

НАУЧНАЯ СТАТЬЯ

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НОВЫЕ ДАННЫЕ О МИКСОМИЦЕТАХ (=МУХОGASTREA, МУСЕТОЗОА) ГОСУДАРСТВЕННОГО ПРИРОДНОГО ЗАПОВЕДНИКА «ДАГЕСТАНСКИЙ» (СЕВЕРНЫЙ КАВКАЗ, РОССИЯ)

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Аннотация. В работе приведена информация об обнаружении на территории Дагестанского заповедника 71 вида миксомицетов, относящихся к 25 родам, 11 семействам и 6 порядкам, выявленных как в ходе сбора спороношений в полевых условиях, так и методом влажной камеры. Наибольшим разнообразием характеризовался пор. Trichiales (22 вида), в то время как пор. Physarales, который является самым крупным по числу описанных таксонов, представлен лишь 19 видами. В ходе полевых сборов было выявлено 34 вида, в то время как во влажных камерах сформировались 43. Таким образом, обоими методами сразу было выявлено лишь 4 вида, что показывает необходимость совместного использования этих методов для полного выявления видового разнообразия миксомицетов.

Ключевые слова: биоразнообразие, влажные камеры, Дагестан, миксомицеты, список видов

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ORIGINAL ARTICLE

**NEW DATA ON MYXOMYCETES (=MYXOGASTREA,
MYCETOZOA) FROM DAGESTAN STATE NATURE RESERVE
(NORTH CAUCASUS, RUSSIA)****Vladimir I. Gmoshinskiy^{1,2}, Andrey V. Matveev¹, Olga A. Lazareva¹**¹ Lomonosov Moscow State University, Faculty of Biology² Polistovsky Natural State Reserve**Corresponding author:** Vladimir I. Gmoshinskiy, rubisco@list.ru

Abstract. This article contains the information about detection of 71 myxomycete species from 25 genera, 11 families and 6 orders on the territory of Dagestan State Nature Reserve. Specimens were obtained by both field surveys and moist chamber culture method. The order Trichiales (22 species) was characterized by the largest diversity (22 species), while the order Physarales, in which there is the largest number of described taxa, was represented by only 19 species. During field survey 34 species were collected, whereas 43 species were obtained from the moist chamber cultures. Thus, only 4 species were discovered by both methods which shows the necessity of combined application of these methods in order to completely reveal the myxomycete diversity.

Keywords: biodiversity, check list, Dagestan, moist chambers, myxomycetes

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Myxomycetes are a group of amoeboid eukaryotic organisms that form diverse macroscopic fruit bodies. According to the current classification, Myxomycetes constitute the phylum Eumycetozoa together with classes Dictyosteliomycetes and Ceratiomyxomycetes (Kang et al., 2017; Leontyev et al., 2019) inside the monophyletic group Amoebozoa (Adl et al., 2019). There are two main methods for recording and isolating Myxomycetes: field collection of fruit bodies and the moist chamber culture technique which means the incubation different substrates of plant origin in Petri dishes with increased moisture (Matveev et al., 2014; Wrigley de Basanta, Estrada-Torres, 2017).

Before the beginning of our research only one species, *Arcyria obvelata*, was registered in Dagestan (Hollys, 1902). In 2017 during the expedition to Dagestan State Nature Reserve sporocarps and samples of substrate for moist chamber cultures were

collected in the field. The results of the field collection analysis have already been published (Matveev, Gmoshinskiy, 2017). However, the list of species obtained from moist chamber cultures was not presented earlier. Thuswise the aim of the current article is to generalize the available data on myxomycete diversity of Dagestan Nature Reserve.

Materials and methods*Study area*

Dagestan State Nature Reserve was established in 1987 with an aim to preserve Kizlyarsky Bay, the most typical area of northwestern coast of Caspian Sea, and Sarykum Barkhan, the largest sand dune in Europe, in their natural state (Zapovedniki Kavkaza, 1990).

Nowadays this reserve occupies an area of almost 20 000 ha. The territory includes several zones with distinctive natural and climatic conditions such as

Table 1

List of collection sites in Dagestan Nature Reserve in 2017

Biotope number	Title	Geographical coordinates	Altitude above sea level	Dates of field work
Loc. 1	Samursky wildlife sanctuary, near the village Primorsky	N 41.87°, E 48.52°	25–10 m	18–21 May
Loc. 2	Tlyaratinsky wildlife sanctuary, village Salda, two-kilometer zone around cordon	N 41.97°, E 46.51°	1700–2200 m	24–28 May
Loc. 3	Sarykum Barkhan area	N 43.01°, E 47.23°	60–100 m	30 May – 2 June

Agrakhansky, Samursky, Tlyaratinsky wildlife sanctuaries and the Sarykum Barkhan area.

The collection of material took place in Samursky and Tlyaratinsky wildlife sanctuaries and in the Sarykum Barkhan area.

Samursky wildlife sanctuary (Table 1, Loc. 1) was transferred under the nature reserve direction only in 2009. Climate in the area of this wildlife sanctuary is temperate, in transition to Mediterranean type. The average annual temperature is 12.6°C. On the major part of the territory winter temperatures are positive and summer temperatures are on average high. Annual precipitation is approximately 400 mm (Ataev, 2018). The wildlife sanctuary was established in order to preserve the unique forestland. The sanctuary territory is occupied with the array of flood plain broad-leaved liana forests of the Samur River delta (Tazhudinova, Guseynov, 2016). Samursky forest consists of poplar, alder, hornbeam forests and oakwoods, that earlier covered approximately all the delta area (Ataev, 2018). Among plants of the sanctuary there are plenty of endemic, relict and also rare and endangered species included in the Red Data Book of Dagestan and the one of Russia, for instance, *Pterocarya pterocarpa* (Michx.) Kunth ex Iljinsk., *Allium paradoxum* (M. Bieb.) G. Don, *Hedera pastuchovii* Woronow, *Anacamptis palustris* (Jacq.) R.M. Bateman, Pridgeon & M.W. Chase (Blagovidov et al., 2018).

Tlyaratinsky wildlife sanctuary also became a part of the nature reserve only in 2009. The territory of Tlyaratinsky region (Table 1, Loc. 2) occupies the mountain range between 1200 and 3081 m above sea level. The landforms of this area are made up by the part of the Great Caucasus range and the mountains of the Lateral range, situated parallel to the main one. Climate of this area is moderately continental and also moderately humid. Annual precipitation in the Avarskoe Koysu valley is approximately 600–800 mm. Average temperature in July is +16°C, in

January – approximately -8°C. Therefore, the coldest month is January and the warmest one is July. In the valley the mean annual temperature is +4°C. The mosaic of highlands, canyons, plateaus and depressions creates unique conditions for various ecosystems with endemic and relict species to emerge and maintain (Imanmirzaev, Abdulzhalimov, 2014). The main forest species are *Acer platanoides* L., *A. trautvetteri* Medw., *Alnus incana* (L.) Moench, *Betula pendula* Roth, *B. litwinowii* Doluch., *Carpinus betulus* L., *Fraxinus excelsior* L., *Pinus uncinata* Ramond ex DC., *Populus tremula* L., *Prunus padus* L., *Quercus macranthera* Fisch. & C.A. Mey. ex Hohen., *Salix caprea* L., *Sorbus aucuparia* L., (Ataev, Kasumov, 2014).

Climate of the Sarykum Barkhan area (Table 1, Loc 3) is warm and dry; the aridity and the continentality are very pronounced. Annual precipitation is only 366 mm (Gorbatovskiy et al., 2017). The highest temperature (+31.4°C) is in August, the lowest one (-1°C) is in February. Sarykum is the unique place in Dagestan where average monthly temperatures are above +20°C for 5 months (from May till September) (Zapovedniki Kavkaza, 1990). Vegetation of the sand dune is represented by typical psammophyte communities, while steppe and meadow communities are less prevalent. Woody communities is not represented. In Sarykum flora there are representatives of 280 species. On top of the sand dune vegetation is completely absent due to the sand movement (Zapovedniki Kavkaza, 1990).

Specimen collection and substrate sampling

Specimen collection was performed on the territory of Dagestan State Nature Reserve in 2017. Three areas of the reserve were surveyed: Samursky and Tlyaratinsky wildlife sanctuaries and also the Sarykum sand dune (Table 1). Throughout the survey specimen of fruit bodies were collected in the field.

Besides that, substrate samples such as pieces of bark, ground leaf litter, decaying wood and dung of herbivorous animals were collected for moist chamber cultivation.

Field sampling

Fruit body specimens with small substrate fragments were collected and then glued to U-shaped paper trays placed in matchboxes (Stephenson, Stempen, 2000). Type of substrate (decaying wood, ground leaf litter, bark, living gramineous plants or macromycete fruit bodies) was marked on matchbox. Specimens were let to dry out at room temperature without direct sunlight. During the field survey fruit bodies that originated from one plasmodium were recognized as one specimen. In case of finding two or more colonies of the same species developing on the same substrate type, they were considered to be separate specimens only when the distance between colonies exceeded 1 m.

Moist chamber cultures

Samples of bark, ground leaf litter, decaying wood and dung of herbivorous animals were collected to set moist chamber cultures. On the whole there were 113 Petri dishes prepared according to standard methodology (Matveev et al., 2014): the incubation lasted for 3 months, chambers were examined every 10 days using dissecting microscope. Then obtained specimens were also glued to U-shaped paper trays and dried out at room temperature. Moreover, all fruit bodies of the same species developing in one moist chamber and recorded during separate examinations were considered as one specimen.

Specimen identification

Identification of myxomycetes was performed using special keys (Martin, Alexopoulos; 1969, Novozhilov, 1993; Ing, 1999; Poulain et al., 2011a, b). Macroscopic features were studied using dissecting microscopes MBS-10, Micromed ST-E-C1 and Leica M50. For identification of microscopic features such as capillitium and spore ornamentation microscope slides were made in 2% KOH and lactophenol and examined using light microscopes Leica DM 2500, Leica DM 500 and Micromed 3 Ver. 3LED. Scanning electron microscope Camscan-S2 (Cambridge Instruments) with the image digitization system was used for the identification of spore, capillitium and peridial surface ornamentation. Sputtering with gold-palladium was performed with ion-spraying machine IB-3 Ion Coater (EIKO).

Annotated species list

In the list below species are arranged in alphabetical order. Authors and names of taxa are given in accordance with nomenclatural information system of Eumycetozoa (Lado, 2005–2021). Total numbers of specimens of obtained from field collections (FC) and moist chamber cultures (MC) are given after species name. The second line shows where the material was collected (Table 1). Also, there is more information stated: a total number of specimens detected by both of aforesaid methods (FC and MC), a brief characteristic of substrate features and a list of herbarium sample numbers in the Collection of Myxomycetes at the Department Mycology and Algology, Faculty of Biology, Lomonosov Moscow State University (MYX). In some cases, one specimen was divided into two matchboxes and a unique number was given for each one. Such duplicates are marked with * in the following list.

Arcyria affinis Rostaf. (5 FC)

Loc. 1: 5 FC, on decaying wood (MYX 8288, MYX 8291), on bark (MYX 8287, MYX 8289, MYX 8290).

Arcyria cinerea (Bull.) Pers. (2 MC)

Loc. 2: 1 MC, on ground leaf litter of *Betula* sp. and of *Acer* sp. (MYX 15599); Loc 3: 1 MC, on bark of *Ailanthus altissima* (MYX 15641).

Arcyria ferruginea Saut. (1 FC)

Loc. 1: 1 FC, on decaying wood (MYX 8292).

Arcyria incarnata (Pers. ex J. F. Gmel.) Pers. (2 FC)

Loc. 2: 2 FC, on decaying wood (MYX 8334, MYX 8335).

Arcyria minuta Buchet in Patouillard (1 FC)

Loc 2: 1 FC, on decaying wood (MYX 8336).

Arcyria obvelata (Oeder) Onsberg (2 FC)

Loc 2: 2 FC, on decaying wood (MYX 8337, MYX 8338).

Badhamia cf. *panicea* (Fr.) Rostaf. in Fuckel (3 FC)

Loc 1: 3 FC, on decaying wood (MYX 8293), on bark (MYX 8294). Specimens were slightly destroyed, so the only features used in identification were reddish hypothallus, capillitium structure and spore ornamentation and size. However, we consider these features to be sufficient to clearly assign our specimen to this species.

Badhamia utricularis (Bull.) Berk. (1 FC, 3 MC)

Loc 1: 1 FC, on bark (MYX 8295), Loc 3: 3 MC, on bark of *Tamarix* sp. (MYX 15503, MYX 15504, MYX 15508).

Calomyxa metallica (Berk.) Nieuwl. (2 MC)

Loc 3: 2 MC, on bark of *Populus* sp. (MYX 15522, MYX 15535, MYX 15539*).

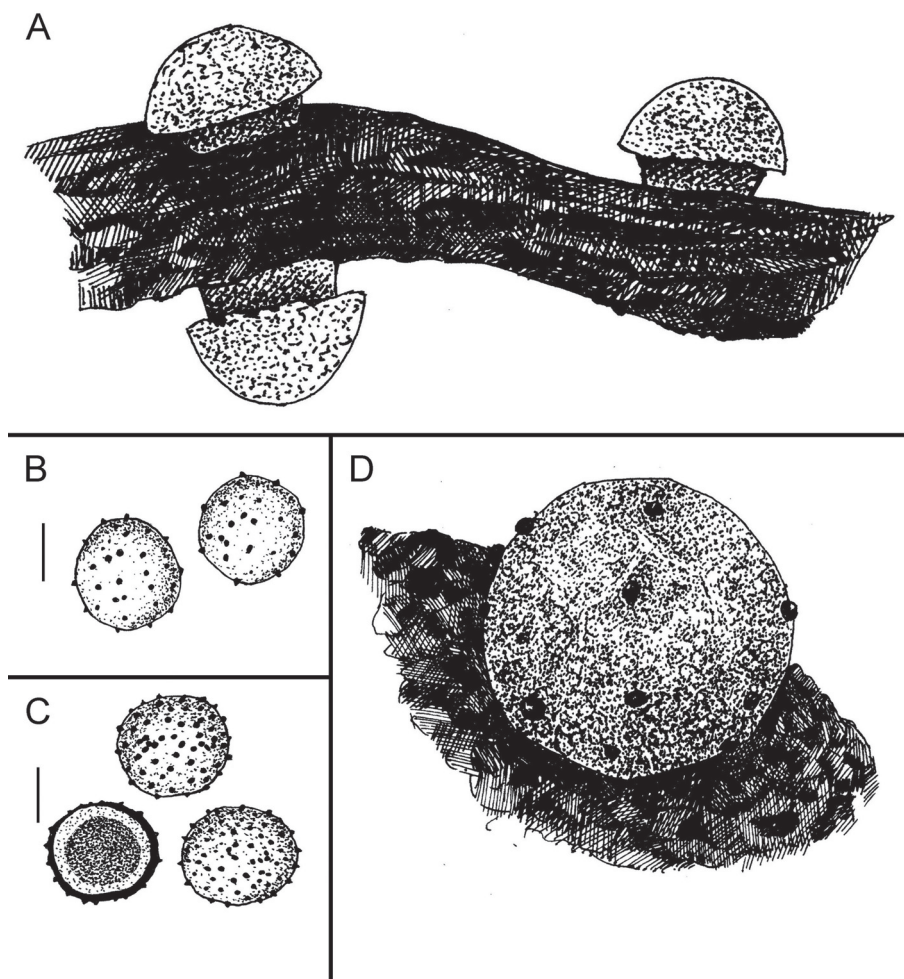


Fig. 1. A–C: *Didymium trachysporum*. A – group of sporophores. B – spores in transmitted light $\times 1000$ (MYX 15609). C – spores in transmitted light $\times 1000$ (MYX 15594). D – *Licea scintillans* (MYX 15642). Single sporangium. Scale bar: 5 μm

Ceratiomyxa fruticulosa (O. F. Müll.) T. Macbr. (5 FC)

Loc 1: 3 FC, on decaying wood (MYX 8296, MYX 8297, MYX 8298); Loc 2: 2 FC, on decaying wood (MYX 8340), on bark (MYX 8339).

Comatricha alta Preuss (1 FC)

Loc 1: 1 FC, on decaying wood (MYX 8299).

Comatricha ellae Härk. (2 MC)

Loc 3: 2 MC, on bark of *Tamarix* sp. (MYX 15501, MYX 15505, MYX 15502*).

Comatricha nigra (Pers. ex J. F. Gmel.) J. Schröt. in Cohn (3 FC)

Loc 1: 3 FC, on decaying wood (MYX 8300, MYX 8301).

Cribraria lepida Meyl. (1 MC)

Loc 1: 1 MC, on bark of *Ulmus* sp. (MYX 15556).

Diderma effusum (Schwein.) Morgan (1 MC)

Loc 3: 1 MC, on ground leaf litter (MYX 15643).

Didymium difforme (Pers.) Gray (4 MC)

Loc 2: 4 MC, on dung of *Ursus* sp. (MYX 15610, MYX 15613, MYX 15611), on small twigs of *Juniperus* sp. (MYX 15580), on bark of *Salix* sp. (MYX 15588).

Didymium cf. *dubium* Rostaf. (1 MC)

Loc 3: 1 MC, on dung of *Lepus* sp. (MYX 15628).

Didymium trachysporum G. Lister (2 MC) (fig. 1 A–C, 2 A–E).

Loc 2: 2 MC, on dry grass on snow field (MYX 15594 cf., on greatly decomposed dung of *Ursus* sp. or of *Equus* sp. (MYX 15609).

Sporophores sessile, pulvinate sporangia on narrowed bases, up to 150 μm in diam., snow-white. Hypothallus inconspicuous. Peridium double, inner layer membranous, tightly incrustated with shell-like inseparable polygonal limy crystals without tapering outgrowths. Capillitium scanty, represented by separate inconspicuous threads (fig. 2 D). Stalk and columella absent. Spores black in mass, light-

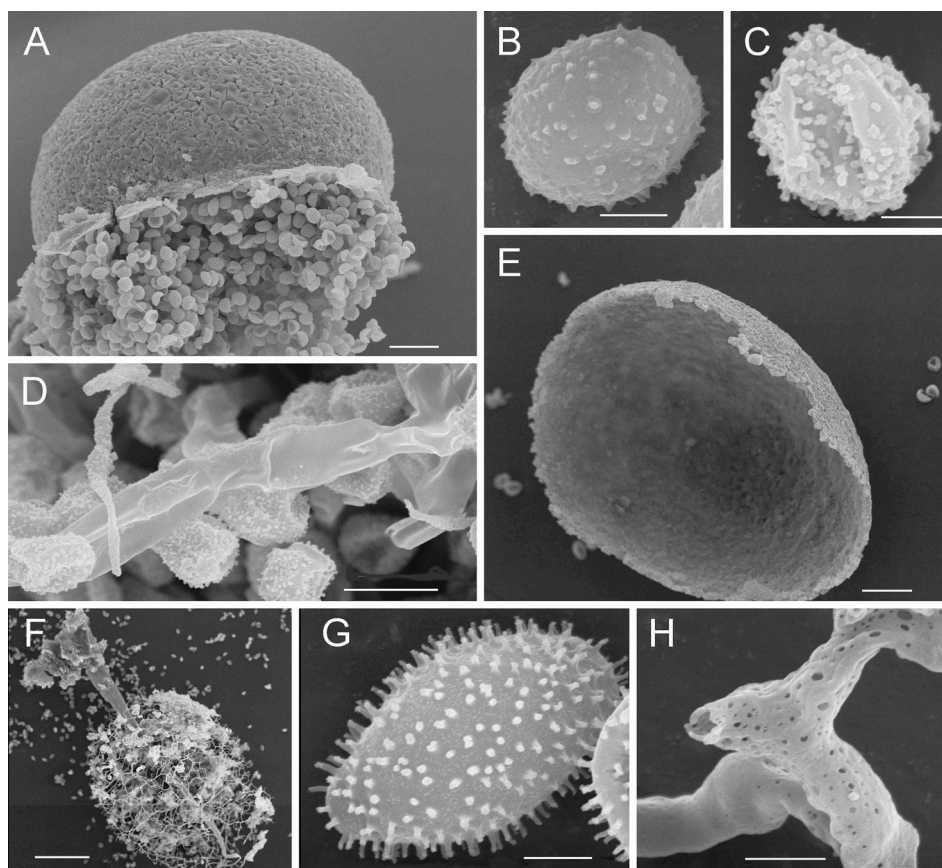


Fig. 2. A–E: *Didymium trachysporum*. A – dehiscent sporangium (MYX 15609) with polygonal limy granules. B – spore (MYX 15609). C – spore (MYX 15594). D – piece of inner peridial surface, a capillitial thread and spores (MYX 15594). E – peridial inner surface (MYX 15609). F – *Macbrideola oblonga*. Sporangium after a partial spore discharge. (MYX 15521). G – *Perichaena liceoides*. Spore. Secondary ornamentation is conspicuous. (MYX 15597). H – *Perichaena luteola*. Piece of capillitial thread (MYX 15604). Scale bars: A, E, G, H – 30 μm , B, C – 3 μm , D – 10 μm , F – 100 μm

brown in transmitted light, globose or lightly angular, 8.9–9.9 μm in diam., with dehiscence zone occupying up to two-thirds of the spore, irregularly ornamented with large warts. Specimen MYX 15594 (fig. 1 B) is distinguished by spores with more densely situated warts than specimen MYX 15609 (fig. 1 C). Moreover, examination of the specimen MYX 15609 spore surface using SEM showed that the main warts are pyramidal with blunt tops. In between them secondary ornamentation in the form of small knobby outgrowths is visible (fig. 2 B).

The most specific features of this species are a small stalkless sporangia or a short plasmodiocarps up to 150 μm wide, covered with tight peridium consisting of polygonal limy crystals without any spinulose outgrowths (Henney et al., 1980). Unlike *Didymium difforme* (Pers.) Gray and *D. commatum* (Lister) Nann.-Bremek., *D. trachysporum* has limy layer that does not separate from the scarious one. On the contrary, limy layer covers it tightly, forming

a solid crust (fig. 2 A). Another significant feature of *D. trachysporum* is comparatively bright spores ornamented with scattered large warts, while *Didymium difforme* and *D. commatum* (Lister) Nann.-Bremek. have darker spores, with bright spots ornamented with small warts that merge into reticulum (Ing, 1999). In case of our specimens, lime is deposited only at the upper part of sporangium, whereas the lower part of the peridium is almost limeless, scarious, fragile and easily dehiscing, therefore the base of sporangium becomes tapered (fig. 2 A), see also Novozhilov et al., 2006, fig. 18.

We are not completely sure whether the specimen MYX 15594 identification is correct, because its spores are quite densely warted in comparison with the specimen MYX 15609. However, according to the shape of fruit body, peridial structure, almost complete absence of capillitium and also spore colour and size (spores of MYX 15609 are 9.2–10.2 μm , while spores of MYX 15594 are 9.8–10.4 μm), these samples are identical.

Didymium squamulosum (Alb. & Schwein.) Fr. & Palmquist (1 MC)

Loc 2: 1 MC, on bark of *Betula litwinowii* (MYX 15595).

Echinostelium apitectum K.D. Whitney (1 MC)

Loc 3: 1 MC, on bark of *Morus* sp. (MYX 15594).

Echinostelium brooksii K.D. Whitney (3 MC)

Loc 2: 3 MC, on bark of *Pinus* sp. (MYX 15583, MYX 15584).

Echinostelium minutum de Bary (1 MC)

Loc 3: 1 MC, on bark of *Salix* sp. (MYX 15540).

Enerthenema papillatum (Pers.) Rostaf. (2 FC)

Loc 1: 2 FC, on decaying wood (MYX 8302, MYX 8303).

Fuligo cinerea (Schwein.) Morgan (1 MC)

Loc 3: 1 MC, on bark of living *Elaeagnus* sp. (MYX 15516).

Fuligo leviderma H. Neubert, Nowotny et K. Baumann (1 FC)

Loc 2: 1 FC, on decaying wood (MYX 8341).

Fuligo septica (L.) F. H. Wigg. (1 FC)

Loc 2: 1 FC, on decaying wood (MYX 8342).

Lamproderma ovoideum Meyl. (1 FC)

Loc 2: 1 FC, on stalks of *Apiaceae* at snow bark in the field (MYX 7766). Earlier this specimen has been marked as a doubtful one (Matveev, Gmoshinskiy, 2017), however the identification correctness was verified after the additional check.

Licea biforis Morgan (1 MC)

Loc 2: 1 MC, on bark of living *Pinus* sp. (MYX 15586).

Fruit bodies were not completely mature, so the identification was based on the overall sporophore appearance.

Licea denudescens H.W. Keller & T.E. Brooks (6 MC)

Loc 2 MC, 1 on bark of living *Populus tremula* (MYX 15590), Loc 3 MC 5, on bark of living *Populus* sp. (MYX 15519, MYX 15527, MYX 15533, MYX 15538*), on bark of living *Salix* sp. (MYX 15545, MYX 15550).

Licea kleistobolus G.W. Martin (5 MC)

Loc 3 MC 5, on bark of living *Morus* sp. (MYX 15497, MYX 15498), on bark of living *Populus* sp. (MYX 15530, MYX 15537), on *Artemisia scoparia* (MYX 15637).

Licea parasitica (Zukal) G.W. Martin (5 MC)

Loc 1 MC 1, on bark of living *Ulmus* sp. (MYX 15560 cf.). Loc 3 MC 4, on bark of living *Populus* sp. (MYX 15528, MYX 15534), on bark of living *Salix* sp. (MYX 15542, MYX 15548).

Specimen 15560 has atypical sporangia. Contrary to the typical ones, its peridium is dark-olive-brown, membranous, completely devoid of dark granulat-

ed material which is highly unlike for this species. However, the rest of features are typical, e.g.: entirely smooth spores 14.5–15.2 μm in diam., warts on the inner peridial surface, and a specific lid on top of the sporangium.

Licea rugosa var. *fujiokana* (Y. Yamam.) D. Wrigley & Lado (2 MC)

Loc 1 MC 2, on dry shoots of *Hedera* sp. (MYX 15564, MYX 15571).

This species is characterized by the presence of small sporangia on dark, non-transparent stalks filled with dark spores. In transmitted light spore shell is irregularly incrassate, whereas spore surface is smooth. *L. rugosa* var. *fujiokana* has relatively small spores in comparison with the typical variety (14–16 μm vs (-9)10–11 μm respectively). On the territory of Russia this variety has been registered in Kedrovaya Pad Reserve, Primorsky Krai (F.M.Bortnikov, pers. comm.) and the typical one – in Sikhote-Alin Nature Reserve, Primorsky Krai (Novozhilov et al., 2017) and Utrish Reserve, Krasnodar Krai (unpublished data).

Licea scintillans McHugh & D.W. Mitch. (1 MC) (Fig. 1 D, 3 A–D)

Loc 3 MC 1, on ground leaf litter (MYX 15642).

Sporangia globose, shining, with tapering bases (80–100 μm in diam.), ochroid-brown, covered with 6–8 separate dark-brown spots (10–20 μm in diam.) (fig. 1 D), with separate black warts in the center of each spot (approximately 5 μm in diam. and 5 μm high). Peridium one-layered, thin, scarious, with inclusions of substrate fragments; outer peridial surface rough due to substrate fragments under SEM (fig. 3 A, D); inner surface smooth (fig. 4 B) or covered with slightly pronounced separate warts. Dehiscence irregular. Stalk absent. Spores brown, shining in mass, olive-brown in transmitted light, spore wall with a pale area, almost smooth, 10.6–12.2 μm in diam.; under SEM ornamented with small warts of different sizes (fig. 3 C).

Appearance of our specimens exactly corresponds to the holotype description (Mitchell, McHugh, 2000). There is only one distinction – spores are ornamented with small warts as seen with the use of SEM (Fig. 3 C), whereas the original description claimed that spores are smooth. Therefore, we assume that the authors have not considered the examination using scanning electron microscope.

This species might be regarded to be rare enough. It has been recorded in the Crimea (Leontyev et al., 2011), Germany and the USA, as well as in Cuba (gbif.org); the holotype has been collected in Great Britain (Mitchell, McHugh, 2000).

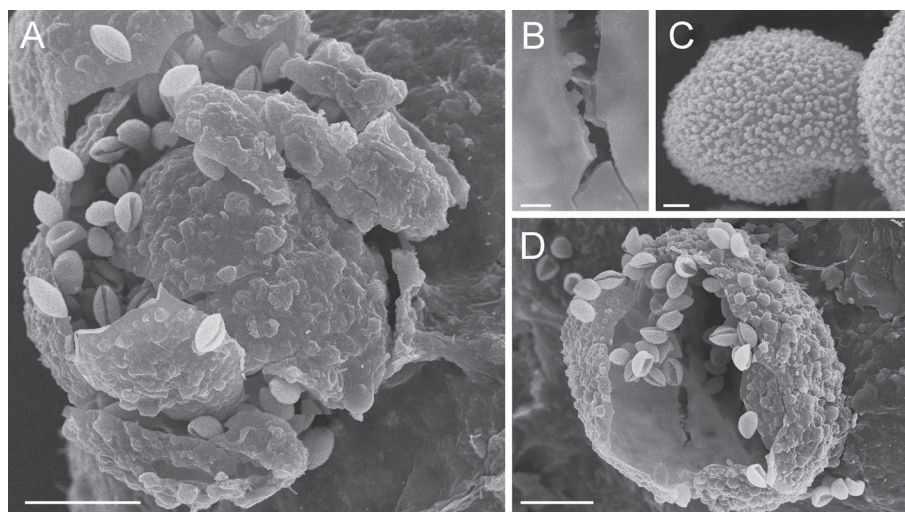


Fig. 3. *Licea scintillans* (MYX 15642). A – destroyed sporangium. B – inner peridial surface. C – spores. D – dehiscing sporangium and spores. Scale bars: A, D – 30 µm, B – 3 µm, C – 1 µm

Licea tenera E. Jahn (4 MC)

Loc 3 MC 4, on dung of *Bos taurus* (MYX 15516, MYX 15514, MYX 15618, MYX 15619).

Lycogala epidendrum (L.) Fr. (5 FC)

Loc 1 FC 3, on decaying wood (MYX 8304); Loc 2 FC 1, on decaying wood (MYX 8343); Loc 3 FC 1 on decaying wood (MYX 8333).

Macbrideola cornea (G. Lister & Cran) Alexop. (6 MC)

Loc 1 6 MC, on bark of living *Ulmus* sp. (MYX 15554, MYX 15555*, MYX 15556, MYX 15559, MYX 15562*), on dry twigs of *Hedera* sp. (MYX 15562, MYX 15572, MYX 15574).

Macbrideola oblonga Pando & Lado (4 MC) (Fig. 2 F).

Loc 3 MC 4, on bark of living *Populus* sp. (MYX 15521), on bark of living *Salix* sp. (MYX 15543, MYX 15544*, MYX 15547, MYX 15549).

The most prominent features of this species are a stalk transparent in transmitted light, oval sporangium and spores 9–10 µm in diam. with ornamentation of small warts.

Metatrichia vesparia (Batsch) Nann.-Bremek. ex G. W. Martin et Alexop. (3 FC)

Loc 2 MC 3, on decaying wood (MYX 8344, MYX 8345, MYX 8346).

Paradiacheopsis rigida (Brândza) Nann.-Bremek. (1 MC)

Loc 3 MC 1, on bark of living *Tamarix* sp. (MYX 15506, MYX 15507*).

Perichaena calongei Lado, D. Wrigley & Estrada (4 MC)

Loc 1 MC 1, on dry twigs of *Hedera* sp. (MYX 15565, MYX 15566*); Loc 3 MC 3, on wood rot

(MYX 15632, MYX 15633, MYX 15634*, MYX 15635).

This species has been described only in 2009. The major features of this species are the presence of oblong, curved, bagel-shaped plasmodiocarps on the dark thickened hypothallus which is similar to a short stalk. Meanwhile, peridial surface is divided into sectors by dark thickenings, which take part in sporangium dehiscence. This species is similar to *P. chrysosperma* which also has oblong plasmodiocarps and large spinules on the capillitial surface. However, *P. chrysosperma* does not bear any dark thickenings dividing peridium into fragments.

On the territory of Russia *P. calongei* has been registered only in the Far East (Novozhilov et al., 2017). However, apparently this species is often determined incorrectly as *P. chrysosperma*. Thus, additional research is required to elucidate this species distribution in Russia.

Perichaena chrysosperma (Curr.) Lister (8 MC)

Loc 1 MC 1, on bark of living *Ulmus* sp. (MYX 15558); Loc 2 MC 2, on bark of living *Quercus* sp. (MYX 15578), on bark of living *Tilia* sp. (MYX 15589); Loc 3 MC 5, on bark of living *Populus* sp. (MYX 15524, MYX 15526*, MYX 15532, MYX 15536*); on bark of living *Juniperus* sp. (MYX 15551, MYX 15552, MYX 15553).

Perichaena corticalis (Batsch) Rostaf. (3 FC, 5 MC)

Loc 1 FC 3, on decaying wood (MYX 8305), on bark (MYX 8306) MC 2, on bark of living *Ulmus* sp. (MYX 15561), on dead twigs of *Hedera* sp. (MYX 15568, 15570*); Loc 2 MC 2, on dung of *Ursus* sp.,

on dung of *Bos taurus* (MYX 15612); Loc 3 MC 1, on bark living *Populus* sp. (MYX 15520).

Perichaena depressa Lib. (15 MC)

Loc 2 MC 8, on bark of living *Quercus* sp. (MYX 15575, MYX 15576, MYX 15577*, MYX 15579), on bark of living *Populus tremula* (MYX 15585, MYX 15591, MYX 15592*, MYX 15593), on dung of *Aves* (MYX 15600, MYX 15601*, MYX 15602); Loc 3 MC 7, on bark of living *Juniperus* sp. (MYX 15510, MYX 15511, MYX 15512); on dung of *Bos taurus* (MYX 15620), on dung of *Lepus* sp. (MYX 15627, one specimen is absent in herbarium), on fruits of *Gleditsia triacanthos* L. (no specimen in herbarium), on bark of living *Robinia* sp. (MYX 15638, MYX 15639, MYX 15640*).

Perichaena liceoides Rostaf. (1 MC) (fig. 2 G)

Loc 2 MC 1, on ground leaf litter of *Betula* sp. and of *Acer* sp. (MYX 15597, MYX 15598*).

Perichaena luteola (Kowalski) Gilert (5 MC) (Fig. 2 H)

Loc 2 MC 4, on dung of *Bos taurus* (MYX 15603, MYX 15604, MYX 15605, MYX 15606*, MYX 15607, MYX 15608*); Loc 3 MC 1, on dung of *Bos taurus* (MYX 15617).

This species often develops on dung of herbivorous animals (Eliasson, Keller, 1999). *Perichaena luteola* differs from *P. liceoides* by less pronounced spore ornamentation as well as the presence of capillitium (fig. 2 H). Since the formation of fruit bodies takes a lot of time, spore mass detaches from membranous peridium and as a result sporangia seem darker.

Perichaena quadrata T. Macbr. (4 MC)

Loc 3 MC 4, on bark of living *Juniperus* sp. (MYX 15513); on dung of *Bos taurus* (MYX 15623, MYX 15624, MYX 15625).

Perichaena vermicularis (Schwein.) Rostaf. (2 MC)

Loc 1 MC 1, on dry twigs of *Hedera* sp. (MYX 15563); Loc 3 MC 1, on dung of *Bos taurus* (MYX 15621).

Physarum album (Bull.) Chevall. (5 FC)

Loc 1 FC 2, on decaying wood (MYX 8307, MYX 8308); Loc 2 FC 3, on decaying wood (MYX 8350, MYX 8351), on bark (MYX 8349).

Physarum bethelii T. Macbr. ex G. Lister (1 MC)

Loc 3 MC 1, on dung of *Ovis* sp. (MYX 15622).

This species occupies an intermediate position between *Physarum album* and *P. viride*. The main characteristics are yellow fusiform capillitial nodules and almost uncalcified peridium. However, the most suitable feature to identify *P. bethelii* is the large spore size ((9-) 10-11 (-12) μm in diam.),

whereas *P. album* and *P. viride* have smaller spores (7–8 μm).

Physarum cinereum (Batsch) Pers. (2 MC)

Loc 3 MC 2, on bark of living *Juniperus* sp. (MYX 15514), on bark of living *Ailanthus altissima* (MYX 15518).

Physarum diderma Rostaf. (1 MC)

Loc 3 MC 1, on *Artemisia scoparia* (herbarium specimen is absent).

Physarum didermoides (Pers.) Rostaf. (2 MC)

Loc 2 MC 1, on bark of living *Salix* sp. (MYX 15587); Loc 3 MC 1, on bark of living *Juniperus* sp. (MYX 15515).

Physarum globuliferum (Bull.) Pers. (1 FC)

Loc 1 FC 1, on decaying wood (MYX 8314).

Physarum leucophaeum Fr. et Palmquist (7 FC, 1 MC)

Loc 1 FC 7, on decaying wood (MYX 8310, MYX 8311, MYX 8312, MYX 8313), on surface of fungus (MYX 8309), MC 1, on dung of *Ovis* sp. (MYX 15627).

Physarum leucopus Link (1 FC, 2 MC)

Loc 1 FC 1, on bark (MYX 8315), MC 2, on dry twigs of *Hedera* sp. (MYX 15567, MYX 15569*, MYX 15573).

Physarum serpula Morgan (4 MC)

Loc 3 MC 4, on bark of living *Morus* sp. (MYX 15500), on bark of living *Populus* sp. (MYX 15523, MYX 15525, MYX 15531).

Reticularia intermedia Nann.-Bremek. (1 FC)

Loc 1 FC 1, on decaying wood (MYX 8316).

Reticularia lycoperdon Bull. (1 FC)

Loc 1 FC 1, on bark (MYX 8317).

Reticularia splendens Morgan (2 FC)

Loc 1 FC 1, on decaying wood (MYX 8318); Loc 2 FC 1, on decaying wood (MYX 8352).

Stemonaria longa (Peck) Nann.-Bremek., R. Sharma & Y. Yamam. (1 MC)

Loc 2 MC 1, on twigs of *Juniperus* sp. (MYX 15582).

Stemonitis axifera (Bull.) T. Macbr. (3 FC)

Loc 1 FC 2, on decaying wood (MYX 8319, MYX 8320), Loc 2 FC 1, on decaying wood and on bark (MYX 8353).

Stemonitis fusca Roth (2 FC)

Loc 1 FC 2, on decaying wood (MYX 8321, one specimen is absent in herbarium).

Stemonitopsis aequalis (Peck) Y. Yamam. (1 MC)

Loc 3 MC 1, on bark of living *Tamarix* sp. (MYX 15509).

This species is frequently recorded in Central Russia, although it is usually collected during the field studies. The major features are microspinulose spores 8-9 μm in diam., pretty long sporangium

stalks and almost closed capillitial net on the sporangium surface.

Stemonitopsis typhina (F. H. Wigg.) Nann.-Bremek. (1 FC)

Loc 1 FC 1, on decaying wood (MYX 8322).

Trichia contorta (Ditmar) Rostaf. (1 FC)

Loc 1 FC 1, on decaying wood (MYX 8323).

Trichia contorta var. *karstenii* (Rostaf.) Ing (2 MC)

Loc 3 MC 2, on bark of living *Salix* sp. (MYX 15541, MYX 15546).

Trichia decipiens (Pers.) T. Macbr. (4 FC)

Loc 1 FC 2 on decaying wood (MYX 8324, MYX 8325); Loc 2 FC 2, on decaying wood (MYX 8348, one specimen is absent in herbarium).

Trichia favoginea (Batsch) Pers. (2 FC)

Loc 1 FC 2, on decaying wood (MYX 8347, MYX 8354).

Trichia persimilis P. Karst. (1 FC)

Loc 2 FC 1, on decaying wood (MYX 8355).

Trichia varia (Pers. ex J. F. Gmel.) Pers. (13 FC)

Loc 1 FC 12, on decaying wood (MYX 8326, MYX 8327, MYX 8329, MYX 8330, MYX 8331, MYX 8332, 5 specimens are absent in herbarium), on decaying wood and on bark (MYX 8328); Loc 2 FC 1, on decaying wood (MYX 8356).

Tubifera ferruginosa (Batsch) J. F. Gmel. (1 FC)

Loc 2 FC 1, on decaying wood (MYX 8357).

Results and discussion

A total of 207 specimens of myxomycete fruit bodies (sporocarps) were found in the territory of three wildlife sanctuaries of Dagestan State Nature Reserve, among them 83 records from field collections and 124 obtained from moist chambers. Altogether there were 71 myxomycete morphospecies recorded from 25 genera, 11 families and 6 orders (Table 2). Among them 118 specimens belonging to 43 species were obtained exclusively from moist chamber cultures and 86 specimens of 34 species were collected exclusively in the field. Thus, only 4 species were detected by both of these methods.

The order Trichiales was presented by the highest diversity (22 species). The order Physarales, which contains the largest number of described species, was represented by only 19 taxa. Such number of detected species is not typical for the majority of well-known biotas. Representatives of this order usually prevail in both species diversity and the number of taxa recorded. Fewer species were discovered in the orders

Stemonitidales and Cribrariales (13 species in both of these orders). The richest in the number of species is the genus *Physarum* represented by 9 species. Besides that, representatives of this genus were recorded in the field (4 species) and also obtained from the moist chamber cultures (7 species). Representatives of the rest most numerous genera were revealed principally by only one of the mentioned methods. For instance, the genus *Perichaena* was represented by 8 species among which all were obtained from the moist chamber cultures, while only *P. corticalis* was collected in the field. Representatives of the genus *Licea* (8 species) were revealed only by the moist chamber method, while species of the genera *Arcyria* and *Trichia* (6 species in each of them) were predominantly found in the field (5 species in each of them), but one species from both genera was obtained from the moist chamber cultures (*Arcyria cinerea* and *Trichia contorta* var. *karstenii*). This case is explainable enough, since there is usually a distinctive correlation between representatives of different genera and their preferable substrates. For example, sporophores of *Licea* species are too small, so their detection in the field is complicated, whereas the majority of species in the genera *Arcyria* and *Trichia* (6 species in both of genera) are xylophilic, and representatives of this ecological-trophic group are not frequently found in moist chambers (Novozhilov, 2000). This might be explained by a whole range of factors, among which the physical impossibility of large plasmodium development and inappropriate condition of constant overwetting are the most crucial.

Most of the specimens collected in the field are assigned to *Trichia varia* (13), while the rest of species are represented by smaller number of specimens (7 or less). The same situation was observed in moist chamber cultures with the most frequent species *Perichaena depressa* (15 specimens), whereas other species were represented by 8 or less specimens.

The results of comparing two methods used once again claim the necessity of their joint application.

Conclusion

In this article we present the first annotated checklist of myxomycetes of Dagestan obtained by both field surveys and moist chamber cultivation. However, we think that this checklist is not comprehensive. Detection of the full species diversity requires additional long-term studies on the whole territory of the Republic of Dagestan (Table 2)

Table 2

Taxonomic structure of the myxomycete biota recorded in the described territory of the Republic of Dagestan

Order	Family	Genus
Ceratiomyxales (1)	Ceratiomyxaceae (1)	<i>Ceratiomyxa</i> (1)
Echinosteliales (3)	Echinosteliaceae (3)	<i>Echinostelium</i> (3)
Cribrariales (13)	Liceaceae (7)	<i>Licea</i> (7)
	Cribrariaceae (1)	<i>Cribraria</i> (1)
	Reticulariaceae (5)	<i>Lycogala</i> (1)
		<i>Reticularia</i> (3)
		<i>Tubifera</i> (1)
Trichiales (22)	Trichiaceae (7)	<i>Metatrichia</i> (1)
		<i>Trichia</i> (6)
	Arcyriaceae (14)	<i>Arcyria</i> (6)
		<i>Perichaena</i> (8)
	Dianemataceae (1)	<i>Calomyxa</i> (1)
Physarales (19)	Physaraceae (14)	<i>Badhamia</i> (2)
		<i>Physarum</i> (9)
		<i>Fuligo</i> (3)
	Didymiaceae (5)	<i>Diderma</i> (1)
		<i>Didymium</i> (4)
Stemonitidales (13)	Stemonitidaceae (13)	<i>Comatrigha</i> (3)
		<i>Enerthenema</i> (1)
		<i>Lamproderma</i> (1)
		<i>Macbrideola</i> (2)
		<i>Paradiacheopsis</i> (1)
		<i>Stemonaria</i> (1)
		<i>Stemonitis</i> (2)
		<i>Stemonitopsis</i> (2)

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