basidiomycota) and 53 species of lichens and allied non-lichenized fungi (Ascomycota) have been revealed within surveyed plot. The species identified are listed below in the alphabetical order with data on substrata and herbarium numbers of specimens. Species new to the Northern Caucasus are marked with an exclamation point. An asterisk shows the species recorded for the Republic of Dagestan for the first time.

Species list of aphyllophoroid fungi

*** *Antrodiella romellii*** (Donk) Niemelä — on fallen branches of *Carpinus betulus*, LE F-334881.

Athelia epiphylla Pers. — on fallen trunk of *Alnus glutinosa*, LE F-334882.

Auricularia auricula-judae (Bull.) Quél. — on fallen branches of *Carpinus betulus*, LE F-334872.

Auricularia mesenterica (Dicks.) Pers. — on fallen branches of *Alnus glutinosa*, LE F-334877.

Baltazaria galactina (Fr.) Leal-Dutra, Dentinger et G.W. Griff. — on fallen trunk of *Alnus glutinosa*, LE F-334887.

Botryobasidium capitatum (Link) Rossman et W.C. Allen — on fallen trunk of *Alnus glutinosa*, LE F-334899.

Brevicellicium olivascens (Bres.) K.H. Larss. et Hjortstam — on fallen branches of *Alnus glutinosa*, LE F-334879.

Ceriporia purpurea (Fr.) Donk — on fallen branches of *Alnus glutinosa*, LE F-334890.

Daedaleopsis confragosa (Bolton) J. Schröt. — on fallen branches of *Alnus glutinosa*.

! *Donkia pulcherrima* (Berk. et M.A. Curtis) Pilát — on fallen trunks of *Alnus glutinosa*, LE F-334873, LE F-334903. Fig. 4, A.

Fibrodontia gossypina Parmasto — on fallen trunk of *Alnus glutinosa*, LE F-334885.

Fomes fomentarius (L.) Fr. — on living trunk of *Alnus glutinosa*.

Fomitopsis pinicola (Sw.) P. Karst. — on fallen trunk of *Alnus glutinosa*, LE F-334874.

Hydnophlebia caspica (Hallenb.) C.L. Zhao — on fallen branches of *Alnus glutinosa*, LE F-334883.

Kneiffiella abdita Riebesehl et Langer — on fallen branches of *Alnus glutinosa*, LE F-334902.

*Lyomyces sambuci (*Pers.) P. Karst. — on fallen branches of *Alnus glutinosa*, LE F-334878.

Mycoacia aurea (Fr.) J. Erikss. et Ryvarden — on fallen trunk of *Alnus glutinosa*, LE F-334901.

Odontia ferruginea Pers. — on fallen trunk of *Alnus glutinosa*, LE F-334904. Fig. 3, B.

! *Phanerochaete cumulodentata* (Nikol.) Parmasto — on fallen branches of *Corylus avellana*, LE F-334871.

Phanerochaete livescens (P. Karst.) Volobuev et Spirin — on fallen branches of *Carpinus betulus*, LE F-334880, LE F-334884, on fallen branches of *Alnus glutinosa*, LE F-334886.

! *Sertulicium granuliferum* (Hallenb.) Spirin et Volobuev — on fallen trunks of *Alnus glutinosa*, LE F-334889, LE F-334906. Fig. 4, B.

Sidera vulgaris (Fr.) Miettinen — on fallen trunk of *Alnus glutinosa*, LE F-334900.

*** *Steccherinum bourdotii*** Saliba et A. David — on fallen trunk of *Alnus glutinosa*, LE F-334893. Fig. 3, A.

Steccherinum ochraceum (Pers. ex J.F. Gmel.) Gray — on fallen branches of *Alnus glutinosa*, LE F-334892.

*** *Stereum subtomentosum*** Pouzar — on fallen trunks of *Alnus glutinosa*, LE F-334895, LE F-334897.

Thelephora ellisii (Sacc.) Zmitr., Shchepin, Volobuev et Myasnikov (≡ *Tomentella ellisii* (Sacc.) Jülich & Stalpers) — on fallen trunk of *Alnus glutinosa*, LE F-334894.

Thelephora extendens Kõljalg, I. Saar et Svantesson (≡ *Tomentella radiosa* (P. Karst.) Rick) — on fallen trunk of *Alnus glutinosa*, LE F-334876.

Trametes hirsuta (Wulfen) Lloyd — on fallen trunk of *Alnus glutinosa*, LE F-334905.

Trametes versicolor (L.) Lloyd — on fallen trunk and stumps of *Alnus glutinosa*.

Trechispora cohaerens (Schwein.) Jülich et Stalpers — on fallen trunk of *Alnus glutinosa*, LE F-334888.

Trechispora farinacea (Pers.) Liberta — on fallen trunk of *Alnus glutinosa*, LE F-334875.

Trichaptum biforme (Fr.) Ryvarden — on fallen trunk of *Alnus glutinosa*, LE F-334896.

Xylodon raduloides Riebesehl et Langer — on fallen trunk of *Alnus glutinosa*, LE F-334898, on fallen branches of *Alnus glutinosa*, LE F-334891.

Figure 3. Basidiomata of *Steccherinum bourdotii* (LE F-334893) (A) and *Odontia ferruginea* (LE F-334904) (B)
Scale bars: 1 cm

Рисунок 3. Базидиомы *Steccherinum bourdotii* (LE F-334893) (A) и *Odontia ferruginea* (LE F-334904) (B)
Масштабные линейки: 1 см

Species list of lichens and allied fungi

Acrocordia gemmata (Ach.) A. Massal. — on trunk of *Alnus glutinosa.*

Alyxoria varia (Pers.) Ertz et Tehler — on trunk and branches of *Alnus glutinosa.*

Anaptychia setifera (Mereschk.) Räsänen — on trunk and branches of *Alnus glutinosa.*

Arthonia atra (Pers.) A. Schneid. — on trunk and branches of *Alnus glutinosa* (DAG 1530).

Arthonia radiata (Pers.) Ach. — on trunk and branches of *Alnus glutinosa.*

**** Arthothelium ruanum* (A. Massal.) Körb.** — on branches of *Alnus glutinosa* (DAG 1525).

Athallia pyracea (Ach.) Arup, Frödén et Søchting — on trunk of *Alnus glutinosa.*

**** Bacidia arceutina* (Ach.) Arnold** — on branches of *Alnus glutinosa* (DAG 1526).

Bacidia polychroa (Th. Fr.) Körb. — on trunk of *Alnus glutinosa.*

Bacidia rubella (Hoffm.) A. Massal. — on trunk of *Alnus glutinosa.*

Bacidina delicata (Larbal. ex Leight.) V. Wirth et Vězda — on trunk of *Alnus glutinosa.*

Bacidina phacodes (Körb.) Vězda — on trunk of *Alnus glutinosa* (DAG 1539).

Bactrospora dryina (Ach.) A. Massal. — on trunk of *Alnus glutinosa* (DAG 1527).

Caloplaca cerina (Hedw.) Th. Fr. — on trunk and branches of *Alnus glutinosa.*

Candelaria concolor (Dicks.) Stein — on trunk of *Alnus glutinosa.*

Candelariella aurella (Hoffm.) Zahlbr. — on trunk of *Alnus glutinosa.*

Candelariella xanthostigma (Ach.) Lettau — on trunk of *Alnus glutinosa.*

Catillaria nigroclavata (Nyl.) Schuler — on trunk of *Alnus glutinosa.*

Diarthonis spadicea (Leight.) Frisch, Ertz, Coppins et P.F.Cannon — on trunk of *Alnus glutinosa* (DAG 1536).

Enterographa crassa (DC.) Fée — on trunk of *Alnus glutinosa.*

Enterographa hutchinsiae (Leight.) A. Massal. — on trunk of *Alnus glutinosa.*

Glaucomaria carpinea (L.) S.Y. Kondr., Lőkös et Farkas — on trunk and branches of *Alnus glutinosa* (margin of apothecia P-).

Glaucomaria leptyrodes (G.B.F. Nilsson) S.Y. Kondr., Lőkös et Farkas — on trunk of *Alnus glutinosa* (disc of apothecia C+ bright yellow, margin of apothecia P+ pale yellow).

Graphis betulina (Pers.) Ach. — on trunk and branches of *Alnus glutinosa.*

**** Graphis pulverulenta* (Pers.) Ach.** — on trunk and branches of *Alnus glutinosa* (DAG 1533).

Graphis scripta (L.) Ach. s. str. — on trunk and branches of *Alnus glutinosa* (DAG 1529).

Gyalolechia flavorubescens (Huds.) Søchting, Frödén et Arup — on trunk of *Alnus glutinosa.*

Lecania cyrtella (Ach.) Th. Fr. — on branches of *Alnus glutinosa.*

Lecania naegelii (Hepp) Diederich et van den Boom — on trunk of *Alnus glutinosa* (DAG 1532).

Lecanora argentata (Ach.) Malme — on trunk of *Alnus glutinosa.*

Lecanora chlarotera Nyl. — on trunk of *Alnus glutinosa.*

Lecidea erythrophaea Flörke ex Sommerf. — on trunk of *Alnus glutinosa* (DAG 1531).

Lecidella elaeochroma (Ach.) M. Choisy — on trunk of *Alnus glutinosa.*

Melanelixia glabra (Schaer.) O. Blanco et al. — on trunk of *Alnus glutinosa.*

Melanelixia subaurifera (Nyl.) O. Blanco et al. — on trunk of *Alnus glutinosa.*

Milospium graphideorum (Nyl.) D. Hawksw. — on crust with *Trentepohlia* growing on trunk of *Alnus glutinosa.*

Myriolecis hagenii (Ach.) Śliwa, Zhao Xin et Lumbsch — on trunk of *Alnus glutinosa.*

Naetrocymbe punctiformis (Pers.) R.C. Harris — on branches of *Alnus glutinosa.*

Parmelia sulcata Taylor — on trunk of *Alnus glutinosa.*

Peridiothelia fuliguncta (Norman) D. Hawksw. — on trunk and branches of *Alnus glutinosa.*

Phaeophyscia nigricans (Flörke) Moberg — on trunk of *Alnus glutinosa.*

Phaeophyscia orbicularis (Neck.) Moberg — on trunk and branches of *Alnus glutinosa.*

Physcia adscendens H. Olivier — on trunk and branches of *Alnus glutinosa.*

Physcia aipolia (Ehrh. ex Humb.) Fürnr. — on trunk of *Alnus glutinosa.*

Physcia stellaris (L.) Nyl. — on trunk of *Alnus glutinosa.*

Physconia distorta (With.) J. R. Laundon — on trunk of *Alnus glutinosa.*

Physconia enteroxantha (Nyl.) Poelt — on trunk of *Alnus glutinosa* (DAG 1534).

Porina aenea (Wallr.) Zahlbr. — on trunk and branches of *Alnus glutinosa* (DAG 1528).

Pyrenula chlorospila Arnold — on trunk and branches of *Alnus glutinosa.*

Pyrenula nitidella (Schaer.) Müll. Arg. — on trunk of *Alnus glutinosa.*

Ramalina farinacea (L.) Ach. — on trunk and branches of *Alnus glutinosa.*

Ramalina pollinaria (Westr.) Ach. — on trunk of *Alnus glutinosa* (DAG 1535).

Xanthoria parietina (L.) Th. Fr. — on trunk and branches of *Alnus glutinosa.*

Our species lists include species and genera new to the Republic of Dagestan and to the Northern Caucasus. Detailed information on these new records is presented below.

New to the Northern Caucasus species of aphyllophoroid fungi

Donkia pulcherrima (Berk. et M.A. Curtis) Pilát — new species to the Northern Caucasus (Fig. 4, A). This remarkable hydnoid fungus grows on dead wood of deciduous trees (aspen, beech, birch, linden, oak), rarely conifers (fir). It is a saprotroph, causing a write rot. According to macromorphology features such as pileate basidiomata, imbricate growth and hydnoid hymenophore, the species was related to the genus *Climacodon* for a long time [2; 3]. The results of molecular phylogenetic studies [4; 5] together with previuosly known micromorphological differences argued the replacement of the species to the genus *Donkia*. Our records of *D. pulcherrima* on fallen trunks of *Alnus glutinosa* are the first findings for the Northern Caucasus. The nearest locality of the species in Russia is known in the Republic of Crimea [6]. Due to its sporadic distribution and a few regional collections, the species is red-listed in five Russian regions, namely Lipetsk Oblast [7], the Republic of Tatarstan [8], the Udmurt Republic [9], the Republic of Sakha (Yakutia) [10], Kamchatka Krai [11].

Phanerochaete cumulodentata (Nikol.) Parmasto — new species to the Northern Caucasus. The species was taxonomically validated in 2015, and the differences with the North American species *Phanerochaete magnoliae* (Berk. et M.A. Curtis) Burds. were stressed [12]. *Ph. cumulodentata* is distributed in temperate and hemiboreal zones of Europe [3] although it seems to be uncommon. It often occurs on fallen branches and thin logs of deciduous trees (alder, aspen, birch, bird cherry, linden, oak, rowan, willow) and occasionally on dead basidiomata of polypores (*Fomes*, *Phellinus*) [12; 13]. In the Caucasus region the species was known from Georgia and Iran [14]. Our finding on fallen branches of *Corylus avellana* is the first record for the Northern Caucasus. The closest localities of the fungus in Russia are registered in the Republic of Crimea [15] and Rostov Oblast [16].

Sertulicium granuliferum (Hallenb.) Spirin et Volobuev — new species to the Northern Caucasus (Fig. 4, B). The species was introduced as a member of newly described genus *Sertulicium* according to the taxonomic revision of *Sistotremastrum* and similar-looking taxa [17]. Previously, the fungus was known under the names of *Trechispora granulifera* Hallenb. (described from Iran) and *Sistotremastrum guttuliferum* Melo, M. Dueñas, Telleria & M.P. Martín (described from Portugal), which are conspecific. *S. granuliferum* is widely distributed in temperate Eurasia. It grows on wood remnants of deciduous trees (alder, aspen, birch, bird cherry, linden, maple, oak), mostly on decayed wood but a few on still corticated, rather tough branches or logs. Our records from fallen trunks of *Alnus glutinosa* are the first findings of the species for the Northern Caucasus. The nearest locality in Russia is revealed in the Donetsk People's Republic [17].

New to the Republic of Dagestan species of aphyllophoroid fungi

Antrodiella romellii (Donk) Niemelä — new species to the Republic of Dagestan. The species is one of the few members of the genus *Antrodiella* with resupinate basidiomata. It grows on fallen branches and trunks of different deciduous trees and shrubs (alder, aspen, birch, bird cherry, elm, hazel, linden, oak, rowan, willow, etc.) [13]. The fungus is widespread species in Russia [18], but so far in the Caucasus it was only recorded in the Karachay-Cherkess Republic [19]. Our record on fallen branches of *Carpinus betulus* is the second finding of the species for the Northern Caucasus.

Steccherinum bourdotii Saliba et A. David — new species to the Republic of Dagestan (Fig. 3, A). This pileate fungus with hydnoid hymenophore belongs to xylosaprotrophs, causing a white rot. It grows on dead wood of a wide range of deciduous tree and shrubs hosts. The main distinguishing morphological characteristic is subglobose to globose shape of basidiospores, 4.5–5.5(–6) x 3–5 µm according to Bernicchia and Gorjón

[3]. Our record on fallen trunk of *Alnus glutinosa* extends the known distribution of the species in the Northern Caucasus, where previously *S. bourdotii* was only registered in Krasnodar Krai [14].

Stereum subtomentosum Pouzar — new species to the Republic of Dagestan. The species is common and widely distributed in Eurasia [20]. It grows on dead wood of various deciduous trees (alder, aspen, beech, birch, elm, hornbeam, maple, oak, etc.), causing a write rot. This corticioid fungus is differentiated by effuse-reflexed to pileate basidiomata with finely tomentose upper sterile surface and hymenium excreting a yellowish liquid when fresh and cut [3]. While the records of the species were known from different regions of the Northern Caucasus and Transcaucasia [14], but our collections from fallen trunks of *Alnus glutinosa* in the Samursky National Park are the first findings of *S. subtomentosum* in the Republic of Dagestan.

Figure 4. Basidiomata of *Donkia pulcherrima* (LE F-334873) (A) and *Sertulicium granuliferum* (LE F-334906) (B)
Scale bars: A – 1 cm, B – 2 cm
Рисунок 4. Базидиомы *Donkia pulcherrima* (LE F-334873) (A) и *Sertulicium granuliferum* (LE F-334906) (B)
Масштабные линейки: A – 1 см, B – 2 см

New to the Republic of Dagestan species of lichenized fungi

Arthothelium ruanum (A. Massal.) Körb. (Fig. 5, A) – new species to the Republic of Dagestan. This temperate-suboceanic lichen is mostly found on smooth bark of deciduous trees and shrubs in humid deciduous forests, often on the basal parts of trunks. The species is uncommon in the studied plot, we found the only specimen. In the Samur forest, similar species *A. spectabile* is more common, which differs by larger spores. Both species are characterized by immersed in substrate thallus.

Bacidia arceutina (Ach.) Arnold – new species to the Republic of Dagestan. The mild-temperate to humid subtropical species is found on bark of broad-leaved trees in open deciduous woodlands. The species was collected on branches of *Alnus glutinosa* within the studied plot. It is distinguishing from other *Bacidia* species of similar appearance by the lack of greenish or purplish apothecial pigments [21].

Graphis pulverulenta (Pers.) Ach. (Fig. 5, B) – new species to the Republic of Dagestan. The taxon of the *G. scripta*-group is characterized by apothecia with mostly acute ends and widely exposed white to grey pruinose discs. It is found on bark of broad-leaved trees in various forest types. Neuwirth and Aptroot [22] recognized four distinct taxa in *G. scripta* s. lat. based on apothecium morphology – *G. betulina*, *G. macrocarpa*, *G. pulverulenta* and *G. scripta* s. str. More recent study based on molecular and morphological characters [23] showed that apothecium morphology cannot be only trait for classification of this complex. In the absence of current revision of the *G. scripta*-group we follow the taxonomy proposed by Neuwirth and Aptroot [22].

Aphyllophoroid fungi

A total of 33 aphyllophoroid fungi species (Agaricomycetes, Basidiomycota) were revealed during carried out spring-time mycological investigations. Among them, six species are recorded for the first time for the Republic of Dagestan, including *Donkia pulcherrima*, *Phanerochaete cumulodentata*, and *Sertulicium granuliferum* which are new to the Northern Caucasus. In addition, 16 species have been registered for the first time for the Samursky National Park.

The taxonomical structure in the order level showed the predominance of *Polyporales* (14 species). The list of leading in species number orders includes *Hymenochaetales* (6 species) and *Trechisporales* (4 species). This structure differs from the typical order spectrum characterized for aphyllophoroid funga of temperate deciduous and boreal forests where the third position in the list of leading orders usually belongs to *Agaricales* or *Russulales*. It seems to be the differences are in connection with the period of basidiomata-based field study, and further additions to species richness of aphyllophoroid fungi within studied forest type are to be expected due to the representatives of these orders first of all.

Corticioid fungi were the main morphological group, which is presented by 17 species, or 51.5 %. This fact corresponds to the proportions revealed for aphyllophoroid fungi in previously studied two 1ha plots in the Samursky National Park [1]. Poroid fungi include 11 species, or 33.3 %. Among hydnoid basidiomycetes, which combine five species, two species (*Donkia pulcherrima*, *Steccherinum bourdotii*) are recorded for the

first time for the Republic of Dagestan. The observed diversity of morphological groups of aphyllophoroid fungi may be indicative of the generally wetter habitats of alder forests in comparison to other forest types that have been previously surveyed.

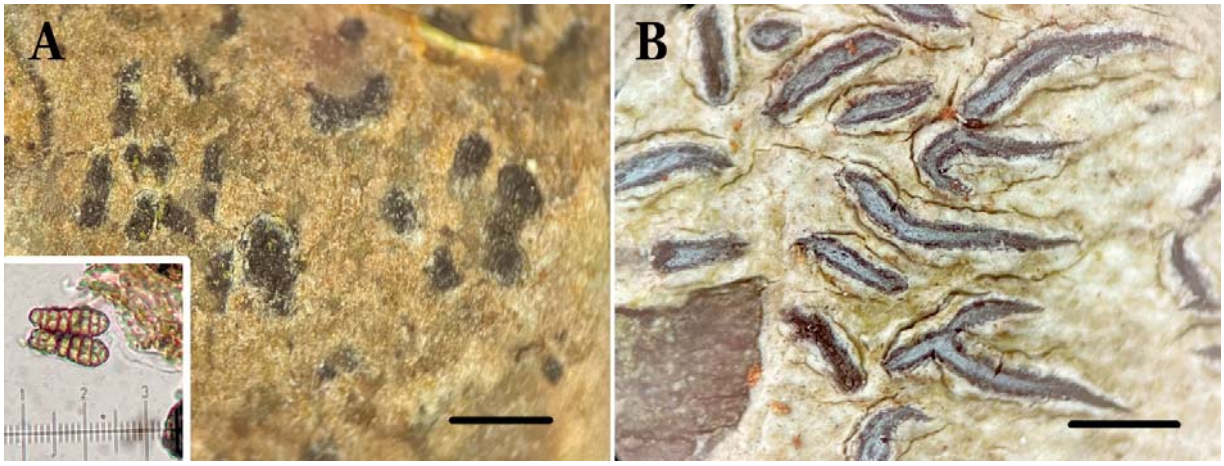

Figure 5. *Arthothelium ruanum* (A), scale bar – 0.5 mm, spores – 600x; *Graphis pulverulenta* (B), scale bar – 0.5 mm
Рисунок 5. *Arthothelium ruanum* (A), масштабная линейка – 0.5 мм, споры – 600x; *Graphis pulverulenta* (B), масштабная линейка – 0.5 мм

Most of species were recorded on dead wood of *Alnus glutinosa* (29 species) as the basic forest-forming tree. A significantly lower number of fungal species were discovered on other woody substrates: on dead wood of *Carpinus betulus* – three species (*Antrodiella romellii*, *Auricularia auricula-judae*, *Phanerochaete livescens*), and on dead wood of *Corylus avellana* – one species (*Phanerochaete cumulodentata*). At the same time, each substrate unit (hornbeam and hazel) turned out to be the habitat of species new to the region. Basidiomata of one species (*Fomes fomentarius*) were registered on living trunk of *Alnus glutinosa*. This species belongs to the group of facultative pathogens, which are primarily destroyed dead wood of fallen and dry standing trees, but sometimes they are able to develop on alive host plants. Mycorrhizal species within the studied plot are presented by *Thelephora ellisii* and *Th. extendens* developing their basidiomata on fallen trunks of black alder.

The distribution of fungal species according to the dimensionality of the substrates inhabited demonstrated that the group of species developing on large-scale substrate units, represented by black alder trunks, was the most prevalent (21 species). Simultaneously, basidiomata of 13 fungal species were observed on dead branches, with 10 species developing on black alder branches and another three on other tree species. One species, *Phanerochaete livescens*, was collected from fallen branches of *Alnus glutinosa* and *Carpinus betulus*. This species was exhibited ecological plasticity with regard to the woody substrates that are appropriate for its growth and development. Another species, *Xylodon raduloides*, was recorded on both dead trunks and fallen branches of *Alnus glutinosa*, which may indicate that there is no strict confinement to the size of the substrate inhabited.

Among remarkable records of aphyllophoroid fungi *Brevicellicium olivascens* and *Hydnophlebia caspica* have to be noted. The latter species is revealed for the second time not only in the Republic of Dagestan, but in Russia. *H. caspica* was earlier recorded on the Gunib Plateau from the on fallen trunk of *Betula* sp. in herb-rich birch forest [24]. This species is found on fallen branches of *Alnus glutinosa* during this survey. *Brevicellicium olivascens* is uncommon corticioid fungus, registered in the Republic of Dagestan for the second time, besides the finding on *Juniperus oblonga* wood from the Gunib Plateau [25].

Lichenized fungi

Fifty-three taxa of lichenized and allied fungi were recorded overall with high diversity in the families *Ramalinaceae* (9 species), *Physciaceae* (8) and *Lecanoraceae* (6). Out of them, three are new to the Republic of Dagestan, i.e. *Arthothelium ruanum*, *Bacidia arceutina*, *Graphis pulverulenta*. Other 21 taxa, already known from the Samur liana forest, were never reported before on the *Alnus* here and through Dagestan. One of the recorded species, i.e. *Milospium graphideorum*, is a lichenicolous fungus and *Peridiothelia fuliguncta* is non-lichenized saprotrophic fungus.

Most of lichenized species are crustose (35, 70.6 %) or foliose (9, 17.6 %), while a smaller proportion are fruticose (6, 11.7 %). The majority has a green globose alga as photobiont (35, 68.6 %), whereas fewer species have a trentepohlioid green alga (16, 31.4 %). The most of revealed species reproduce sexually (45, 84.9 %), fewer by means of soredia or isidia (8, 15.1 %). The trunk bark hosts 33 taxa, 16 species have been revealed on trunk and branches, and only four species (*Arthothelium ruanum*, *Bacidia arceutina*, *Lecania cyrtella*, *Naetrocymbe punctiformis*) – on branches.

Among the species of conservation value, *Enterographa hutchinsiae* is listed in the Red Data Book of the Republic of Dagestan as vulnerable [26]. This epiphytic lichen belongs to a predominantly tropical genus and has oceanic tendency in its distribution. Within Russia, it is found only in the Caucasus as whole the species of the genus *Enterographa*. Other species rarely recorded in the region, and therefore they are considered of some conservation interest at least at the regional level are *Bactrospora dryina*, *Diarthonis spadicea*, and *Enterographa crassa*. They are recognized as species of old-growth forests and are also growing in the Republic of Dagestan only in the Samur liana forest. *Bactrospora dryina* is rare and threatened in most European countries and specifically related to old-growth floodplain forests [27]. This

vulnerable species included in the red lists of Austria, Great Britain, Italy, Germany, Switzerland, Sweden, with main threats of habitat loss and eutrophication due to the way in which forests or rivers are managed [27; 28]. Similar patterns of anthropogenic transformation we observe in the studied communities. *Diarthonis spadicea* within the Caucasus found mainly on protected areas or in virgin forests (e.g. [29; 30]. This conforms to habitat that has been the focus of our study. *Enterographa crassa* is subtropical epiphytic lichen found on smooth bark in riparian, open, humid-warm woodlands. Such communities with suitable habitat are rare in Dagestan and preserved only in the delta of the Samur River. In the Caucasus this species known besides our locality also from the Western Caucasus in Khosta Yew-box grove [31] and from Transcaucasia (Talysh) [32], as *Chiodecton venosum* (Pers.) Zahlbr.).

Revealed epiphytic lichens of alder are not specific, with the exception of new records. They replicate the common epiphytes observed in the Samur forest, which core is characterized by thermophilic lowland deciduous forest species. Low diversity of epiphytes on the alder plot (53 species) we explain with strongly shaded trunks by lianas (Fig. 2) and monodominant community in general. A previous study on a 1-ha plot in the old growth core forest, which was dominated by *Quercus robur* with *Acer campestre* and *Carpinus betulus*, revealed the presence of 82 species (60 on oak, 53 on hornbeam and 25 on maple). Additionally, a notable number of species were observed to be specific to these phorophytes [33]. Other data obtained on two 1-ha plots in polydominant communities also in Samur forest showed a total diversity of epiphytes at 89 species [1]. Compared these data with, e.g., 112 species in an old-growth lowland forest in the Czech Republic [34] show a low diversity of epiphytes on studied plots (include present data) within Samur liana forest.

Similar trends of low diversity, lichen crusts predominance and high proportion of lichens with *Trentepohlia* photobiont revealed within alder and all previously studied plots in the Samur liana forest. In our view, these similarities due to the relict character of the forest – it is an isolated and rather small lowland forest remnant with uniform microclimatic conditions, which lichens communities are in the last stages of succession.

CONCLUSION

Our research expanded the knowledge on species richness and taxonomical diversity of aphyllophoroid and lichenized fungi inhabit the forests dominated by *Alnus glutinosa* in the Samursky National Park. A total of nine species are new to the Republic of Dagestan, including three fungal species revealed for the first time for the Northern Caucasus. Nevetheless, the taxonomical structure of aphyllophoroid fungi revealed reflects the spring period of basidiomata-based field study, and it demonstrates further possibilities for additions to the species richness revealed.

Most of aphyllophoroid fungi species were recorded on dead wood of *Alnus glutinosa* as the main forest-forming tree. At the same time, each of other woody substrates (*Carpinus betulus* and *Corylus avellana*) turned out to be the habitat of species new to the Republic of Dagestan. The predominance of fungal species developing on large-scale substrate units, represented by fallen trunks, allows us to consider these species group as more vulnarable in a case of anthropogenical habitat disturbance, such as logging and removal of large dead wood units.

The majority of epiphytic lichens discovered on alder are not specific to this woody substrate, except for single findings. These species belong to epiphytes inhabiting the Samur forest, the core of the lichenobiota of which is composed of thermophilous lichens of lowland deciduous forests. In our opinion, the relict character of the forest, which is an isolated and rather small forest massif with relatively homogeneous climatic conditions, causes a high similarity between the species composition of lichens revealed in the surveyed sample plot with *Alnus glutinosa* and previously studied plots dominated by *Carpinus betulus*, *Populus alba*, and *Quercus robur*.

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All authors are equally participated in the writing of the manuscript and are responsible for plagiarism, self-plagiarism and other ethical transgressions.

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