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New data on myxomycete diversity of the Republic of Tatarstan (Russia)

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Abstract. A checklist is provided for species of myxomycetes found in the Republic of Tatarstan (Russia), including new records from the Volzhsko-Kamsky Reserve and the outskirts of the city of Kazan. The annotated list includes 85 species found by the authors, of which 77 were recorded in the field (484 specimens) and 17 — from moist chamber cultures (117 specimens). Sixty-seven species were found only in the field, and eight species were obtained only in moist chamber cultures. Sixty-one species of myxomycetes are recorded for the first time in the Republic of Tatarstan. Four rare species — *Craterium dictyosporum*, *Echinostelium paucifilum*, *Oligonema intermedium*, and *Stemonaria fuscoides* are new for Russia. Twenty-five species known from the literature are also included in the additional list. In total, 110 species of myxomycetes are known from the Republic of Tatarstan.

Keywords: Amoebozoa, *Craterium dictyosporum*, *Echinostelium paucifilum*, Myxogastria, *Oligonema intermedium*, *Stemonaria fuscoides*, distribution, ecology, plasmodial slime molds, species inventory, Russia.

Новые данные о разнообразии миксомицетов Республики Татарстан (Россия)

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Резюме. Представлен список видов миксомицетов, обнаруженных в Республике Татарстан (Россия), включая новые находки из Волжско-Камского заповедника и окрестностей г. Казани. Аннотированный список включает 85 видов, найденных авторами, из которых 77 были зарегистрированы в полевых условиях (484 образца) и 17 — во влажных камерах (117 образцов). Шестьдесят семь видов отмечены только в поле, а восемь видов выявлены только во влажных камерах. Шестьдесят один вид миксомицетов приводятся впервые для Республики Татарстан. Четыре редких вида — *Craterium dictyosporum*, *Echinostelium paucifilum*, *Oligonema intermedium* и *Stemonaria fuscoides* зарегистрированы впервые в России. Всего в Республике Татарстан выявлено 110 видов миксомицетов, в том числе 25 видов, известных по литературным и гербарным данным, которые представлены в отдельном списке.

Ключевые слова: Amoebozoa, *Craterium dictyosporum*, *Echinostelium paucifilum*, Myxogastria, *Oligonema intermedium*, *Stemonaria fuscoides*, инвентаризация видов, миксомицеты, плазмодиальные слизевики, экология миксомицетов, Россия.

The Republic of Tatarstan is located in the center of the European part of Russia on the East European Plain, at the confluence of two rivers—the Volga and the Kama. A plain with small hills occupies the right side of the Volga, and 90% of the southeastern portion of the republic is characterized by an elevation of no more than 200 m above sea level (Salakhov, Arkhipova, 2013; The Republic..., 2021). A large number of lakes and rivers account for a wide diversity of landscapes, soils, vegetation, and flora (Salakhov, Arkhipova, 2013; Akhmadishina, 2015).

The climate is moderately continental, characterized by warm summers and moderately cold winters. The warmest month of the year is July (+19 to +21 °C), and the coldest month is January (−13 to −14 °C). The average annual precipitation ranges from 460 to 520 mm (The Republic..., 2021).

Throughout the region, forest-steppe is primary vegetation, the southern portion of the republic is characterized by treeless steppe vegetation, whereas the northern part of Tatarstan is covered by boreal coniferous forests with a predominance of *Pinus sylvestris* L. and *Picea abies* (L.) H. Karst. Eighteen percent of the territory is covered by broadleaf deciduous forests typically dominated by *Quercus robur* L., *Tilia cordata* Mill., *Betula pendula* Roth, and *Populus tremula* L. (Salakhov, Arkhipova, 2013). The soils are very diverse, ranging from gray forest soils and podzolic soils in the north and west to various types of black-colored soils in the south.

The first records of myxomycetes from Tatarstan appear to be 38 species reported by Shiliakow (1889), but some of these species were later reduced to synonyms. Unfortunately, the herbarium specimens cited in this work have not been preserved. Yachevsky (1907) listed the species reported by Shiliakow together with two additional species *Perichaena corticalis* and *Trichia persimilis*, referring to own specimens and unpublished specimens collected in Kazan by Shiliakow. Novozhilov (2005) mentioned six additional species of myxomycetes recorded in Tatarstan. All these papers dealing specifically with Tatarstan myxomycetes were taken into consideration in the review of the myxomycetes of Russia published by Bortnikov *et al.* (2020). Sadykov (2021) noted 13 species of myxomycetes for the forest parks of Kazan, and three of them were listed for this region for the first time. There is also unpublished information about the collections of Yachevsky stored in the herbarium of the All-Russian Institute of Plant Protection (FSBSI VIZR) (LEP), which was kindly provided by V. I. Gmoshinskiy, who revised these specimens. Included in these were herbarium specimens of *Physarum gyrosum* Rostaf. which was not previously listed for the territory of Tatarstan. As a result, 49 species of myxomycetes had been identified previously in the studied region. The purpose of this paper is to provide new data on myxomycete diversity in the Republic of Tatarstan.

Material and Methods

The material considered herein was collected by the first coauthor in 2016 during the XIV International workshop of the Commission for the Study of Macromycetes, in the Volga-Kama Reserve, the surrounding areas of Kazan and during the field excursions in

the museum-reserve "Ostrov-Grad Sviyazhsk". Twenty-five localities in the Moskovsky and Zelenodolsky districts located in coniferous and deciduous forests as well as raised bogs and swamps were surveyed, albeit not always with the same intensity.

Study area

Kazan, Moskovsky District: **1** — near the campus "Lake Glubokoe", mixed oak forests with the dominant tree species *Quercus robur* with higher proportions of *Tilia cordata*, *Betula pendula*, and with *Sorbus aucuparia* L. in the shrub layer, the herb layer contains *Carex melanostachya* M. Bieb. ex Willd. and *Pteridium aquilinum* (L.) Kuhn., 55°50′46″N, 48°58′29″E, 24 VIII 2016; **2** — *ibid*., with *Tilia cordata*, *Betula pendula*, the undergrowth contains *Sorbus aucuparia* and *Euonymus europaeus* L., herbaceous layer contains *Carex melanostachya*, *Pteridium aquilinum*, 55°50′46″N, 48°58′28″E, 25 VIII 2016; **3** — a deep ravine with a linden forest with *Tilia cordata*, *Betula pendula* and *Pinus sylvestris*, undergrowth with *Sorbus aucuparia* and *Euonymus europaeus*, the herb layer with *Carex melanostachya*, *Equisetum hyemale* L., *E. sylvaticum* L., *Aegopodium podagraria* L., *Asarum europaeum* L., 55°50′31″ N, 48°58′23″E, 23 VIII 2016; **4** — *ibid*., 55°50′30″N, 48°58′16″E, 26 VIII 2016; **5** — pine forest with *Pinus sylvestris*, *Tilia cordata* and *Betula pendula*, undergrowth with *Sorbus aucuparia* and *Euonymus europaeus*, herb layer with *Carex melanostachya*, *Pteridium aquilinum* along the road to the lake, 55°50′46″N, 48°58′28″E, 22 VIII 2016; **6** — a deep ravine with a linden forest with *Tilia cordata*, *Betula pendula* and *Pinus sylvestris*, undergrowth with *Sorbus aucuparia* and *Euonymus europaeus*, the herb layer with *Carex melanostachya*, *Equisetum hyemale* L., *E. sylvaticum* L., *Aegopodium podagraria* L., *Asarum europaeum* L., 55°50′31″N, 48°58′17″E, 25 VIII 2016.

Zelenodolsky District: **7** — the Volga-Kama Reserve (V-KR), oak forest with *Quercus robur*, *Tilia cordata*, and *Acer platanoides* L., the herb layer with *Carex melanostachya*, *Aegopodium podagraria*, 55°52′17″N, 48°42′32″E, 23 VIII 2016; **8** — V-KR, mixed light coniferous and dark coniferous forests with *Pinus sylvestris*, *Picea abies*, *Betula pendula*, and *Populus tremula*, 55°53′32″N, 48°44′05″E, 22 VIII 2016; **9** — V-KR, oak forest with *Quercus robur*, *Tilia cordata*, and *Acer platanoides* L., the herb layer with *Carex melanostachya*, *Aegopodium podagraria*, 55°52′17″N, 48°43′03″E, 23 VIII 2016; **10** — *ibid*., 55°52′17″N, 48°43′02″E, 23 VIII 2016; **11** — V-KR, mixed light coniferous and dark coniferous forests with *Pinus sylvestris*, *Picea abies*, *Betula pendula*, and *Populus tremula*, 55°53′22″N, 48°43′19″E, 23 VIII 2016; **12** — V-KR, the border of the raised bog "Dolgoe", 55°54′34″N, 48°46′18″E, 24 VIII 2016; **13** — V-KR, *Pinus sylvestris* forest with an admixture *Betula pendula* near the animal farm and the bog "Dolgoe", 55°55′00″N, 48°46′09″E, 24 VIII 2016; **14** — V-KR, mixed light coniferous and dark coniferous forests with *Pinus sylvestris*, *Picea abies*, *Betula pendula*, and *Populus tremula*, 55°53′29″N, 48°44′07″E, 22 VIII 2016; **15** — *ibid*., 55°53′31″N, 48°44′06″E, 22 VIII 2016; **16** — *ibid*., the raised sphagnum bog "Dolgoe" with *Betula pendula*, 55°54′34″N, 48°46′19″E, 24 VIII 2016; **17** — V-KR, mixed light coniferous and dark coniferous forests with *Pinus sylvestris*, *Picea abies*, sphagnum swamp in depression with *Betula pendula*, 55°53′29″N, 48°44′06″E, 22 VIII 2016; **18** — *ibid*., 55°53′29″N, 48°44′08″E, 22 VIII 2016; **19** — *ibid*., 55°53′27″N, 48°44′14″E, 22 VIII 2016; **20** — the historical, architectural and art museum-reserve "Island-grad Sviyazhsk", oak forest (*Quercus robur*), 55°46′20″N, 48°39′35″E, 26 VIII 2016; **21** — surrounding area of the village of Urnyak, oak forest (*Quercus robur*) with few *Betula pendula*, herb layer contains *Carex melanostachya*, *Aegopodium podagraria*, it is dense, 55°51′29″N, 48°45′30″E, 26 VIII 2016; **22** — *ibid*., with few *Betula pendula* and *Tilia cordata*, herb layer dense, contains cereals and other grasses, 55°51′26″N, 48°45′26″E, 26 VIII 2016; **23** — Ayshinskoye forestry, birch forest (*Betula pendula*) with few trees of *Tilia cordata* and *Picea abies*, herb layer dense, with *Carex melanostachya*, *Aegopodium podagraria*, and *Pteridium aquilinum*, 55°53′05″N, 48°29′23″E, 25 VIII 2016; **24** — *ibid*., the border of raised sphagnum bog with *Betula pendula* and *Populus tremula*, herb layer dense with *Sphagnum* spp. and *Menyanthes trifoliata* L., 55°53′06″N, 48°29′06″E, 25 VIII 2016; **25** — *ibid*., coniferous forest (*Pinus sylvestris*), there is no herb layer, 55°53′06″N, 48°29′07″E, 25 VIII 2016.

In the field, we identified all sporocarps that were on the same substrate and clustered together (thus probably originating from one plasmodium) as one colony and collected them as one sample. The records were georeferenced using a hand-held GPS device, in coordinate system WGS 84/UTM.

For the experiments with moist chamber cultures, the material was selected as follows. Three main groups of substrata were sampled for the present study: 1) dead outer part of the bark from larger living shrubs or trees (51 samples); 2) ground leaf and twigs litter (33 samples); 3) weathered dung of moose (4 samples). From each of the 88 substrate samples, one moist chamber culture was prepared within 2–6 months after returning from the field surveys, using disposable plastic Petri dishes (90 mm diam.) lined with filter paper as described by Novozhilov *et al.* (2000). Cultures were moistened with distilled water adjusted to pH 7.0 and checked 3–6 times over a period of approximately 2.5 months under high magnification with a dissecting microscope.

Specimens were identified by both authors using a morphospecies concept to the lowest possible taxonomic level according to Martin and Alexopoulos (1969) and various original descriptions (Farr, 1976; Poulain *et al.*, 2011a, b). To make identifications, sporocarps were preserved as permanent slides in lactophenol. Myxomycete nomenclature follows Lado (2005–2022) and Lado, Hernández-Crespo (2021). The volume of systematic groups of myxomycetes in the work is taken by the classification of myxomycetes (Leontyev *et al.*, 2019). The genus *Ceratiomyxa* was included in this study due to its ecological equivalence to the true myxomycetes.

For an estimate of species abundance, the ACOR scale of Stephenson *et al.* (1993) was adapted. It is based on the proportion of a species to the total number of records so that R = rare (<0.5%, 1–2 records for this survey), O = occasional (0.5–1.5%, 3–8 records), C = common (1.5–3%, 9–18 records), and A = abundant (> 3%, more than 18 records).

All microscope measurements and observations were made under a Zeiss Axio Imager A1 microscope with differential interface contrast (DIC). Air-dried sporocarps were studied with a Zeiss motorized stereo microscope Discovery V20 at the Center for collective use of scientific equipment of the V. L. Komarov Botanical Institute RAS, as well as a Zeiss Primo Star microscope and a Bresser Advance ICD stereomicroscope at the Department of Pharmacognosy and Botany of the Volgograd State Medical University.

Results and Discussion

As a result of our research, we identified 85 species of myxomycetes. The species list given below was compiled from the records collected by authors. In the list, after each taxon name the following data are given: abundance according to the ACOR scale, and in brackets, number specimens found in field/moist chamber cultures. Next, the occurrence of a species on six different substrate types is listed. After abbreviation **LOC:** the numbers of all collecting localities of each species follow. Finally, the numbers of all specimens or only three of them (for species with more than 10 specimens) are given

referring to the herbarium LE. Since all field specimens were collected within a short period by the first author, the dates of collection are given in the description of the localities.

For this list, all myxomycetes substrates were classified as follows: b — bark of living trees; lg — grass litter; ll — leaf litter; lt — twigs litter; m — living mosses; s — soil; w — decaying coarse wood debris.

An asterisk in superscript (*) indicates the new species for the Russian Federation. An exclamation mark (!) indicates a species recorded as a new one for the Republic of Tatarstan. For the taxa already reported for Tatarstan the references are given as numbers in superscript preceding the taxon name: 1 — Shiliakow, 1889; 2 — Yachevsky, 1907; 3 — Novozhilov, 2005; 4 — Bortnikov *et al*., 2020; 5 — Sadykov, 2021; 6 — information about the collection of Yachevsky stored in the herbarium of FSBSI VIZR (Gmoshinskiy, pers. comm.).

All specimens collected during the study are stored in the Mycological Herbarium of the Komarov Botanical Institute of the Russian Academy of Sciences (LE).

[1, 2, 3, 4]**Arcyria cinerea** (Bull.) Pers. — A (22/35); b: 32, ll: 2, lt: 3, m: 1, s: 1, w: 18; **LOC:** 1, 2, 7, 11, 12, 16, 18, 21, 23, 25; LE 279613, LE 279615, LE 279622, etc. This species is one of the most common in the study region, occurs on a variety of substrates and tree species.

[1, 2, 3, 4, 5]**A. denudata** (L.) Wettst. — C (15/0); s: 1, w: 14 (*Betula pendula*, *Quercus robur*); **LOC:** 7, 8, 11, 22, 23; LE 279644, LE 279683, LE 279705, etc.

[1, 2, 4]**A. incarnata** (Pers. ex J. F. Gmel.) Pers. — C (9/0); w: 9 (*Quercus robur*); **LOC**: 3, 7, 13, 20, 21; LE 279708, LE 279737, LE 279782, LE 279786, LE 279923, LE 280020, LE 280037, LE 280044, LE 280053.

!**A. insignis** Kalchbr. et Cooke — R (1/0); w: 1 (*Quercus robur*); **LOC:** 7; LE 279716.

!**A. magna** Rex — R (1/0); w: 1 (*Pinus sylvestris*); **LOC:** 8; LE 279919.

!**A. minuta** Buchet — C (1/12); b: 12 (*Quercus robur*), w: 1; **LOC:** 1, 7, 21, 22; LE 279977, LE 278695, LE 278706, etc.

[1, 2, 3, 4]**A. obvelata** (Oeder) Onsberg — R (3/0); w: 3 (*Pinus sylvestris*); **LOC:** 13, 21, 25; LE 279749, LE 279761, LE 279828.

!**A. oerstedii** Rostaf. — R (1/0); w: 1 (*Betula pendula*); **LOC:** 23; LE 279830.

[3, 4]**A. pomiformis** (Leers) Rostaf. — A (2/23); b: 21 (*Quercus robur*, *Tilia cordata*), lt: 2, w: 2; **LOC:** 1, 7, 8, 21; LE 279597, LE 279920, LE 278692, etc.

!**Badhamia lilacina** (Fr.) Rostaf. — R (1/0); w: 1 (*Betula pendula*); **LOC:** 24; LE 279790.

!**B. populina** Lister et G. Lister — R (2/0); w: 2 (*Populus tremula*, *Pinus sylvestris*); **LOC:** 11, 13; LE 279904, LE 280057. It was found at the edge of the swamp.

!**Ceratiomyxa fruticulosa** (O. F. Mull.) T. Macbr. — C (13/0); w: 13; **LOC:** 7, 8, 11, 22; LE 279598, LE 279599, LE 279600, etc.

!**Collaria arcyrionema** (Rostaf.) Nann.-Bremek. ex Lado — C (16/0); w: 16 (*Picea abies*, *Betula pendula*); **LOC:** 11, 12, 17; LE 279635, LE 279654, LE 279679, etc. It was found in coniferous forests in swampy depressions.

!**C. lurida** (Lister) Nann.-Bremek. — R (1/0); w: 1 (*Betula pendula*); **LOC:** 18; LE 279732.

!**Comatricha laxa** Rostaf. — R (1/0); w: 1 (*Betula pendula*); **LOC:** 16; LE 280064.

[1, 2, 3, 4]**C. nigra** (Pers. ex J. F. Gmel.) J. Schröt. — R (2/0); w: 2 (*Betula pendula*, *Pinus sylvestris*); **LOC:** 3, 8; LE 279728, LE 279765. It was found in the coniferous forest.

*!**Craterium dictyosporum** (Rostaf.) H. Neubert et al. — C (9/0); lg: 2, ll: 1, m: 6; **LOC:** 16, 24; LE 279646, LE 279703, LE 279827, LE 279883, LE 279942, LE 279944, LE 279947, LE 280069, LE 280070. The species has very distinct spore ornamentation of large warts forming short ridges and merging into an incompletely developed network (Neubert *et al.*, 1995; Baba, Abdullah, 2018). All the finds of this species in Tatarstan were made in the *Sphagnum* raised bog, where this species formed many large colonies of sporangia (20 to 200 or more) on the mosses, the leaf litter, and grasses lying on the sphagnum.

[3, 4]**Cribraria argillacea** (Pers. ex J. F. Gmel.) Pers. — R (2/0); w: 2 (*Pinus sylvestris*); **LOC:** 13; LE 279714, LE 279751.

[1, 2, 3, 4]**C. cancellata** (Batsch) Nann.-Bremek. — A (20/0); w: 20; **LOC:** 2, 3, 8, 11, 13, 17, 19, 23, 24; LE 279595, LE 279610, LE 279612. It was found in various habitats.

!**C. intricata** Schrad. — R (1/0); w: 1 (*Betula pendula*); **LOC:** 18; LE 279788.

[1, 2, 3, 4]**C. microcarpa** (Schrad.) Pers. — R (1/0); w: 1 (*Picea abies*); **LOC:** 16; LE 279956.

!**C. piriformis** Schrad. — O (5/0); w: 5 (*Pinus sylvestris*); **LOC:** 7, 8, 18; LE 279839, LE 279848, LE 279861, LE 280036, LE 280043. It was found predominantly in coniferous forests.

!**C. stellifera** Nowotny et H. Neubert — R (2/0); w: 2; **LOC:** 12; LE 279647, LE 279688. The calyculus of this species is almost absent. The spores are reddish-ochre in mass, light brown in transmitted light, finely warted (Neubert *et al.*, 1993). In Russia, this species has been reported only once on the Kola Peninsula (Novozhilov *et al.*, 2020). In Tatarstan, it was found on the coarse woody debris (CWD) of spruce and birch lying in the water on the bank of the raised sphagnum bog.

!**C. violacea** Rex — O (0/4); lt: 4 (*Quercus robur*); **LOC:** 1, 7; LE 278737, LE 278922, LE 278923, LE 278928.

!**Diachea leucopodia** (Bull.) Rostaf. — R (2/0); w: 2 (*Quercus robur*, *Betula pendula*); **LOC:** 7, 21; LE 279731, LE 279771.

!**Diderma hemisphaericum** (Bull.) Hornem. — R (0/1); lt: 1 (*Quercus robur*); **LOC:** 1; LE 278736.

!**D. simplex** (J. Schröt.) E. Sheld. — O (7/0); m: 7; **LOC:** 16; LE 279655, LE 279711, LE 279722, LE 279756, LE 279768, LE 279773, LE 279878. It was found in the raised bog on *Sphagnum* spp.

!**Didymium iridis** (Ditmar) Fr. — O (5/0); ll: 1, m: 4; **LOC:** 12, 16; LE 279810, LE 279818, LE 279884, LE 279937, LE 279939. It was found predominantly in the raised bog on *Sphagnum* spp.

!**D. melanospermum** (Pers.) T. Macbr. — R (2/0); m: 1 (*Sphagnum* sp.), w: 1 (*Pinus sylvestris*); **LOC:** 14, 16; LE 279873, LE 279876. This species was found in the raised bog.

!**D. nigripes** (Link) Fr. — R (1/0); ll: 1 (*Betula pendula*); **LOC**: 18; LE 279809.

!**Echinostelium minutum** de Bary — C (0/15); b: 14 (*Quercus robur*), lt: 1 (*Quercus robur*); **LOC:** 1, 7, 21; LE 278688, LE 278697, LE 278699, etc.

*!**E. paucifilum** K. D. Whitney — O (0/5); b: 5 (*Quercus robur*); **LOC:** 1, 7; LE 278693, LE 278698, LE 278712, LE 278722, LE 278877. In our specimens, the spores are much larger than in the descriptions in source: 13–21 vs. 11.5–15.5 μm (Whitney, 1980; Lizárraga *et al.*, 2016).

!**Enerthenema papillatum** (Pers.) Rostaf. — O (4/0); w: 4 (*Pinus sylvestris*); **LOC:** 2; 8; LE 279601, LE 279685, LE 279760, LE 279863.

!**Fuligo intermedia** T. Macbr. — R (1/0); w: 1 (*Populus tremula*); **LOC:** 24; LE 279918.

!**F. leviderma** H. Neubert et al. — O (4/0); w: 4 (*Populus tremula*, *Betula pendula*); **LOC:** 11, 18, 24; LE 279691, LE 279769, LE 279845, LE 279930.

!**F. luteonitens** L. G. Krieglst. et Nowotny — O (4/0); w: 4 (*Betula pendula*, *Quercus robur*); **LOC:** 1, 8, 9; LE 279820, LE 279931, LE 279988, LE 280001.

[1, 2, 3, 4, 6]**F. septica** (L.) F. H. Wigg. — A (29/0); lg: 2, ll: 3, m: 1, w: 23; **LOC:** 1, 2, 7–11, 13, 16, 18, 20, 21, 23–25; LE 279590, LE 279591, LE 279607, etc. This is one of the most common species of myxomycetes in the study region. It was recorded in mass in different habitats, mainly on CWD.

[5]**Hemitrichia serpula** (Scop.) Rostaf. ex Lister — O (4/0); w: 4 (*Betula pendula*, *Quercus robur*); **LOC:** 7, 9, 12, 20; LE 279673, LE 279834, LE 279953, LE 279983.

!**Licea minima** Fr. — R (1/0); w: 1(*Pinus sylvestris*); **LOC:** 8; LE 279608.

!**L. pusilla** Schrad. — R (1/0); w: 1 (*Pinus sylvestris*); **LOC:** 8; LE 279877.

!**L. variabilis** Schrad. — R (1/0); w: 1 (*Picea abies*); **LOC:** 12; LE 279909.

!**Lycogala conicum** Pers. — R (1/0); w: 1 (*Betula pendula*); **LOC:** 11; LE 279626.

[1, 2, 3, 4, 5, 6]**L. epidendrum** (L.) Fr. — O (6/0); w: 6; **LOC:** 7, 8, 11, 15; LE 279596, LE 279624, LE 279632, LE 279642, LE 279865, LE 279921.

!**L. exiguum** Morgan — R (2/0); w: 2; **LOC:** 16, 18; LE 279933, LE 279990. It was found on CWD of coniferous trees.

[1, 2, 3, 4, 6]**L. flavofuscum** (Ehrenb.) Rostaf. — R (1/0); w: 1 (*Quercus robur*); **LOC:** 20, LE 279932. Shiliakow noted that this species occurs mainly in deciduous forests (Shiliakow, 1889).

[1, 2, 3, 4, 5]**Metatrichia vesparia** (Batsch) Nann.-Bremek. ex G. W. Martin et Alexop. — A (33/1); lg: 1, lt: 1, w: 32; **LOC:** 1–3, 5–8, 11, 13, 17, 18, 23–25; LE 279618, LE 279619, LE 279636, etc. It was found in various types of habitats on CWD of various tree species.

!**Oligonema flavidum** (Peck) Peck — C (10/0); w: 10 (*Betula pendula*); **LOC:** 8, 11; LE 279638, LE 279640, LE 279681, etc. Most of the specimens were found in the swamps.

*!**O. intermedium** M. de Haan — R (3/0); w: 3 (*Betula pendula*); **LOC:** 11; LE 279689, LE 280038, LE 279785. The species is characterized by small rounded crowded sporangia and characteristic ornamentation of spores with a fine mesh (De Haan, 2004; Poulain *et al*., 2011a, b).

!**Perichaena chrysosperma** (Curr.) Lister — C (1/8); b: 5 (*Tilia cordata*, *Quecus robur*), lt: 3 (*Tilia cordata*, *Quecus robur*), w: 1; **LOC:** 1, 2, 7, 21; LE 278728, LE 278730, LE 278731, LE 278898, LE 278907, LE 278920, LE 278931, LE 278934, LE 278921. The habitats of this species are associated with broadleaf forests.

[2, 3, 4]**P. corticalis** (Batsch) Rostaf. — R (0/1); lt: 1(*Quercus robur*); **LOC:** 7; LE 278921.

!**P. depressa** Lib. — R (0/1); lt: 1 (*Quercus robur*); **LOC:** 7; LE 278924.

!**P. liceoides** Rostaf. — O (0/4); lt: 4 (*Quercus robur*); **LOC:** 7, 21; LE 278870, LE 278872, LE 278873, LE 278929.

!**Physarum album** (Bull.) Chevall. — C (16/0); ll: 2, m: 1, w: 13; **LOC:** 2, 3, 8, 12, 13, 22, 23; LE 279588, LE 279593, LE 279602, etc.

!**P. compressum** Alb. et Schwein. — R (1/1); b: 1, w: 1; **LOC:** 8, 21; LE 280060, LE 278862.

!**P. didermoides** (Pers.) Rostaf. — R (0/1); b: 1 (*Tilia cordata*); **LOC:** 7; LE 278906.

!**P. flavicomum** Berk. — R (1/0); w: 1 (*Betula pendula*); **LOC:** 18; LE 279682.

!**P. globuliferum** (Bull.) Pers. — A (25/0); lg: 1, ll: 8, m: 2, w: 14; **LOC:** 1–3, 8, 13, 14, 16, 21, 23; LE 279706, LE 279715, LE 279742, etc. It was often found in different habitats and substrates, but mainly on CWD.

!**P. leucopus** Link — R (1/0); w: 1 (*Quercus robur*); **LOC:** 21; LE 279905.

!**P. viride** (Bull.) Pers. — O (4/1); ll: 1, lt: 1, m: 1, w: 2; **LOC:** 7, 12, 13, 16, 17; LE 279674, LE 279693, LE 279844, LE 280029, LE 278927.

!**Reticularia intermedia** Nann.-Bremek. — R (1/0); w: 1 (*Betula pendula*); **LOC:** 8; LE 279999.

!**R. jurana** Meyl. — R (2/0); w: 2 (*Betula pendula*); **LOC:** 11, 17; LE 279717, LE 279799.

!**R. splendens** Morgan — R (2/0); w: 2 (*Pinus sylvestris*); **LOC:** 5; LE 279657, LE 279864.

*!**Stemonaria fuscoides** Nann.-Bremek. et Y. Yamam. — R (1/0); m: 1; **LOC:** 16; LE 279964. This species is characterized by an opaque columella that branches in the upper part into two or three main branches of the capillitium in the apical part and spiny-reticulated spores. (Nannenga-Bremekamp *et al*., 1984; Damasceno *et al*., 2009). It was found in the raised bog on *Sphagnum* sp.

!**S. longa** (Peck) Nann.-Bremek. et al. — O (3/2); b: 2, w: 3; **LOC:** 2, 3, 7, 9, 21; LE 279659, LE 279725, LE 279897, LE 278859, LE 278903. It was found mainly in deciduous forests.

[1, 2, 3, 4]**Stemonitis axifera** (Bull.) T. Macbr. — A (31/0); m: 1, w: 30; **LOC:** 1, 2, 4, 7, 8, 11, 12, 14, 15, 17, 20, 21, 23, 24; LE 279592, LE 279637, LE 279643, etc. It is often found in a variety of habitats, on CWD.

!**S. flavogenita** E. Jahn — O (4/0); w: 4 (*Pinus sylvestris*, *Betula pendula*); **LOC:** 8, 14, 18, 23; LE 279589, LE 279639, LE 279656, LE 279938. Found in coniferous and mixed forests.

[1, 2, 4]**S. fusca** Roth — A (21/0); w: 21; **LOC:** 1–3, 4, 6–8, 11, 12, 18, 25; LE 279609, LE 279668, LE 279713, etc. It is often found in different habitats, mainly on CWD. Shiliakow cited it also *Stemonitis dictyospora* Rostaf. (Shiliakow, 1889) that is considered a synonym of *S. fusca* now (Lado, 2005–2022).

!**S. herbatica** Peck — O (4/0); ll: 2, w: 2; **LOC:** 11, 23; LE 279850, LE 279896, LE 279996, LE 280054. Occurs mainly on deciduous species.

!**S. pallida** Wingate — O (4/2); b: 2 (*Quercus robur*), w: 4 (*Quercus robur*, *Tilia cordata*); **LOC:** 1, 2, 7, 18; LE 279811, LE 279849, LE 279869, LE 279898, LE 278710, LE 278717.

!**S. smithii** T. Macbr. — O (6/0); w: 6 (*Betula pendula*, *Picea abies*); **LOC:** 11, 12, 18; LE 279680, LE 279733, LE 279822, LE 279840, LE 279901, LE 279998. This species was found in coniferous forests with an admixture of birch.

!**S. splendens** Rostaf. — O (6/0); w: 6 (*Betula pendula*, *Acer platanoides*); **LOC:** 7, 8, 23–25; LE 279727, LE 279730, LE 279935, LE 279982, LE 279994, LE 280021.

!**Stemonitopsis amoena** (Nann.-Bremek.) Nann.-Bremek. — R (1/0); w: 1 (*Pinus sylvestris*); **LOC:** 8; LE 280003.

!**S. hyperopta** (Meyl.) Nann.-Bremek. — R (2/0); w: 2; **LOC:** 1, 23; LE 279710, LE 280035.

!**S. microspora** (Lister) Nann.-Bremek. — O (4/0); m: 1, w: 3; **LOC:** 11, 16, 18; LE 279671, LE 279778, LE 279934, LE 279963. It was found mainly on CWD of coniferous trees.

!**S. typhina** (F. H. Wigg.) Nann.-Bremek. — C (12/0); w: 12; **LOC:** 1, 7, 11, 17, 23, 24; LE 279620, LE 279677, LE 279699, etc. It was found mainly on CWD of deciduous trees.

!**Symphytocarpus amaurochaetoides** Nann.-Bremek. — R (1/0); w: 1 (*Betula pendula*); **LOC:** 2; LE 280022.

!**S. flaccidus** (Lister) Ing et Nann.-Bremek. — R (1/0); m: 1 (*Sphagnum* sp.); **LOC:** 13; LE 279698. It was found in the pine forest, in a swampy depression.

!**S. trechisporus** (Berk. ex Torrend) Nann.-Bremek. — C (10/0); b: 1, lg: 3, m: 6; **LOC:** 16–18, 21; LE 279645, LE 279664, LE 279667, etc. It was found on *Sphagnum* spp. and grasses in swampy habitats.

[1, 2, 3, 4]**Trichia affinis** de Bary — O (6/0); w: 6 (*Tilia cordata*, *Betula pendula*, *Pinus sylvestris*); **LOC:** 2, 18, 23, 25; LE 279779, LE 279890, LE 279929, LE 279992, LE 280051, LE 280056. This species was found on very wet CWD in deciduous and mixed forests.

[1, 2, 3, 4]**T. botrytis** (J. F. Gmel.) Pers. — R (1/0); w: 1; **LOC:** 18; LE 279870. It was found on the dead bark of *Pinus sylvestris*.

[1, 2, 3, 4, 5]**T. decipiens** (Pers.) T. Macbr. — C (8/0); w: 8; **LOC:** 8, 12, 15–17; LE 279662, LE 279675, LE 279678, LE 279806, LE 279926, LE 279957, LE 279970, LE 280014. This species was found on CWD in coniferous and mixed forests with *Betula pendula* and *Tilia cordata*.

[1, 2, 3, 4, 5]**T. favoginea** (Batsch) Pers. — A (38/0); m: 1, w: 37; **LOC:** 2, 3, 7, 8, 12, 18, 20, 23, 25; LE 279641, LE 279652, LE 279653, etc. This is one of the most common species, found everywhere on wet CWD of different trees.

[2, 3, 4, 5]**T. persimilis** P. Karst. — R (2/0); w: 2; **LOC:** 3, 18; LE 279650, LE 279726. It was found mainly on CWD of deciduous trees. Yachevsky (1907) cites this based on the specimens collected by Shiliakow, which he revised himself.

[3, 4, 5]**T. scabra** Rostaf. — O (6/0); lg: 1, w: 5; **LOC:** 9, 11, 24; LE 279676, LE 279700, LE 279832, LE 279836, LE 279907, LE 280065. It was found mainly on CWD of deciduous trees.

[1, 2, 3, 4, 5]**T. varia** (Pers. ex J. F. Gmel.) Pers. — O (5/0); w: 5; **LOC:** 8, 18, 23; LE 279694, LE 279800, LE 279881, LE 279894, LE 280032. This species was found predominantly on CWD of birch in coniferous and mixed forests.

This study is based on 601 specimens collected by the first author and representing 85 morphospecies from 26 genera. Most observations were made in the field (484 records); a total of 88 moist chamber cultures added another 117 records. Forty-one species were classified as rare for the whole study area (accounting for less than 0.5% of all records); most of them were represented by only one (27) or two (22) records, and two species were represented by three records. We report 61 taxa for the first time for Tatarstan and four species (*Craterium dictyosporum*, *Echinostelium paucifilum*, *Oligonema intermedium*, and *Stemonaria fuscoides*) are reported for the first time from Russia.

The most frequent species in Tatarstan are *Arcyria cinerea* (57 records), *Trichia favoginea* (38), *Metatrichia vesparia* (34), *Stemonitis axifera* (31), *Fuligo septica* (29), *Physarum globuliferum* (25), *Arcyria pomiformes* (25), and *Cribraria cancellata* (20). It should be noted that *Arcyria pomiformes* was predominantly found in the moist chamber culture, *Arcyria cinerea* was found equally in the culture of the moist chamber and in the field, and the remaining abundant species were found exclusively in the field.

The sampling effort was probably sufficient to recover all of the most common species in the entire study area if the data set is taken as a whole (85 species from 601 records, 76% complete according to the final figure of the Chao1 = 112 ± 14). However, since the material was collected in a limited area and a very short period, and considering that, experiments with moist chamber cultures were performed only for three biotopes, we cannot unambiguously opinion the number of species that can potentially be found in this area. We obtained data only for the available localities and only under these conditions. Further work will allow us to identify more species, as the Republic of Tatarstan has a large territory and a significant range of diversity of natural conditions from southern taiga to broad-leaved forests and northern steppes. Looking at the substrate assemblages, partial data sets were most complete for the bark of living

trees (11 species, 96 records, 92%, Chao1 = 12 ± 2) followed by coarse woody debris (70 species, 415 records, 78%, Chao1 = 90 ± 11), and litter (28 species, 90 records, 60%, Chao1 = 47 ± 15).

To analyze the diversity of myxomycetes on different substrates, we identified three assemblages: on the bark of living trees (corticolous), on decayed wood (xylophylic), as well as on the forest floor, including mosses and soil (litter-inhabitants). We did take in account coprophilic assemblage since only four moist chamber cultures were prepared with the dung of moose, and myxomycetes were not registered on this substrate. Species richness and Shannon diversity increased from bark (11 species, H´= 1.9, D = 4.9) over forest floor (28 species, H´= 3.0, D = 15.4), to coarse woody debris (70 species, H´= 3.6, D = 25.4).

All habitats in which we collected material can be tentatively divided into deciduous forests, coniferous forests, bogs and swamps. We found the greatest diversity in coniferous forests (57 species, 197 records, 66%, Chao1 = 86 ± 15, H´= 3.5, D = 23.3), then in deciduous forests (48 species, 276 records, 61%, Chao1 = 79 ± 20, H´= 3.3, D = 17.8) and least species we found in swamps (36 species, 128 records, 54%, Chao1 = 66 ± 23, H´= 3. 3, D = 21.9), however, there were the most species that were not found in other habitats, including three of four species new to Russia (excluding *Echinostelium paucifilum*).

In addition to the species identified by us in the Republic of Tatarstan, 25 species of myxomycetes are known according to the literature and herbarium data.

Arcyodes incarnata (Alb. et Schwein.) O. F. Cook — in "German Switzerland" ["Gorky Park" in Kazan] on rotten wood (Shiliakow, 1889).

Arcyria imperialis (G. Lister) Q. Wang et Yu Li — the species was listed as *Arcyria oerstedioides* Flatau et Schirmer. for Dubravnyi Forest Park on CWD *Acer platanoides* (Sadykov, 2021), but during revision by Gmoshinskiy, this specimen was redefined as *Arcyria stipata* var. *imperialis* (G. Lister) Y. Yamam. (Gmoshinskiy, pers. comm.), which is now a synonym *Arcyria imperialis* according to the Lado nomenclatural system (2005–2022).

Cribraria aurantiaca Schrad. — in the village of Krasnaya Gorka [Kazan] on rotten stumps (Shiliakow, 1889).

C. splendens (Schrad.) Pers. — without location and substrate (Novozhilov, 2005).

C. tenella Schrad. — in "German Switzerland" on rotten wood (Shiliakow, 1889).

C. vulgaris Schrad. — firstly cited by Shiliakow in the village of Krasnaya Gorka [Kazan] on rotten stumps. However, Yachevsky (1907) considered this species as a synonym of *C. aurantiaca* Schrad. Bortnikov *et al.* (2020) lists this record as *C. vulgaris*, following the original source (Shiliakow, 1889). Since Shiliakow listed both (*C. aurantiaca* and *C. vulgaris*) of these species in his work, and they are both widespread in the forest zone, we follow his opinion and also cite them together.

Comatricha longipila Nann.-Bremek. — without location and substrate (Novozhilov, 2005).

Diderma globosum Pers. — in the forest near the village of Nadezhdino [40 km east of Kazan] on grass stems and ground leaf litter (Shiliakow, 1889).

D. ochraceum Hoffm. — one time in the forest near the village of Nadezhdino on grass stems (Shiliakow, 1889).

D. radiatum (L.) Morgan — without location and substrate (Novozhilov, 2005).

D. spumarioides (Fr. et Palmquist) Fr. — one time in the forest near the village of Derbyshki [Derbyshki Station, Kazan] on mosses (Shiliakow, 1889).

Didymium difforme (Pers.) Gray — in "German Switzerland" on leaf litter and grass stems (Shiliakow, 1889).

Hemitrichia calyculata (Speg.) M. L. Farr — in Dubravnyi Forest Park in Kazan on CWD *Acer platanoides* and *Betula pendula* (Sadykov, 2021).

H. clavata (Pers.) Rostaf. — in Kazan on rotten stump in ravine (Shiliakow, 1889) and in Dubravnyi Forest Park in Kazan on CWD *Acer platanoides* and *Betula pendula* (Sadykov, 2021).

Lamproderma nigrescens (Rostaf.) Rostaf. — in "German Switzerland" on *Polyporus* sp. (Shiliakow, 1889); Shiliakow emphasized that spores are smooth. Yachevsky (1907) listed these specimens as *L. arcyrioides*; however, he did not study the specimens. Later works referred to Yachevsky's opinion (Novozhilov, 2005; Bortnikov *et al.*, 2020). We should keep in mind that in the original description of *L. arcyrioides* (Rostafinsky, 1875) the spores are minutely spinulose; while in the protologue of *L. nigrescens* (Rostafinsky, 1875) the spores are smooth. Therefore, we follow the original source. Noteworthy that this is the only report of *L. nigrescens* for Russia.

L. columbinum (Pers.) Rostaf. — in Kazan on rotten wood in a cold cellar (icehouse) near ice (Shiliakow, 1889).

Leocarpus fragilis (Dicks.) Rostaf. — in the forest near the village of Troitskoe [Kazan] commonly on mosses, branches, and bark of trees (Shiliakow, 1889).

Lindbladia tubulina Fr. — in Kazan and "German Switzerland" in the ravines on branches, cones of spruce, fallen leaves (Shiliakow, 1889).

Metatrichia floriformis (Schwein.) Nann.-Bremek. — in Kazan on the rotten stump, as *Trichia decaisneana* de Bary (Shiliakow, 1889). Yachevsky (1907) considered this species synonymous with *Trichia botrytis* (J. F. Gmel.) Pers., referring to a monograph by Lister (1894), who considered *T. decaisneana* synonymous with *Trichia botrytis* var. *lateritia* (Lév.) Lister. However, *T. decaisneana* and *T. botrytis* var. *lateritia* are now considered synonymous with *Metatrichia floriformis* (Martin, Alexopoulos, 1969; Nannenga-Bremekamp, 1985; Poulain *et al.*, 2011a, b; Lado, 2005–2022). Since Shiliakow cited two species in his work and they are both common in the forest zone, we consider it necessary to include both of them: *Metatrichia floriformis* and *Trichia botrytis*.

Mucilago crustacea P. Micheli ex F. H. Wigg. — in the forests around the villages of Troitskoe and Nadezhdino on grass stems, on tree trunks (Shiliakow, 1889).

Physarum gyrosum Rostaf. — in Kazan on cucumber leaves, VI 1931, *V. Sudeikin*, LEP 000375 (Gmoshinskiy, pers. comm.).

P. sulphureum Alb. et Schwein. — in "German Switzerland" on rotten log (Shiliakow, 1889).

Reticularia lycoperdon Bull. — near of the village of Troitskoe on rotten stumps (Shiliakow, 1889), and in Kazan on CWD and on bark of living trees (Yachevsky, 1907).

Trichia contorta (Ditmar) Rostaf. — in "German Switzerland" on rotten mossy stumps (Shiliakow, 1889), and Dubravnyi Forest Park, Gorkinskii Forest Park in Kazan, on CWD of *Acer platanoides* and *Populus tremula* (Sadykov, 2021).

Tubifera ferruginosa (Batsch) J. F. Gmel. — near the village of Troitskoe and Kazan on rotten stumps (Shiliakow, 1889; Yachevsky, 1907).

All of the species listed above are common in the boreal and broadleaf forest zones and can be found regularly.

If to summarize the results of the present study, previous reports (Shiliakov, 1889; Yachevsky, 1907; Novozhilov, 2005; Bortnikov *et al.*, 2020; Sadykov, 2021) and the species reported by Gmoshinskiy, 110 species of myxomycetes are currently known from the Republic of Tatarstan.

The data on the myxomycete biota of Tatarstan presented herein are not surprising since the species recorded in our study are widespread in coniferous and mixed forests. However, for the little-studied region of Tatarstan the results obtained in this study represent additional information on the distribution and ecology of myxomycetes. We hope that this paper will encourage further study of myxomycetes, especially in certain specific habitats for myxomycetes such as bogs and swamps, where new species can be discovered and additional records can be obtained.

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