

Species composition and distribution of soil fungi in the Kolsay Kolderi National Park (Kazakhstan)

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Abstract: The article is devoted to the studies of species composition and distribution of soil fungi in the Kolsay Kolderi National Park, southeast Kazakhstan. During the studies, 91 species of soil micromycetes belonging to 27 genera, 16 families, 9 orders, 7 classes were identified. The genera *Penicillium* (39 species), *Aspergillus* (12), *Trichoderma* (6) and *Talaromyces* (6) were the most numerous, 1-4 species were found in the remaining genera. The source of the greatest number of fungal species was rhizosphere of *Artemisia* sp. – 28 species and *Rosa* spp. – 27 fungal species, followed by *Picea schrenkiana* – 21 species, *Sorbus tianschanica* – 19 species, *Spiraea hypericifolia* – 18 species, *Juniperus* spp. and *Salix* spp. – 17 species each. The most significant number of species of soil fungi was obtained from Kolsay, Taldy, Kokzhazyk and Tanbaly gorges. The fungi of Eurotiomycetes and Sordariomycetes classes occupied in Kurmety and Karabulak gorges – 100%, Kokzhazyk with Tanbaly – 96%, Kolsay and Kayindy – 95%, Koldenen – 80%, Taldy – 78%, in lateral branches of Kudurga gorge (Botamoynak and Sarybastau) – 71%, Saty – 70%. *Metarhizium carneum*, *Purpureocillium lilacinum*, *Aspergillus niger*, *Talaromyces rugulosus*, *Trichoderma viride* were the most common species found in all or most gorges.

Key Words: biocoenosis, Kungey Alatau ridge, mycobiota, micromycete, rhizosphere

INTRODUCTION

Soil fungi are a large ecological group of organisms present in all biocoenoses and taking an active part in the processes of decomposition of organic matter, the functioning of the soil and the creation of its structure,

as well as in the regulation of the species structure of other soil-living organisms.

Until now, soil fungi remain an insufficiently studied group of organisms, which is associated with the impossibility of direct observation of them various in the environment, with laborious and complex methods of isolation from soils, with the complexity of species identification and instability of the system and nomenclature [Aleksandrova et al., 2006; Shumilova et al., 2014].

Currently, in Kazakhstan, soil fungi are one of the poorly studied components of biocoenosis [Assylbek et al., 2020; Kyzmetova et al., 2021; Rakhimova et al., 2020]. Information on the composition of soil micromycetes in many regions of Kazakhstan is extremely fragmentary. The purpose of our research was to study the species composition and distribution of soil fungi in the Kolsay Kolderi National Park.

MATERIAL AND METHODS

Soil sampling. Soil samples were collected on the territory of the Kolsay Kolderi National Park located in the Kungei Alatau, Kazakhstan, during the vegetation season of 2020. Most of the Kungey Alatau mountain range is located on the territory of Kyrgyzstan, only the eastern part of the northern slope of the ridge is in the southeast of Kazakhstan. The ridge is only 31 kilometers wide. On the territory of Kazakhstan, the southern slope is shorter and steeper than the northern one [Akzhygitova et al., 2003].

Soil samples were collected at a depth of 5-20 cm, in the rhizosphere of plants: *Artemisia* sp., *Berberis heteropoda* Schrenk, *Betula pendula* Roth, *Crataegus* spp., *Ephedra* spp., *Elaeagnus rhamnoides* (L.) A. Nelson, *Juniperus* spp., *Lonicera* spp., *Malus sieversii* (Ledeb) M. Roem., *Picea schrenkiana* Fisch. et C.A. Mey., *Populus tremula* L., *Populus* spp., *Prunus armeniaca* L., *Ribes meyeri* Maxim., *Rosa* spp., *Salix* spp., *Sorbus tianschanica* Rupr., *Spiraea hypericifolia* L. The geographic location of each sample was recorded using digital Global Positioning System (GPS, Garmin). *Isolation of fungi and preparation of medium.* Isolation

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of soil fungi was carried out by the serial dilution method [Watanabe, 2002]. Suspensions of the standard dilution level (1: 10.000) were plated on potato-glucose agar, which was prepared from 1800 g of potatoes per 4500 ml of water, 40 g of sucrose, 40 g of agar. The medium was autoclaved at 120°C for 30 minutes. A pinch of ampicillin (30 mg/ml) was added to the autoclaved medium to avoid the bacterial growth [Watanabe, 2002]. Petri dishes were labeled, sealed with parafilm to avoid contamination, and incubated at 25-27°C.

Characterization of colonies and identification. Colonies of fungi were examined in 5-10 days. Color, texture and growth rate of colonies were analyzed. All characteristics of the colonies were recorded by a digital camera (Canon 600E). Fungal colonies were observed and photographed using a photomicroscope Polyvar system, microscope with Nomarski interference contrast optics (Reichert-Jung). The morphological characteristics of observed fungi were compared with those in the available literature [Domsch et al. 2007; Houbraken et al., 2011; Jaklitsch, 2009; 2011; Pidoplichko, Mil'ko, 1971; Pitt, 1979; Ramirez, 1982; Raper, Fennel, 1965, Raper, Thom, 1949; 1968; Seifert et al., 2011; Sutton, 1980; Visagie et al., 2014; Watanabe, 2002]. The fungi taxonomic list was compiled using the Dictionary of fungi [Kirk et al., 2008]. The names and authors of the fungal taxa are given in accordance with the Index Fungorum database.

RESULTS AND DISCUSSION

During the studies of species composition and distribution of soil fungi in the Kolsay Kolderi National Park, 91 fungal species belonging to 27 genera, 16 families, 9 orders, 7 classes were identified. Below is a list of identified species.

Fungi

Ascomycota Caval.-Sm.

INSERTAE SEDIS

Spicaria cephalospora Kamyschko – Kokzhazyk gorge, mixed forest, *Salix* spp. rhizosphere, 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek.

Dothideomycetes O.E. Erikss. & Winka

DAVIDIELLACEAE C.L. Schoch, Spatafora, Crous & Shoemaker

Cladosporium herbarum (Pers.) Link – Koldenen gorge, spruce forest, rhizosphere of *Rosa* spp., 1836 m a.s.l., 43°02'05.6" N, E78°31'00.0" E, 25.09.2020, Zh.

Aitymbet; Kolsay gorge, northern slope in the vicinity of the Upper Kolsay lake, spruce forest, rhizosphere of *Juniperus* spp., 2050 m a.s.l., 42°55'15.6" N, 78°21'28.8" E, 23.08.2020, A.M. Assylbek.

Pleosporales Luttr. ex M.E. Barr

PLEOSPORACEAE Nitschke

Alternaria sp. – Botamoinak gorge (lateral branch Kudurga gorge), floodplain mixed forest, rhizosphere of *Picea schrenkiana*, 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek; Kolsay gorge, west coast of the Upper Kolsay lake, spruce forest, rhizosphere of *Juniperus* spp., 2638 m a.s.l., 42°54'47.0" N, 78°20'41.4" E, 23.08.2020, A.M. Assylbek.

Eurotiomycetes O.E. Erikss. & Winka

Eurotiales G.W. Martin ex Benny & Kimbr.

ASPERGILLACEAE Link

Aspergillago clavatoflava (Raper & Fennel) Samson, Houbraken & Frisvad – gorge Kayindy, birch forest, rhizosphere of *Picea schrenkiana*, 1734 m a.s.l., 43°00'04.6" N, 78°27'07.3" E, 23.09.2020, G. Sypabekkyzy.

Aspergillus amstelodami (L. Mangin) Thom & Church – Karabulak gorge, spruce forest, rhizosphere of *Rosa* spp., 2180 m a.s.l., 43°00'29.2" N, 78°31'01.3" E, 24.09.2020, E.S. Sametova.

Aspergillus candidus Link – Kayindy gorge, eastern shore of Kayindy lake, mixed forest, rhizosphere of *Artemisia* sp., 1820 m a.s.l., 42°58'55.7" N, 78°27'55.1" E, 23.09.2020, G. Sypabekkyzy; left bank of the Shelek river, Suyk tugay, rhizosphere of *Artemisia* sp., 1501 m a.s.l., 43°20'02.8" N, 78°50'74.0" E, 26.09.2020, A.M. Assylbek.

Aspergillus flavipes (Bainier & R. Sartory) Thom & Church – Sarybastau gorge (lateral branch Kudurga gorge), mixed forest, rhizosphere of *Betula pendula*, 1784 m a.s.l., 43°01'59.1" N, 78°13'39.5" E, 21.08.2020, A.M. Assylbek; *ibid.*, road from Kudurga to Kurmety gorge, *Artemisia* sp. rhizosphere, 1571 m a.s.l., 43°02'46.6" N, 78°18'34.5" E, 21.08.2020, U.K. Jetigenova; Kokzhazyk gorge, mixed forest, *Salix* spp. rhizosphere, 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek.

Aspergillus halophilicus M.Chr., Papav. & C.R. Benj. – Kolsay gorge, road from Saty village to Lower Kolsay lake, floodplain deciduous forest, rhizosphere of *Salix* spp., 1647 m a.s.l., 43°00'49.4" N, 78°20'33.5" E, 23.08.2020, G. Sypabekkyzy.

Aspergillus janus Raper & Thom – Kayindy gorge, northern shore of Kayindy lake, spruce forest, rhizosphere of *Rosa* spp., 1871 m a.s.l., 42°59'05.0" N, 78°27'52.8" E, 23.09.2020, B.Y. Dzhunuskanova; *ibid.*, mixed forest, rhizosphere of *Spiraea hypericifolia*, 1687 m a.s.l., 43°00'49.6" N, 78°26'24.7" E, 23.09.2020, Zh. Aitymbet; *ibid.*, eastern shore of Kayindy lake, mixed forest, rhizosphere of *Salix* spp., 1820 m a.s.l., 42°58'55.7" N, 78°27'55.1" E, 23.09.2020, G. Sypabekkyzy

Aspergillus nidulans (Eidam) G. Winter – Koldenen gorge, spruce forest, rhizosphere of *Rosa* spp., *Berberis heteropoda*, 1836 m a.s.l., 43°02'05.6" N, E78°31'00.0" E, 25.09.2020, Zh. Aitymbet.

Aspergillus niger Tiegh. – Kurmety gorge, spruce forest, *Artemisia* sp. rhizosphere, 1827 m a.s.l., 42°59'52.7" N, 78°17'09.0" E, 25.07.2020, Zh. Aitymbet; Taldy gorge, deciduous forest, rhizosphere of *Betula pendula*, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek; *ibid.*, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Picea schrenkiana*, 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova; Botamoinak gorge, floodplain mixed forest, rhizosphere of *Ephedra* spp., 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek; *ibid.*, road from Kudurga to Kurmety gorge, rhizosphere of *Lonicera* spp., *Artemisia* sp., 1571 m a.s.l., 43°02'46.6" N, 78°18'34.5" E, 21.08.2020, U.K. Jetigenova; Kokzhazyk gorge, mixed forest, rhizosphere of *Picea schrenkiana* and *Rosa* spp., 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek; *ibid.*, spruce forest, rhizosphere of *Rosa* spp. and *Spiraea hypericifolia*, 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova; Kolsay gorge, road from Saty village to Lower Kolsay lake, floodplain deciduous forest, rhizosphere of *Artemisia* sp., 1647 m a.s.l., 43°00'49.4" N, 78°20'33.5" E, 23.08.2020, G. Sypabekkyzy; *ibid.*, west coast of the Upper Kolsay lake, spruce forest, rhizosphere of *Juniperus* spp., *Ribes meyeri*, 2638 m a. s. l., 42°54'47.0" N, 78°20'41.4"E, 23.08.2020, A.M. Assylbek.

Aspergillus parvulus G. Sm. – Kolsay gorge, west coast of the Upper Kolsay lake, spruce forest, rhizosphere of *Ribes meyeri*, 2638 m a.s.l., 42°54'47.0" N, 78°20'41.4" E, 23.08.2020, A.M. Assylbek.

Aspergillus sulphureus Desm. – Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Sorbus tianschanica*, 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A.

Imanalinova.

Aspergillus terricola Marchal & É.J. Marchal – Koldenen gorge, spruce forest, rhizosphere of *Berberis heteropoda* 1836 m a.s.l., 43°02'05.6" N, 78°31'00.0" E, 25.09.2020, Zh. Aitymbet; Kolsay gorge, west coast of the Upper Kolsay lake, spruce forest, rhizosphere of *Juniperus* spp., 2638 m a.s.l., 42°54'47.0" N, 78°20'41.4" E, 23.08.2020, A.M. Assylbek; *ibid.*, the road from the Middle to the Upper Kolsay, spruce forest, rhizosphere of *Artemisia* sp., 2530 m a.s.l., 42°55'04.7" N, 78°20'37.2" E, 23.08.2020, B.Y. Dzhunuskanova.

Aspergillus ustus (Bainier) Thom & Church – Botamoinak gorge, floodplain mixed forest, rhizosphere of *Rosa* spp., 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek; *ibid.*, road from Kudurga to Kurmety gorge, rhizosphere of *Salix* spp., *Crataegus* spp., *Lonicera* spp., т. 324, 1571 m a.s.l., 43°02'46.6" N, 78°18'34.5" E, 21.08.2020, U.K. Jetigenova; Kokzhazyk gorge, mixed forest, rhizosphere of *Salix* spp., *Picea schrenkiana*, 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek; Kolsay gorge, northern slope in the vicinity of the Upper Kolsay lake, spruce forest, rhizosphere of *Rosa* spp., 2050 m a.s.l., 42°55'15.6" N, 78°21'28.8" E, 23.08.2020, A.M. Assylbek.

Aspergillus wentii Wehmer – Kokzhazyk gorge, mixed forest, rhizosphere of *Rosa* spp., 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek; Kayindy gorge, eastern shore of Kayindy lake, mixed forest, rhizosphere of *Picea schrenkiana*, 1820 m a.s.l., 42°58'55.7" N, 78°27'55.1" E, 23.09.2020, G. Sypabekkyzy.

Penicillium atramentosum Thom – Sarybastau gorge, mixed forest, rhizosphere of *Betula pendula*, 1784 m a.s.l., 43°01'59.1" N, 78°13'39.5" E, 21.08.2020, A.M. Assylbek.

Penicillium aurantiogriseum Dierckx – Kolsay gorge, road from Saty village to Lower Kolsay lake, floodplain deciduous forest, rhizosphere of *Spiraea hypericifolia*, 1647 m a.s.l., 43°00'49.4" N, 78°20'33.5" E, 23.08.2020, G. Sypabekkyzy.

Penicillium bilaiae Chalab. – Kolsay gorge, northern slope in the vicinity of the Upper Kolsay lake, spruce forest, rhizosphere of *Juniperus* spp., 2050 m a.s.l., 42°55'15.6" N, 78°21'28.8" E, 23.08.2020, A.M. Assylbek.

Penicillium brevicompactum Dierckx – Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Prunus armeniaca*, 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A.

Imanalinova; Kayindy gorge, mixed forest, rhizosphere of *Spiraea hypericifolia*, 1687 m a.s.l., 43°00'49.6" N, 78°26'24.7" E, 23.09.2020, Zh. Aitymbet.

Penicillium camemberti Thom – road from Kudurga to Kurmety gorge, *Artemisia* sp. rhizosphere, 1571 m a.s.l., 43°02'46.6" N, 78°18'34.5" E, 21.08.2020, U.K. Jetigenova; Kolsay gorge, west coast of the Upper Kolsay lake, spruce forest, rhizosphere of *Juniperus* spp., 2638 m a.s.l., 42°54'47.0" N, 78°20'41.4" E, 23.08.2020, A.M. Assylbek.

Penicillium canescens Sopp – Kayindy gorge, mixed forest, rhizosphere of *Spiraea hypericifolia*, 1687 m a.s.l., 43°00'49.6" N, 78°26'24.7" E, 23.09.2020, Zh. Aitymbet; left bank of the Shelek River, Suyk tugay, rhizosphere of *Artemisia* sp., 1501 m a.s.l., 43°20'02.8" N, 78°50'74.0" E, 26.09.2020, A.M. Assylbek; *ibid.*, rhizosphere of *Populus* spp., 1655 m a.s.l., 43°23'33.9" N, 78°48'40.03" E, 25.09.2020, A.M. Assylbek; Kolsay gorge, road from Saty village to Lower Kolsay lake, floodplain deciduous forest, rhizosphere of *Picea schrenkiana*, *Elaeagnus rhamnoides*, *Salix* spp., 1647 m a.s.l., 43°00'49.4" N, 78°20'33.5" E, 23.08.2020, G. Sypabekkyzy.

Penicillium citreonigrum Dierckx – Taldy gorge, along the Taldy river, floodplain deciduous forest, rhizosphere of *Spiraea hypericifolia*, 1694 m a.s.l., 43°01'33.9" N, 78°15'29.6" E, 26.07.2020, G. Sypabekkyzy; Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Populus* spp., 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova.

Penicillium commune Thom – Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Sorbus tianschanica*, 1853 m a.s.l., 42°59'27.6" N, 78°19'31.1" E, 27.07.2020, A.M. Assylbek.

Penicillium concavorugulosum S. Abe – Kokzhazyk gorge, mixed forest, rhizosphere of *Rosa* spp., 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek; *ibid.*, spruce forest, rhizosphere of *Artemisia* sp., 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova.

Penicillium decumbens Thom – Kolsay gorge, the northern shore of the Lower Kolsay lake, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Sorbus tianschanica*, 1853 m a.s.l., 42°59'27.6" N, 78°19'31.1" E, 27.07.2020, A.M. Assylbek; Botamoinak gorge, floodplain mixed forest, rhizosphere of *Rosa* spp., 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek; *ibid.*, road from

Kudurga to Kurmety gorge, rhizosphere of *Crataegus* spp., 1571 m a.s.l., 43°02'46.6" N, 78°18'34.5" E, 21.08.2020, U.K. Jetigenova; Kokzhazyk gorge, spruce forest, rhizosphere of *Spiraea hypericifolia*, 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova; Tanbaly gorge (lateral branch Kokzhazyk gorge), spruce forest, rhizosphere of *Rosa* spp., 2067 m a.s.l., 43°01'56.4" N, 78°34'44.6" E, 22.08.2020, U.K. Jetigenova; Koldenen gorge, spruce forest, rhizosphere of *Spiraea hypericifolia*, 1836 m a.s.l., 43°02'05.6" N, 78°31'00.0" E, 25.09.2020, Zh. Aitymbet.

Penicillium expansum Link – Taldy gorge, deciduous forest, rhizosphere of *Betula pendula*, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek; Kolsay gorge, west coast of the Upper Kolsay lake, spruce forest, rhizosphere of *Juniperus* spp., 2638 m a.s.l., 42°54'47.0" N, 78°20'41.4" E, 23.08.2020, A.M. Assylbek.

Penicillium fennelliae Stolk – Kayindy gorge, birch forest, rhizosphere of *Picea schrenkiana*, 1734 m a.s.l., 43°00'04.6" N, 78°27'07.3" E, 23.09.2020, G. Sypabekkyzy.

Penicillium glabrum (Wehmer) Westling – Taldy gorge, along the Taldy river, floodplain deciduous forest, *Artemisia* sp. rhizosphere, 1694 m a.s.l., 43°01'33.9" N, 78°15'29.6" E, 26.07.2020, G. Sypabekkyzy; Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Sorbus tianschanica*, 1853 m a.s.l., 42°59'27.6" N, 78°19'31.1" E, 27.07.2020, A.M. Assylbek; *ibid.*, rhizosphere of *Picea schrenkiana*, 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova; Kokzhazyk, mixed forest, rhizosphere of *Salix* spp., 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek; *ibid.*, spruce forest, rhizosphere of *Salix* spp., *Artemisia* sp., 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova; Kayindy gorge, mixed forest, rhizosphere of *Spiraea hypericifolia*, 1687 m a.s.l., 43°00'49.6" N, 78°26'24.7" E, 23.09.2020, Zh. Aitymbet

Penicillium griseofulvum Dierckx – Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Picea schrenkiana*, 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova.

Penicillium herquei Bainier & Sartory – left bank of the Shelek River, riparian forest, rhizosphere of *Betula pendula*, 1441 m a.s.l., 43°04'40.6" N, 78°23'50.0" E, 25.09.2020, G. Sypabekkyzy.

Penicillium implicatum Biourge – Kokzhazyk gorge, spruce forest, rhizosphere of *Picea schrenkiana*, 2208 m

a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova; Kayindy gorge, eastern shore of Kayindy lake, mixed forest, rhizosphere of *Betula pendula*, 1820 m a.s.l., 42°58'55.7" N, 78°27'55.1" E, 23.09.2020, G. Sypabekkyzy.

Penicillium italicum Wehmer – Taldy gorge, deciduous forest, rhizosphere of *Betula pendula*, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek.

Penicillium jensenii K.W. Zaleski – Kolsay gorge, the road from the Middle to the Upper Kolsay, spruce forest, rhizosphere of *Picea schrenkiana*, 2530 m a.s.l., 42°55'04.7" N, 78°20'37.2" E, 23.08.2020, B.Y. Dzhunuskanova.

Penicillium melinii Thom – Kurmety gorge, spruce forest, rhizosphere of *Rosa* spp., 1865 m a.s.l., 42°59'30.8" N, 78°16'44.7" E, 25.07.2020, A.K. Dzhienbekov; Kolsay gorge, deciduous forest, rhizosphere of *Rosa* spp., 1550 m a.s.l., 43°02'33.5" N, 78°20'38.5" E, 23.08.2020, U.K. Jetigenova.

Penicillium nalgiovense Laxa – Kokzhazyk gorge, spruce forest, rhizosphere of *Picea schrenkiana*, *Rosa* spp., 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova; Kolsay gorge, deciduous forest, rhizosphere of *Juniperus* spp., 1550 m a.s.l., 43°02'33.5" N, 78°20'38.5" E, 23.08.2020, U.K. Jetigenova.

Penicillium oxalicum Currie & Thom – Sarybastau gorge, mixed forest, rhizosphere of *Betula pendula*, 1784 m a.s.l., 43°01'59.1" N, 78°13'39.5" E, 21.08.2020, A.M. Assylbek; Kokzhazyk gorge, mixed forest, rhizosphere of *Sorbus tianschanica*, 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek.

Penicillium palitans Westling – Kayindy gorge, eastern shore of Kayindy lake, mixed forest, rhizosphere of *Salix* spp., 1820 m a.s.l., 42°58'55.7" N, 78°27'55.1" E, 23.09.2020, G. Sypabekkyzy.

Penicillium parvum Raper & Fennell (Fig. 1a) – Botamoinak gorge, floodplain mixed forest, rhizosphere of *Juniperus* spp., *Rosa* spp., *Artemisia* sp., *Berberis heteropoda*, *Sorbus tianschanica*, *Picea schrenkiana* 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek; Sarybastau gorge, mixed forest, rhizosphere of *Elaeagnus rhamnoides*, *Artemisia* sp., *Betula pendula*, 1784 m a.s.l., 43°01'59.1" N, 78°13'39.5" E, 21.08.2020, A.M. Assylbek; Kolsay gorge, road from Saty village to Lower Kolsay lake, floodplain deciduous forest, rhizosphere of *Picea schrenkiana*, *Artemisia* sp., 1647 m a.s.l., 43°00'49.4" N, 78°20'33.5" E, 23.08.2020, G. Sypabekkyzy.

Penicillium raperi G. Sm. – Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Populus* spp., 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova.

Penicillium roqueforti Thom – Kolsay gorge, deciduous forest, rhizosphere of *Juniperus* spp., 1550 m a.s.l., 43°02'33.5" N, 78°20'38.5" E, 23.08.2020, U.K. Jetigenova; left bank of the Shelek river, riparian forest, rhizosphere of *Betula pendula*, 1441 m a.s.l., 43°04'40.6" N, 78°23'50.0" E, 25.09.2020, G. Sypabekkyzy.

Penicillium resticulosum Birkinshaw, Raistrick & G. Sm. – Kurmety gorge, spruce forest, rhizosphere of *Rosa* spp., 1865 m a.s.l., 42°59'30.8" N, 78°16'44.7" E, 25.07.2020, A.K. Dzhienbekov.

Penicillium solitum Westling – Kurmety gorge, spruce forest, rhizosphere of *Sorbus tianschanica*, 1827 m a.s.l., 42°59'52.7" N, 78°17'09.0" E, 25.07.2020, Zh. Aitymbet; *ibid.*, rhizosphere of *Betula pendula*, 1865 m a.s.l., 42°59'30.8" N, 78°16'44.7" E, 25.07.2020, A.K. Dzhienbekov.

Penicillium spinulosum Thom – Koldenen gorge, spruce forest, rhizosphere of *Spiraea hypericifolia*, 1836 m a.s.l., 43°02'05.6" N, 78°31'00.0" E, 25.09.2020, Zh. Aitymbet.

Penicillium thomii Maire – Kokzhazyk gorge, spruce forest, *Artemisia* sp. rhizosphere, 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova.

Penicillium velutinum J.F.H. Beyma – Kokzhazyk gorge, spruce forest, *Salix* spp. rhizosphere, 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova.

Penicillium sp. 1. – Kurmety gorge, spruce forest, rhizosphere of *Rosa* spp., 1865 m a.s.l., 42°59'30.8" N, 78°16'44.7" E, 25.07.2020, A.K. Dzhienbekov; Taldy gorge, floodplain deciduous forest, *Artemisia* sp. rhizosphere, 1694 m a.s.l., 43°01'33.9" N, 78°15'29.6" E, 26.07.2020, G. Sypabekkyzy; Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Sorbus tianschanica*, 1853 m a.s.l., 42°59'27.6" N, 78°19'31.1" E, 27.07.2020, A.M. Assylbek; mixed forest, rhizosphere of *Populus* spp., 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova.

Penicillium sp. 2. – Taldy gorge, along the Taldy river, floodplain deciduous forest, 1694 m a.s.l., 43°01'33.9" N, 78°15'29.6" E, 26.07.2020, G. Sypabekkyzy.

Penicillium sp. 3. – Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Populus* spp., 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova.

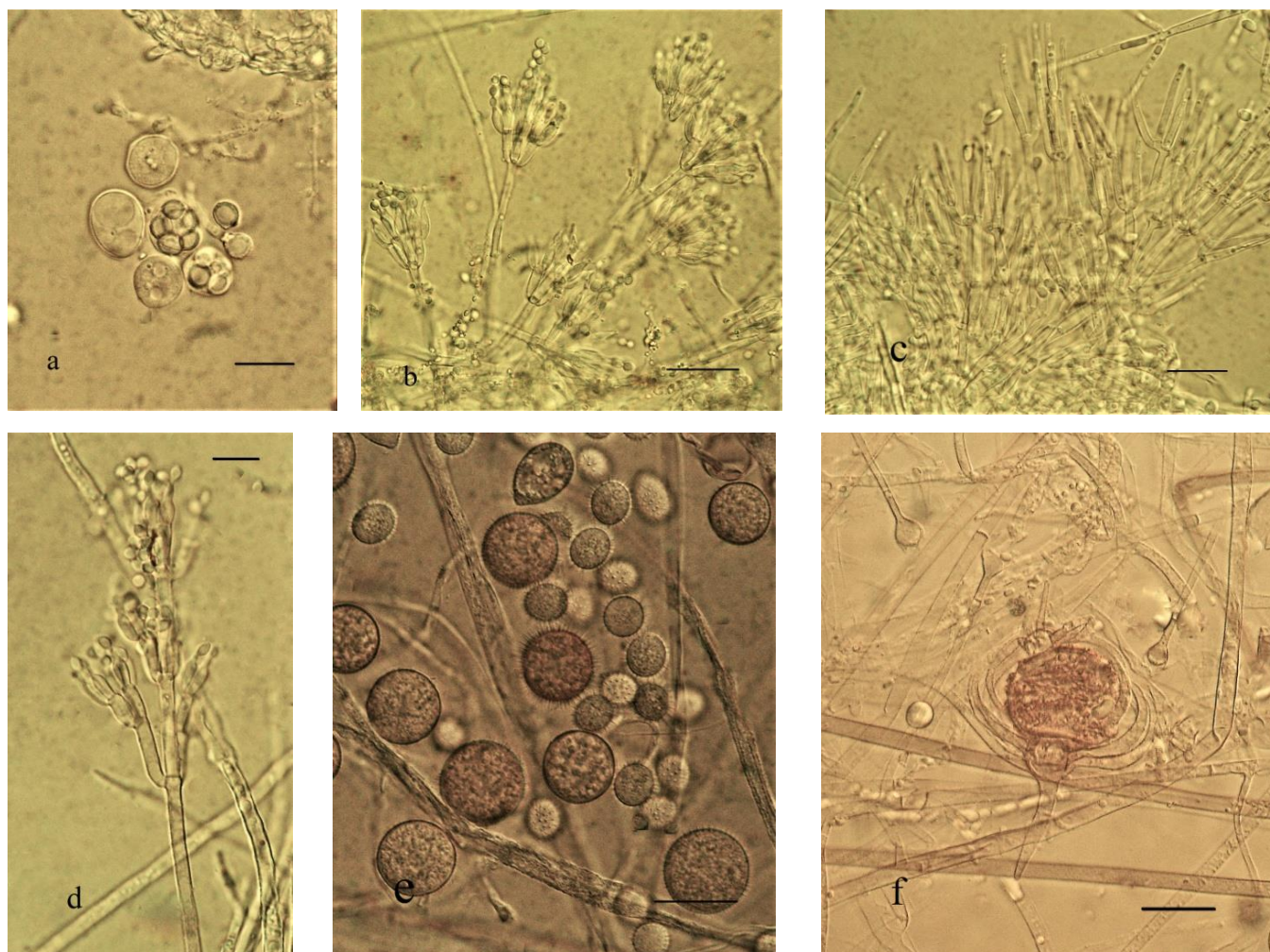


Figure 1. Soil fungi in the Kolsay Kolderi National Park: a – asci with ascospores of *Penicillium parvum*, scale 10 μ m; b – conidiophores of *Talaromyces variabilis*, scale 20 μ m; c – conidiophores of *Metarhizium carneum*, scale 15 μ m; d – conidiophores of *Purpureocillium lilacinum*, scale 10 μ m; e – conidia of *Cunninghamella echinulata*, scale 20 μ m; f – zygote of *Absidia spinosa*, scale 40 μ m.

E, 27.07.2020, A. Imanalinova.

Penicillium sp. 4. – Botamoinak gorge, floodplain mixed forest, *Artemisia* sp. rhizosphere, 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek.

Penicillium sp. 5. – Kokzhazyk gorge, mixed forest, rhizosphere of *Picea schrenkiana*, 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek; Tanbaly gorge, spruce forest, rhizosphere of *Rosa* spp., 2067 m a.s.l., 43°01'56.4" N, 78°34'44.6" E, 22.08.2020, U.K. Jetigenova; Kayindy gorge, northern shore of Kayindy lake, spruce forest, rhizosphere of *Artemisia* sp., 1871 m a.s.l., 42°59'05.0" N, 78°27'52.8" E, 23.09.2020, B.Y. Dzhunuskanova; ibid., spruce forest, rhizosphere of *Artemisia* sp., 1910 m a.s.l., 42°59'18.0"

N, 78°27'40.8" E, 23.09.2020, A.M. Assylbek.

Penicillium sp. 6. – Kurmety gorge, rhizosphere of *Spiraea hypericifolia*, 1571 m a.s.l., 43°02'46.6" N, 78°18'34.5" E, 21.08.2020, U.K. Jetigenova.

Penicillium sp. 7. – Kokzhazyk gorge, spruce forest, rhizosphere of *Spiraea hypericifolia*, 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova.

Penicillium sp. 8. – Tanbaly gorge, spruce forest, rhizosphere of *Rosa* spp., 2067 m a.s.l., 43°01'56.4" N, 78°34'44.6" E, 22.08.2020, U.K. Jetigenova.

Penicillium sp. 10 – Kayindy gorge, northern shore of Kayindy lake, spruce forest, rhizosphere of *Artemisia* sp., 1871 m a.s.l., 42°59'05.0" N, 78°27'52.8" E, 23.09.2020, B.Y. Dzhunuskanova.

Talaromyces duclauxii (Delacr.) Samson, N. Yilmaz, Frisvad & Seifert – Taldy gorge, along the Taldy river, floodplain deciduous forest, rhizosphere of *Rosa* spp., 1694 m a.s.l., 43°01'33.9" N, 78°15'29.6" E, 26.07.2020, G. Sypabekkyzy; Saty gorge, spruce forest, *Artemisia* sp. rhizosphere, 1991 m a.s.l., 42°53'27.6" N, 78°23'49.8" E, 22.08.2020, G. Sypabekkyzy; Kayindy gorge, mixed forest, rhizosphere of *Spiraea hypericifolia*, 1687 m a.s.l., 43°00'49.6" N, 78°26'24.7" E, 23.09.2020, Zh. Aitymbet; Kolsay gorge, the road from the Middle to the Upper Kolsay, spruce forest, rhizosphere of *Artemisia* sp., 2530 m a.s.l., 42°55'04.7" N, 78°20'37.2" E, 23.08.2020, B.Y. Dzhunuskanova.

Talaromyces purpleogenus Samson, N. Yilmaz, Houbraken, Spierenb., Seifert, Peterson, Varga & Frisvad – Kayindy gorge, eastern shore of Kayindy lake, mixed forest, rhizosphere of *Salix* spp., 1820 m a. s. l., 42°58'55.7" N, 78°27'55.1" E, 23.09.2020, G. Sypabekkyzy

Talaromyces ruber (Stoll) N. Yilmaz, Houbraken, Frisvad & Samson – Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Prunus armeniaca*, 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova

Talaromyces rugulosus (Thom) Samson, N. Yilmaz, Frisvad & Seifert – Taldy gorge, floodplain deciduous forest, rhizosphere of *Rosa* spp., 1694 m a.s.l., 43°01'33.9" N, 78°15'29.6" E, 26.07.2020, G. Sypabekkyzy; Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Sorbus tianschanica*, 1853 m a.s.l., 42°59'27.6" N, 78°19'31.1" E, 27.07.2020, A.M. Assylbek; *ibid.*, mixed forest, rhizosphere of *Populus* spp., *Prunus armeniaca*, *Juniperus* spp., 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova; Botamoinak gorge, floodplain mixed forest, rhizosphere of *Sorbus tianschanica*, 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek; Kokzhazyk gorge, spruce forest, rhizosphere of *Picea schrenkiana*, 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova; left bank of the Shelek River, Suyk tugay, rhizosphere of *Rosa* spp., 1655 m a.s.l., 43°23'33.9" N, 78°48'40.03" E, 25.09.2020, A.M. Assylbek; Kolsay gorge, road from Saty village to Lower Kolsay lake, floodplain deciduous forest, rhizosphere of *Artemisia* sp., *Salix* spp., 1647 m a.s.l., 43°00'49.4" N, 78°20'33.5" E, 23.08.2020, G. Sypabekkyzy; *ibid.*, the road from the Middle to the Upper Kolsay, spruce forest, 2530 m a.s.l., 42°55'04.7" N, 78°20'37.2" E, 23.08.2020, B.Y. Dzhunuskanova.

Talaromyces variabilis (Sopp) Samson, N. Yilmaz,

Frisvad & Seifert (Fig. 1b) – Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Sorbus tianschanica*, 1853 m a.s.l., 42°59'27.6" N, 78°19'31.1" E, 27.07.2020, A.M. Assylbek; *ibid.*, mixed forest, rhizosphere of *Populus* spp., *Juniperus* spp., 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova; Saty gorge, spruce forest, rhizosphere of *Ribes meyeri*, 1991 m a.s.l., 42°53'27.6" N, 78°23'49.8" E, 22.08.2020, G. Sypabekkyzy; Koldenen gorge, spruce forest, rhizosphere of *Rosa* spp., 1836 m a.s.l., 43°02'05.6" N, 78°31'00.0" E, 25.09.2020, Zh. Aitymbet.

Talaromyces varians (G. Sm.) Samson, N. Yilmaz & Frisvad – Kokzhazyk gorge, mixed forest, rhizosphere of *Picea schrenkiana*, 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek.

Leotiomycetes O.E. Erikss. & Winka

Helotiales Nannf. ex Korf & Lizon

PLOETTNERULACEAE Kirschst.

Cadophora fastigiata Lagerb. & Melin – Botamoinak gorge, floodplain mixed forest, rhizosphere of *Rosa* spp., 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek.

SCLEROTINIACEA Whetzel

Monilia sp. – Saty gorge, floodplain mixed forest, rhizosphere of *Berberis heteropoda*, 1884 m a.s.l., 43°02'41.4" N, 78°24'25.2" E, 20.08.2020, A.M. Assylbek.

Sordariomycetes O.E. Erikss. & Winka

Cordanales Hern.-Restr. & Crous

CORDANACEAE Nann.

Cordana bisbyi (Timonin) Hern.-Restr., Gené & Guarro – Koldenen gorge, spruce forest, rhizosphere of *Spiraea hypericifolia*, 1836 m a.s.l., 43°02'05.6" N, 78°31'00.0" E, 25.09.2020, Zh. Aitymbet.

Hypocreales Lindau

INSERTAE SEDIS

Acronium vitis Catt. – left bank of the Shelek River, Suyk tugay, rhizosphere of *Rosa* spp., 1655 m a.s.l., 43°23'33.9" N, 78°48'40.03" E, 25.09.2020, A.M. Assylbek; Kolsay gorge, road from Saty village to Lower Kolsay lake, floodplain deciduous forest, rhizosphere of *Picea schrenkiana*, 1647 m a.s.l., 43°00'49.4" N, 78°20'33.5" E, 23.08.2020, G. Sypabekkyzy.

Cephalosporium coremioides Raillo – Kolsay gorge,

road from Saty village to Lower Kolsay lake, floodplain deciduous forest, rhizosphere of *Salix* spp., 1647 m a.s.l., 43°00'49.4" N, 78°20'33.5" E, 23.08.2020, G. Sypabekkyzy; *ibid.*, the road from the Middle to the Upper Kolsay, spruce forest, rhizosphere of *Sorbus tianschanica*, 2530 m a.s.l., 42°55'04.7" N, 78°20'37.2" E, 23.08.2020, B.Y. Dzhunuskanova.

Cephalosporium glutineum Kamyschko – Koldenen gorge, spruce forest, rhizosphere of *Rosa* spp., 1836 m a.s.l., 43°02'05.6" N, 78°31'00.0" E, 25.09.2020, Zh. Aitymbet.

Cephalosporium terricola Kamyschko – Kokzhazyk gorge, mixed forest, rhizosphere of *Picea schrenkiana*, 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek; Saty gorge, spruce forest, rhizosphere of *Ribes meyeri*, 1991 m a.s.l., 42°53'27.6" N, 78°23'49.8" E, 22.08.2020, G. Sypabekkyzy.

Geosmithia putterillii (Thom) Pitt – Taldy gorge, along the Taldy river, floodplain deciduous forest, rhizosphere of *Sorbus tianschanica*, 1694 m a.s.l., 43°01'33.9" N, 78°15'29.6" E, 26.07.2020, G. Sypabekkyzy.

CLAVICIPITACEAE O.E. Erikss.

Metarhizium carneum (Duché & R. Heim) Kepler, S.A. Rehner & Humber (Fig. 1c) – Kurmety gorge, spruce forest, rhizosphere of *Betula pendula*, 1827 m a.s.l., 42°59'52.7" N, 78°17'09.0" E, 25.07.2020, Zh. Aitymbet; Taldy gorge, deciduous forest, rhizosphere of *Juniperus* spp., *Artemisia* sp., *Spiraea hypericifolia*, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek; *ibid.*, aspen forest, rhizosphere of *Juniperus* spp., 1677 m a.s.l., 43°01'42.8" N, 78°15'29.8" E, 26.07.2020, G. Sypabekkyzy; Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Malus sieversii*, 1853 m a.s.l., 42°59'27.6" N, 78°19'31.1" E, 27.07.2020, A.M. Assylbek; *ibid.*, rhizosphere of *Prunus armeniaca*, *Populus* spp., 1865 m a.s.l., 42°59'18.2" N, 78°19'36.3" E, 27.07.2020, A. Imanalinova; Saty gorge, floodplain mixed forest, rhizosphere of *Spiraea hypericifolia*, *Artemisia* sp., 1884 m a.s.l., 43°02'41.4" N, 78°24'25.2" E, 20.08.2020, A.M. Assylbek; Botamoinak gorge, spruce forest, rhizosphere of *Rosa* spp., 1859 m a.s.l., 43°01'52.2" N, 78°13'06.3" E, 21.08.2020, A.M. Assylbek; *ibid.*, floodplain mixed forest, rhizosphere of *Spiraea hypericifolia*, *Ephedra* spp., *Artemisia* sp., 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek; Sarybastau gorge, mixed forest, rhizosphere of *Juniperus* spp., 1784 m a.s.l., 43°01'59.1" N, 78°13'39.5" E, 21.08.2020, A.M.

Assylbek; *ibid.*, road from Kudurga to Kurmety gorge, rhizosphere of *Elaeagnus rhamnoides*, *Salix* spp., 1571 m a.s.l., 43°02'46.6" N, 78°18'34.5" E, 21.08.2020, U.K. Jetigenova; Kokzhazyk gorge, spruce forest, rhizosphere of *Spiraea hypericifolia*, 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova; Kayindy gorge, spruce forest, rhizosphere of *Artemisia* sp., 1910 m a.s.l., 42°59'18.0" N, 78°27'40.8" E, 23.09.2020, A.M. Assylbek; *ibid.*, northern shore of Kayindy lake, spruce forest, rhizosphere of *Artemisia* sp., 1871 m a.s.l., 42°59'05.0" N, 78°27'52.8" E, 23.09.2020, B.Y. Dzhunuskanova.

CORDYCIPTACEAE Kreisel ex G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora

Samsoniella alboaurantia (G. Sm.) Mongkols., Noisrip., Thanakitp., Spatafora & Luangsaard – Kolsay gorge, road from Saty village to Lower Kolsay lake, floodplain deciduous forest, rhizosphere of *Elaeagnus rhamnoides*, 1647 m a.s.l., 43°00'49.4" N, 78°20'33.5" E, 23.08.2020, G. Sypabekkyzy; *ibid.*, the road from the Middle to the Upper Kolsay, spruce forest, rhizosphere of *Artemisia* sp., 2530 m a.s.l., 42°55'04.7" N, 78°20'37.2" E, 23.08.2020, B.Y. Dzhunuskanova.

HYPOCREACEAE De Not.

Acrostalagmus albus Preuss – Kolsay gorge, the road from the Middle to the Upper Kolsay, spruce forest, rhizosphere of *Sorbus tianschanica*, 2530 m a.s.l., 42°55'04.7" N, 78°20'37.2" E, 23.08.2020, B.Y. Dzhunuskanova.

Pachybasium terricola Kamyschko – Kokzhazyk gorge, birch forest, rhizosphere of *Sorbus tianschanica*, 2210 m a.s.l., 43°00'24.9" N, 78°34'53.4" E, 22.08.2020, A.K. Dzhienbekov.

Trichoderma aureoviride Rifai – Kurmety gorge, spruce forest, rhizosphere of *Betula pendula*, 1865 m a.s.l., 42°59'30.8" N, 78°16'44.7" E, 25.07.2020, A.K. Dzhienbekov.

Trichoderma harzianum Rifai – Taldy gorge, along the Taldy river, floodplain deciduous forest, rhizosphere of *Sorbus tianschanica*, 1694 m a.s.l., 43°01'33.9" N, 78°15'29.6" E, 26.07.2020, G. Sypabekkyzy; Kolsay gorge, west coast of the Upper Kolsay lake, spruce forest, rhizosphere of *Ribes meyeri*, 2638 m a.s.l., 42°54'47.0" N, 78°20'41.4" E, 23.08.2020, A.M. Assylbek.

Trichoderma koningii Oudem. – Taldy gorge, along the Taldy river, floodplain deciduous forest, *Artemisia* sp. rhizosphere, 1694 m a.s.l., 43°01'33.9" N, 78°15'29.6" E, 26.07.2020, G. Sypabekkyzy.

Trichoderma polysporum (Link) Rifai – Kurmety gorge, spruce forest, *Artemisia* sp. rhizosphere, 1827 m a.s.l., 42°59'52.7" N, 78°17'09.0" E, 25.07.2020, Zh. Aitymbet; *ibid.*, *Salix* spp. rhizosphere, 1865 m a.s.l., 42°59'30.8" N, 78°16'44.7" E, 25.07.2020, A.K. Dzhienbekov; Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Malus sieversii*, 1853 m a.s.l., 42°59'27.6" N, 78°19'31.1" E, 27.07.2020, A.M. Assylbek; Botamoinak gorge, spruce forest, rhizosphere of *Rosa* spp., *Ephedra* spp., 1859 m a.s.l., 43°01'52.2" N, 78°13'06.3" E, 21.08.2020, A.M. Assylbek.

Trichoderma viride Pers. – Kurmety gorge, spruce forest, rhizosphere of *Picea schrenkiana*, 1810 m a.s.l., 43°00'25.2" N, 78°17'05.4" E, 25.07.2020, A.M. Assylbek; Taldy gorge, deciduous forest, *Salix* spp. rhizosphere, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek; *ibid.*, aspen forest, rhizosphere of *Berberis heteropoda*, 1677 m a.s.l., 43°01'42.8" N, 78°15'29.8" E, 26.07.2020, G. Sypabekkyzy; Kolsay gorge, the northern shore of the Lower Kolsay lake, mixed forest, rhizosphere of *Sorbus tianschanica*, 1853 m a.s.l., 42°59'27.6" N, 78°19'31.1" E, 27.07.2020, A.M. Assylbek; Saty gorge, floodplain mixed forest, rhizosphere of *Spiraea hypericifolia*, 1884 m a.s.l., 43°02'41.4" N, 78°24'25.2" E, 20.08.2020, A.M. Assylbek; road from Kudurga to Kurmety gorge, rhizosphere of *Spiraea hypericifolia*, 1571 m a.s.l., 43°02'46.6" N, 78°18'34.5" E, 21.08.2020, U.K. Jetigenova; Kokzhazyk gorge, mixed forest, rhizosphere of *Artemisia* sp., *Picea schrenkiana*, *Rosa* spp., *Salix* spp., 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek; *ibid.*, spruce forest, *Artemisia* sp. rhizosphere, 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova; Koldenen gorge, spruce forest, rhizosphere of *Spiraea hypericifolia*, 1836 m a.s.l., 43°02'05.6" N, 78°31'00.0" E, 25.09.2020, Zh. Aitymbet; Kolsay gorge, northern slope in the vicinity of the Upper Kolsay lake, spruce forest, rhizosphere of *Rosa* spp., 2050 m a.s.l., 42°55'15.6" N, 78°21'28.8" E, 23.08.2020, A.M. Assylbek.

Trichoderma sp. – Taldy gorge, along the Taldy river, floodplain deciduous forest, rhizosphere of *Spiraea hypericifolia*, 1694 m a.s.l., 43°01'33.9" N, 78°15'29.6" E, 26.07.2020, G. Sypabekkyzy.

NECTRIACEAE Tul. & C. Tul.

Fusarium solani (Mart.) Sacc (*F. javanicum*) – Kayindy gorge, spruce forest, rhizosphere of *Juniperus* spp., 1910 m a.s.l., 42°59'18.0" N, 78°27'40.8" E, 23.09.2020, A.M. Assylbek.

Fusarium sp. – Taldy gorge, deciduous forest, *Artemisia* sp. rhizosphere, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek.

Fusarium sp. 1. – Taldy gorge, deciduous forest, *Artemisia* sp. rhizosphere, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek; Saty gorge, floodplain mixed forest, *Artemisia* sp. rhizosphere, 1884 m a.s.l., 43°02'41.4" N, 78°24'25.2" E, 20.08.2020, A.M. Assylbek; Botamoinak gorge, spruce forest, rhizosphere of *Sorbus tianschanica*, 1859 m a.s.l., 43°01'52.2" N, 78°13'06.3" E, 21.08.2020, A.M. Assylbek; *ibid.*, floodplain mixed forest, rhizosphere of *Ephedra* spp., *Artemisia* sp., 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek; Sarybastau gorge, mixed forest, rhizosphere of *Elaeagnus rhamnoides*, 1784 m a.s.l., 43°01'59.1" N, 78°13'39.5" E, 21.08.2020, A.M. Assylbek.

Fusarium sp. 2 – Kayindy gorge, northern shore of Kayindy lake, spruce forest, rhizosphere of *Rosa* spp., 1871 m a.s.l., 42°59'05.0" N, 78°27'52.8" E, 23.09.2020, B.Y. Dzhunuskanova; left bank of the Shelek River, Suyk tugay, rhizosphere of *Rosa* spp., 1655 m a.s.l., 43°23'33.9" N, 78°48'40.03" E, 25.09.2020, A.M. Assylbek.

OPHIOCORDYCIPTACEAE G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora

Purpureocillium lilacinum (Thom) Luangsa-ard, Houbraken, Hywel-Jones & Samson (Fig. 1d) – Taldy gorge, deciduous forest, rhizosphere of *Salix* spp., *Betula pendula*, *Artemisia* sp., *Rosa* spp., *Berberis heteropoda*, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek; aspen forest, rhizosphere of *Populus* spp., *Berberis heteropoda*, *Spiraea hypericifolia*, 1677 m a.s.l., 43°01'42.8" N, 78°15'29.8" E, 26.07.2020, G. Sypabekkyzy; Saty gorge, spruce forest, rhizosphere of *Rosa* spp., *Artemisia* sp., *Sorbus tianschanica*, 1914 m a.s.l., 42°53'31.4" N, 78°23'59.2" E, 20.08.2020, U.K. Jetigenova; *ibid.*, floodplain mixed forest, *Artemisia* sp. rhizosphere, 1884 m a.s.l., 43°02'41.4" N, 78°24'25.2" E, 20.08.2020, A.M. Assylbek; Botamoinak gorge, spruce forest, rhizosphere of *Rosa* spp., *Sorbus tianschanica*, *Spiraea hypericifolia*, *Salix* spp., *Ephedra* spp., 1859 m a.s.l., 43°01'52.2" N, 78°13'06.3" E, 21.08.2020, A.M. Assylbek; *ibid.*, floodplain mixed forest, rhizosphere of *Rosa* spp., *Artemisia* sp., *Berberis heteropoda*, *Sorbus tianschanica*, 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek; Sarybastau gorge, mixed forest, rhizosphere of *Elaeagnus rhamnoides*, *Betula pendula*, 1784 m a.s.l., 43°01'59.1" N, 78°13'39.5" E,

21.08.2020, A.M. Assylbek; *ibid.*, road from Kudurga to Kurmety gorge, rhizosphere of *Salix* spp., *Crataegus* spp., *Lonicera* spp., *Spiraea hypericifolia*, *Artemisia* sp., 1571 m a.s.l., 43°02'46.6" N, 78°18'34.5" E, 21.08.2020, U.K. Jetigenova; Kokzhazyk gorge, mixed forest, rhizosphere of *Salix* spp., *Picea schrenkiana*, *Sorbus tianschanica*, 1576 m a.s.l., 43°00'13.3" N, 78°34'49.1" E, 22.08.2020, A.M. Assylbek; *ibid.*, spruce forest, rhizosphere of *Spiraea hypericifolia*, *Picea schrenkiana*, 2208 m a.s.l., 43°00'05.1" N, 78°34'43.1" E, 22.08.2020, U.K. Jetigenova; road from Saty village to Lower Kolsay lake, deciduous forest, rhizosphere of *Rosa* spp., 1550 m a.s.l., 43°02'33.5" N, 78°20'38.5" E, 23.08.2020, U.K. Jetigenova; Kayindy gorge, spruce forest, rhizosphere of *Salix* spp., 1910 m a.s.l., 42°59'18.0" N, 78°27'40.8" E, 23.09.2020, A.M. Assylbek; *ibid.*, northern shore of Kayindy lake, spruce forest, rhizosphere of *Artemisia* sp., 1871 m a.s.l., 42°59'05.0" N, 78°27'52.8" E, 23.09.2020, B.Y. Dzhunuskanova; *ibid.*, eastern shore of Kayindy lake, mixed forest, rhizosphere of *Picea schrenkiana*, 1820 m a.s.l., 42°58'55.7" N, 78°27'55.1" E, 23.09.2020, G. Sypabekkyzy; *ibid.*, birch forest, rhizosphere of *Picea schrenkiana*, 1734 m a.s.l., 43°00'04.6" N, 78°27'07.3" E, 23.09.2020, G. Sypabekkyzy; Karabulak gorge, spruce forest, rhizosphere of *Sorbus tianschanica*, 2130 m a.s.l., 43°00'43.5" N, 78°31'12.7" E, 24.09.2020, B.Y. Dzhunuskanova; *ibid.*, spruce forest, rhizosphere of *Rosa* spp., *Picea schrenkiana*, 2180 m a.s.l., 43°00'29.2" N, 78°31'01.3" E, 24.09.2020, E.S. Sametova; Koldenen gorge, spruce forest, rhizosphere of *Salix* spp., 1890 m a.s.l., 43°01'30.3" N, 78°31'24.0" E, 24.09.2020, B.Y. Dzhunuskanova; *ibid.*, rhizosphere of *Rosa* spp., *Sorbus tianschanica*, *Spiraea hypericifolia*, 1836 m a.s.l., 43°02'05.6" N, 78°31'00.0" E, 25.09.2020, Zh. Aitymbet; Kolsay gorge, road from Saty village to Lower Kolsay lake, floodplain deciduous forest, rhizosphere of *Juniperus* spp., *Salix* spp., *Artemisia* sp., *Populus* spp., 1647 m a.s.l., 43°00'49.4" N, 78°20'33.5" E, 23.08.2020, G. Sypabekkyzy; *ibid.*, the road from the Middle to the Upper Kolsay, spruce forest, rhizosphere of *Sorbus tianschanica*, *Ribes meyeri*, 2530 m a.s.l., 42°55'04.7" N, 78°20'37.2" E, 23.08.2020, B.Y. Dzhunuskanova.

Sordariales Chadev. ex D. Hawksw. & O.E. Erikss.

CHAETOMIACEAE G. Winter

Humicola nigrescens Omvik – Saty gorge, spruce forest, rhizosphere of *Sorbus tianschanica*, *Rosa* spp., 1914 m a.s.l., 42°53'31.4" N, 78°23'59.2" E, 20.08.2020, U.K. Jetigenova.

Xylariales Nannf.

HYPOXYLACEAE DC.

Nodulisporium africanum G. Sm. – Karabulak gorge, spruce forest, rhizosphere of *Rosa* spp., 2180 m a.s.l., 43°00'29.2" N, 78°31'01.3" E, 24.09.2020, E.S. Sametova.

Zygomycota Moreau

Mucorales Dumort.

CUNNINGHAMELLACEAE Naumov ex R.K. Benj.

Cunninghamella echinulata (Thaxt.) Thaxt. ex Blakeslee (Fig. 1e) – Taldy gorge, deciduous forest, *Artemisia* sp. rhizosphere, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek; Botamoinak gorge, floodplain mixed forest, rhizosphere of *Artemisia* sp., *Caragana* spp., 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek.

LICHTHEIMIACEAE Kerst. Hoffm., Walther & K. Voigt

Lichtheimia corymbifera (Cohn) Vuill. – Taldy gorge, aspen forest, rhizosphere of *Populus tremula*, 1677 m a.s.l., 43°01'42.8" N, 78°15'29.8" E, 26.07.2020, G. Sypabekkyzy; Botamoinak gorge, floodplain mixed forest, rhizosphere of *Ephedra* spp., 1774 m a.s.l., 43°01'51.6" N, 78°13'07.8" E, 21.08.2020, A.M. Assylbek; Sarybastau gorge, mixed forest, *Artemisia* sp. rhizosphere, 1784 m a.s.l., 43°01'59.1" N, 78°13'39.5" E, 21.08.2020, A.M. Assylbek.

MUCORACEAE Dumort.

Absidia spinosa Lendn. (Fig 1f) – Taldy gorge, deciduous forest, rhizosphere of *Juniperus* spp., *Artemisia* sp., *Populus tremula*, *Crataegus* spp., *Spiraea hypericifolia*, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek; *ibid.*, aspen forest, rhizosphere of *Juniperus* spp., 1677 m a.s.l., 43°01'42.8" N, 78°15'29.8" E, 26.07.2020, G. Sypabekkyzy; Saty gorge, spruce forest, *Artemisia* sp. rhizosphere, 1914 m a.s.l., 42°53'31.4" N, 78°23'59.2" E, 20.08.2020, U.K. Jetigenova; Botamoinak gorge, spruce forest, rhizosphere of *Salix* spp., *Ephedra* spp., 1859 m a.s.l., 43°01'52.2" N, 78°13'06.3" E, 21.08.2020, A.M. Assylbek; Kayindy gorge, eastern shore of Kayindy lake, mixed forest, rhizosphere of *Artemisia* sp., 1820 m a.s.l., 42°58'55.7" N, 78°27'55.1" E, 23.09.2020, G. Sypabekkyzy.

Mucor mucedo Fresen. – Taldy gorge, deciduous forest, rhizosphere of *Betula pendula*, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek; *ibid.*,

aspen forest, rhizosphere of *Berberis heteropoda*, 1677 m a.s.l., 43°01'42.8" N, 78°15'29.8" E, 26.07.2020, G. Sypabekkyzy; Saty gorge, spruce forest, *Artemisia* sp. rhizosphere, 1914 m a.s.l., 42°53'31.4" N, 78°23'59.2" E, 20.08.2020, U.K. Jetigenova; Botamoinak gorge, spruce forest, rhizosphere of *Sorbus tianschanica*, *Salix* spp., *Ephedra* spp., 1859 m a.s.l., 43°01'52.2" N, 78°13'06.3" E, 21.08.2020, A.M. Assylbek; Sarybastau gorge, mixed forest, *Artemisia* sp. rhizosphere, 1784 m a.s.l., 43°01'59.1" N, 78°13'39.5" E, 21.08.2020, A.M. Assylbek.

Zoopagomycetes Doweld

Zoopagales Bessey ex R.K. Benj.

PIPTOCEPHALIDACEAE J. Schröt.

Piptocephalis cylindrospora Bainier – Taldy gorge, deciduous forest, rhizosphere of *Populus tremula*, 1677 m a.s.l., 43°01'56.7" N, 78°15'19.2" E, 26.07.2020, A.M. Assylbek; *ibid.*, aspen forest, rhizosphere of *Juniperus* spp., 1677 m a.s.l., 43°01'42.8" N, 78°15'29.8" E, 26.07.2020, G. Sypabekkyzy.

The genera *Penicillium* (31 species, 8 *Penicillium* sp.), *Aspergillus* (12), *Trichoderma* (5 species, 1 *Trichoderma* sp.), and *Talaromyces* (6) were the most numerous, 1-4 species were found in the remaining genera. It should be noted that *Penicillium* is the dominant genus in rather rich forest soil in the Kolsay Kolderi National Park, as well as in soil of small-leaved, mixed, and coniferous forests of the Russian Far East [Egorova, Kovaleva, 2012; Egorova et al., 2013] and the European part of Russia [Kurakov & Semenova 2016]. Significant numbers of *Penicillium* were also found

in soil of Turkey [Asan, Ekmekci, 1994; Asan, 2000; 2004], particularly in forest soils of Edirne Söğütlük –12 species [Kolanlarli et al., 2019].

The greatest number of species of soil fungi was characteristic of the rhizosphere of *Artemisia* sp. – 28 species and *Rosa* spp. – 27 species (Fig. 2).

Somewhat fewer species were found in the rhizosphere of spruce (*Picea schrenkiana*) – 21 species, *Sorbus tianschanica* (19 species), *Spiraea hypericifolia* – 18 species, *Juniperus* spp. and *Salix* spp. – 17 species each.

In the rhizosphere of *Betula pendula*, *Ephedra* spp., *Populus* spp., *Berberis heteropoda* from 8 to 11 species of soil micromycetes were recorded, in the rhizosphere of *Crataegus* spp., *Elaeagnus rhamnoides*, *Prunus armeniaca*, *Ribes meyeri* – 4-6 species, in the rhizosphere of *Lonicera* spp., *Malus sieversii*, *Populus tremula* – 2-3 species. Only one representative of soil fungi was found in the rhizosphere of *Caragana* sp.

The greatest number of species of soil fungi was registered in Kolsay, Taldy and Kokzhazyk gorges with a lateral gorge Tanbaly (Fig. 3).

It should be noted that representatives of the class Eurotiomycetes dominate in all gorges except Taldy, Karabulak and Saty. Species of the class Sordariomycetes are recorded in all gorges, but only in the Karabulak and Saty gorges they make up 60-66% of the total number of species, and in the Taldy gorge – 39%. Representatives of Zygomycota were recorded only in the Saty and Taldy gorges and in the lateral gorges of the Kudurga gorge – Botamoinak and Sarybastau.

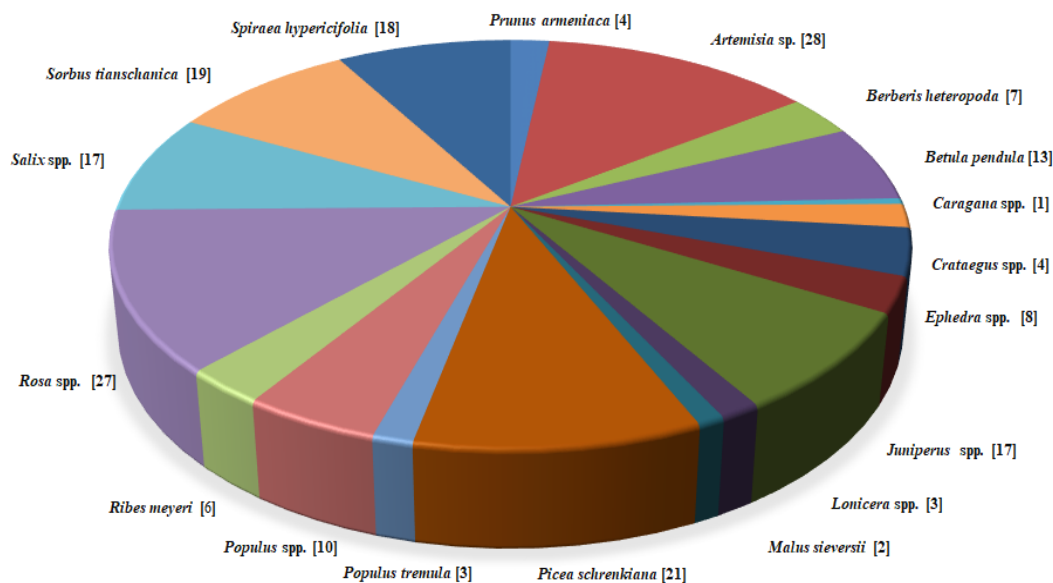


Figure 2. Fungal biodiversity of soil fungi in the rhizosphere of various plants.

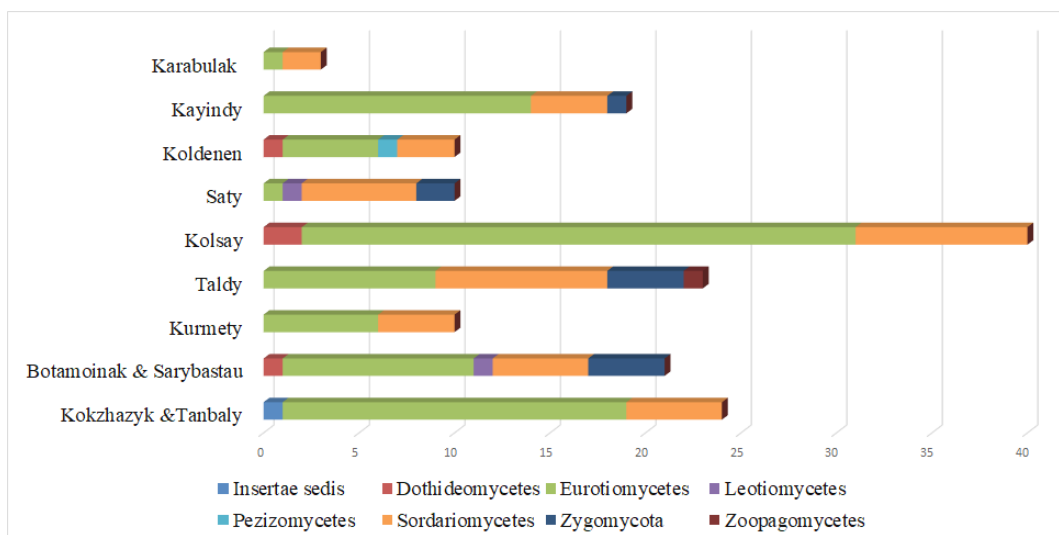


Figure 3. The number of species and the species composition of soil fungi in different gorges.

In general, the classes Eurotiomycetes and Sordariomycetes classes were in Kurmety and Karabulak gorges 100%, Kokzhazyk with lateral branch Tanbaly – 96%, Kolsay and Kayindy – 95%, Koldenen – 80%, Taldy – 78%, in lateral branches of Kudurga gorge (Botamoinak and Sarybastau) – 71%, Saty – 70%. Representatives of the class Leotiomycetes were found in the Saty gorge and in the lateral branches of the Kudurga gorge; a species of the class Zoopagomycetes (*Piptocephalis cylindrospora*) – in the Taldy gorge, a representative of the class Dothideomycetes (*Alternaria* sp.) – in the lateral branches of the Kudurga gorge.

Metarhizium carneum, *Purpureocillium lilacinum*, *Aspergillus niger*, *Talaromyces rugulosus*, *Trichoderma viride* were the most common species found in all or most gorges.

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Kolsay Kolderi Milli Parkında (Qazaxıstan) torpaq göbələklərinin növ tərkibi və yayılması

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Məqalə Kolsay Kolderi Milli parkında (Qazaxıstan) torpaq göbələklərinin növ tərkibi və yayılmasının öyrənilməsinə həsr edilmişdir. Tədqiqat zamanı torpaq mikromisetlərinin 7 sinfə, 9 sıraya, 16 fəsilə və 27 cinsə aid 91 növü müəyyən edilmişdir. *Penicillium* (39 növ), *Aspergillus* (12), *Trichoderma* (6) və *Talaromyces* (6) cinsləri çoxsaylı, digər cinslər isə 1-4 nöllə təmsil olunmuşdur. Torpaq göbələklərinin ən çox növü *Artemisia* sp. – 28 növ və *Rosa* spp. – 27 növ rizosfer üçün xarakterik olmuşdur. Digərlərindən isə *Picea schrenkiana* – 21 növ, *Sorbus tianschanica* – 19 növ, *Spiraea hypericifolia* – 18 növ, *Juniperus* spp. və *Salix* spp. hər birində 17 növə rast gəlinmişdir. Ən çox torpaq göbələk növləri Kolsay, Taldı və Kökjazıq və Tanbalı dərələrində qeydə alınıb. Eurotiomycetes və Sordariomycetes sinifləri Kurmeti və Karabulak dərələrində 100 %, Tanbalı dərəsi ilə Kökjazıq – 96 %, Kolsay və Kaindı – 95 %, Koldenen – 80 %, Taldı – 78 %, Kudurginsky dərəsinin yan şaxələrinə (Botamoynak) – Sarıbastu 71 %, Satı – 70 % təşkil etmişdir. *Metarhizium carneum*, *Purpureocillium lilacinum*, *Aspergillus niger*, *Talaromyces rugulosus*, *Trichoderma virid* növləri hər yerdə və ya əksər yarpaqlarda ən çox yayılmış növlər olmuşdur.

Açar sözlər: bioseno, Kungey Alatau silsiləsi, mikrobiota, mikromiset, rizosfer

Видовой состав и распространение почвенных грибов в Национальном парке Кольсай Колдери (Казахстан)

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Статья посвящена изучению видового состава и распространения почвенных грибов в Национальном парке Колсай Колдери (Казахстан). В ходе исследований выявлен 91 вид почвенных микромицетов, относящихся к 7 классам, 9 порядкам, 16 семействам и 27 родам. Наиболее многочисленными были роды *Penicillium* (39 видов), *Aspergillus* (12), *Trichoderma* (6) и *Talaromyces* (6), в остальных родах обнаружено 1-4 вида. Наибольшее количество видов почвенных грибов было характерно для ризосферы *Artemisia* sp. – 28 видов и *Rosa* spp. – 27 видов. Несколько меньше видов было обнаружено в ризосфере ели *Picea schrenkiana* – 21 вид, *Sorbus tianschanica* – 19 видов, *Spiraea hypericifolia* – 18 видов, *Juniperus* spp. и *Salix* spp. – 17 видов. Наибольшее количество видов почвенных грибов зарегистрировано в ущельях Колсай, Талды, Кокжызык и Танбалы. Классы Eurotiomycetes и Sordariomycetes составили в ущельях Курмети и Карабулак 100%, Кокжызык с боковым ответвлением Танбалы – 96%, Колсай и Кайнды – 95%, Колденен – 80%, Талды – 78%, в боковых ответвлениях Кудургинского ущелья (Ботамойнак и Сарыбастау) – 71%, Саты – 70%. *Metarhizium carneum*, *Purpureocillium lilacinum*, *Aspergillus niger*, *Talaromyces rugulosus*, *Trichoderma viride* были наиболее распространенными видами, найденными во всех или большинстве ущелий.

Ключевые слова: биоценоз, хребет Кунгей Алатау, микобиота, микромицет, ризосфера