Annals of Agrarian Science

Journal homepage: http://journals.org.ge/index.php

New species of gasteroid fungi for Georgia's mycobiota

A. Jorjadze[a], K. Tigishvili[a], I. Kupradze[a], K. Batsatsashvili[b,*]

[a]Department of Spore-producing Plants and Fungi, Institute of Botany, Ilia State University;
1, Botanikuri Str., Tbilisi, 0105, Georgia
[b]School of Natural Sciences and Medicine, Ilia State University; 3/5 K. Cholokashvili Ave., Tbilisi, 0162, Georgia

Received: 14 December 2020; accepted: 28 December 2020

A B S T R A C T

Nineteen species of gasteroid fungi of 10 genera and six families were recorded in steppe and semi-desert habitats of Georgia, the South Caucasus, in 2019 within the framework of a research project "Dryland cryptogams of Georgia: diversity, conservation and potential as bioindicators of desertification" supported by Shota Rustaveli National Science Foundation. Five species: *Cyathus stercoreus* (Schwein.) De Toni, *Disciseda bovista* (Klotzsch) Henn., *Gastrosporium simplex* Mattir., *Geastrum floriforme* Vittad. and *Geastrum xerophilum* Long ex Desjardin are new for Georgia's mycobiota.

Keywords: Agaricomycetes, Gasteromycetes, Biodiversity, Drylands, Kvernakebi, Gareji.

*Corresponding author: Ketevan *Batsatsashvili;* E-mail address: ketevan_batsatsashvili@iliauni.edu.ge

Introduction

Gasteroid fungi (Gasteromycetes) is a group in the phylum Basidiomycota with basidiospores developing in angiocarps, friutbodies closed until basidiospore maturation. Species of this group are mainly terrestrial, epigeous or nypogeous, partly saprobic and partly ectomycorrhizal; they are cosmopolitan, occurring especially in warm dry areas [1]. The first comparatively large (28 species) of Georgia's gasteroid fungi was included in a work by Voronov [2]. Data on separate species are given in works by Haussknecht [3], Voronov [4], Voronikhin [5, 6], Singer [7], Vasilkov [8], Kreisel [9], Jorjadze [10-12] and annual reports of the Department of spore-producing plants and fungi of the Institute of Botany, Ilia State University, Tbilisi, Georgia. The first annotated checklist of Georgia's gasteroid fungi was published by Nakhutsrishvili in 1972 and later in 1982 with 53 species recorded throughout the country [13, 14].

Materials & Methods

Study area

The study area covers parts of the major distribution range of Georgia's semi-arid open forests of *Pistacia mutica* Fisch. & C.A. Mey. and *Juniper* spp., scrub constituted by various hemi-xerophilic species with predominance of *Paliurus spina-christi* Mill., various steppe communities mostly made up of *Botriochloa ischaemum* (L.) Keng, semi-desert vegetation dominated by *Artemisia lerchiana* Weber and a number of transitional and mixed communities [15, 16]; it particularly includes southern slopes and foothills of the Kvernakebi low range along the left banks of the river Mtkvari (Kura), and Gareji and Taribana drylands on the Iori plateau. The 70 km long Kvernakebi range stretches along the left bank of Mtrkvari from the river Sakashetiskhevi to the west reaching the river Aragvi to the east. The 170 km long and 50-60 km wide Iori plateau is stretched from the northwest to the southeast between the rivers Mtkvari and Alazani. The elevations within the study area mostly

range from 300 m (Chachuna Sanctuary) to 750 m (Garedji area) but in places reach 800 m a.s.l. Conglomerates, sandstone, clay and in places limestone shape the geological profile [17-19].

The mean annual temperature of the semi-arid areas of the eastern Caucasus is 12-13°C. Summer is very warm with the mean monthly temperature of July between 22-24°C; winter in mild as on the major portion of the East Georgian territory with the main temperature of January ranging between - 4°C and 4°C. The average annual precipitation ranges between 400-600 mm; precipitation decreases to the east being the lowest on Iori plateau. The major portion of the annual precipitation falls in spring and summer in a form of the heavy downpours. Precipitation is the lowest in winter months with unstable snow cover, which is in some years absent [18, 20].

Specimen collection and identification

Fruitbodies of gasteroid fungi were collected in various semi-arid habitats of east Georgia from June to December, 2019. Carpophores and habitats were photographed for each collection using Nicon Coolpix L830. Geographic coordinates were recorded for each locality Garmin Etrex 20. Habitat characteristics: slope exposure and inclination, plant cover; and substrate were also recorded.

Species were identified and stored at the Herbarium of the Department of spore-producing plants and fungi of the Institute of Botany of Ilia State University (at the Cryptogam Herbarium, which is a part of the National Herbarium of Georgia, TBI). Melzer's iodine reagent or 5% KOH was used for treatment of small sections of gleba for microscopical examination Olympus CX31RBSF binocular microscope. Various keys were used for species identification [21-26, etc.].

Fungi nomenclature follows Index Fungorum [27]. Vascular plant nomenclature in the short descriptions of examined habitats follow Gviniashvili et al. [28].

Results & Discussion

Nineteen species of gasteroid fungi of 10 genera and six families were recorded in steppe and semi-desert habitats of Georgia, the South Caucasus, in 2019 within the framework of a research project "Dryland cryptogams of Georgia: diversity, conservation and potential as bioindicators of desertification" supported by Shota Rustaveli National Science Foundation. The genus *Geastrum* was the most diverse with six species recorded.

The most abundant were fruitbodies of *Disciseda bovista* (Klotzsch) Henn., *Disciseda candida* (Schwein.) Lloyd, *Tulostoma brumale* Pers. and *Tulostoma fimbriatum* Fr. It is noteworthy that eighteen fruitbodies of *T. fimbriatum* were collected in a single open place on 35 cm2 area among *Paliurus spina-christi* shrubs in the Kotsakhuri dry gorge on the Kvernakebi study area.

Chlorophyllum agaricoides (Czern.) Vellinga and *Tulostoma volvulatum* I.G. Borshch. Were found in every of the three study areas (Kvernakebi, Gareji and Taribana).

Five species: *Cyathus stercoreus* (Schwein.) De Toni, *Disciseda bovista* (Klotzsch) Henn., *Gastrosporium simplex* Mattir., *Geastrum floriforme* Vittad. and *Geastrum xerophilum* Long ex Desjardin are new for Georgia's mycobiota.

Below a list of the recorded species is given: families, genera and species are listed in alphabetic order. Locality, habitat, substrate, collection date and collector name are given for the species recorded. Specimen descriptions are given for the species new for Georgia's mycobiota.

Agaricaceae Chevall

***Disciseda bovista* (Klotzsch) Henn., Hedwigia 42 (Beibl.): (128) (1903) (Fig. 1a)**

Fruitbody spherical or depressed spherical to discoid, 1-5 cm diam. Exoperidium thick, with breakages, at maturity cracks into two unequal parts, the upper part disappears, the lower one remains in as a disc encrusted with soil and plant debris. Endoperidium spherical 1-3.5 cm diam., leathery, smooth, persistent, at first greyish, later brown, opens at tip with a single ostiole. Gleba at first white, dense, later brown and pulverulent. Spores globose, 6-8 μm diam., verrucose, brownish, with or without short sterigmal remnants.

Habitat: On sandy soil.

Material examined: Near David Gareji Monastery, Sagarejo Municipality, 600 m a.s.l., N45.3765 E41.4532, 11.11.2019, A. Jorjadze, TBI5022821; Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022817.

Geographic distribution: Argentina, Armenia, Australia, Austria, Czech, Denmark, France, Germany, Holland, Hungary, India, Iran, Israel, Italy, Kazakhstan, Mongolia, Netherlands, New Zealand, Norway, Poland, Republic, Romania, Russia, Slo-

vakia, Spain, Sweden, Switzerland, Turkmenistan, Ukraine; North and Southern Africa [9, 23, 29, 30].

Notes: *Disciseda bovista* is morphologically similar to *Disciseda candida,* but is characterized by larger and strongly ornamented spores [31].

***Disciseda candida* (Schwein.) Lloyd, Mycol. Writ. 1: 100 (1902) (Fig. 1b)**

Material examined: On sandy soil, steppe community, everywhere, scattered, Gareji dryland, Sagarejo Municipality, 800 m a.s.l., N45.3183 E41.4747, 14.10.2019, A. Jorjadze, TBI5022799; on sandy soil, Taribana, Chachuna Sanctuary, Dedoplistskaro Municipality, 360 m a.s.l., N45.9764 E41.2766, 29.10.2019, A. Jorjadze, TBI5022786; on sandy soil, steppe community, Gareji dryland, Sagarejo Municipality, 825 m a.s.l., N45.3483 E41.4842, 19.11.2019, A. Jorjadze, TBI5022820.

Geographic distribution: Armenia, Australia, Austria, Czech Republic, Denmark, France,Germany, Holland, Hungary, India, Iran, Kazakhstan, Lithuania, New Zealand, Norway, Poland, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Ukraine, United States; South Africa and South America [9, 23, 25, 30, 32, 33].

***Chlorophyllum agaricoides* (Czern.) Vellinga, Mycotaxon 83: 416 (2002) (Fig. 1c)**

Material examined: Near *Salsola* sp., on sandy soil, Kvernakebi Range, Kaspi Municipality, 670 m a.s.l., N41.9672 E44.3374, 14.09.2019, A. Jorjadze, TBI5022797; under *Salsola* sp., on sandy soil, Kvernakebi Range, Kaspi Municipality, 650 m a.s.l., N41.96186 E44.3466, 23.09.2019, A. Jorjadze, TBI5022812; under *Salsola* sp., on sandy soil, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022780; on soil, steppe community, near David Gareji Monastery, Sagarejo Municipality, 600 m a.s.l., N45.37652 E41.4532, 11.11.2019, A. Jorjadze, TBI5022823.

Geographic distribution: Algeria, Armenia, Australia, Austria, Bulgaria, Czech Republic, France, Germany, Hungary, Israel, Italy, Kazakhstan, Kyrgyzstan, Lithuania, Mongolia, New Zealand, Romania, Russia, Slovakia, Sweden, Tajikistan, Turkmenistan, Ukraine, Uzbekistan; South Africa, South America [9, 23, 32, 33].

***Mycenastrum corium* (Guers.) Desv., Annls Sci. Nat., Bot., sér. 2 17: 147 (1842) (Fig. 1d)**

Material examined: On sandy soil, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022779.

Geographic distribution: Algeria, Armenia, Austria, Belgium, Bulgaria, Czech Republic, Denmark, Ethiopia, Finland, France, Germany, Hungary, India, Mexico, Israel, Italy, Kazakhstan, Kenya, Kyrgyzstan, Lithuania, New Zealand, Norway, Poland, Romania, Russia, Slovakia, Socotra (Yemen), South African Rep., Spain, Sweden, Tanzania, Netherlands, Tunisia, Turkmenistan, Uganda, Ukraine, United States, Uzbekistan, Zanzibar; Eastern Africa, South America [9, 23, 26, 30, 32-34].

***Tulostoma brumale* Pers., Neues Mag. Bot. 1: 86 (1794) (Fig. 1e)**

Material examined: On sandy soil, Kvernakebi Range, Kaspi Municipality, 670 m a.s.l., N41.9672 E44.3374, 14.09.2019, A. Jorjadze, TBI5022810; among mosses, under *Rhamnus pallasii* Fisch. & C.A.Mey., Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022809; among mosses, under *Paliurus spina-christi,* Kotsakhuri dry gorge, Kvernakebi Range, Kaspi Municipality, 600 m a.s.l., N41.9602 E44.3801, 01.12.2019, A. Jorjadze, TBI5022808.

Geographic distribution: Armenia, Austria, Azerbaijan, Belgium, Bulgaria, Czech Republic, Denmark, England, Estonia, Finland, France, Germany, Greece, Hungary, India, Iran Ireland, Italy, Japan, Kazakhstan, Lithuania, Netherlands, New Zealand, Norway, Poland, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Tunesia, Turkmenistan, Ukraine; North America [9, 23, 30, 32, 33].

***Tulostoma fimbriatum* Fr., Syst. mycol. (Lundae) 3(1): 43 (1829) (Fig. 1f)**

Material examined: On sandy soil, Kvernakebi Range, Kaspi Municipality, 650 m a.s.l., N41.9621 E44.3462, 23.09.2019, A. Jorjadze, TBI5022808.

Geographic distribution: Argentina, Armenia, Austria, Czech Republic, Denmark, France, Germany, Hungary, Iran, Italy, Kazakhstan, Lithuania, Lithuania, Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Ukraine; North America [9, 23, 29, 30, 32, 33].

Note: Eighteen carpophores found on area of 35 cm^2.

***Tulostoma volvulatum* I.G. Borshch., Mat. Bot. Geogr. Aralo-Kaspi Imp. Akad. Nauk. St. Petersb. 7: 189 (1865) (Fig. 1g)**

Material examined: On sandy soil, Uplistsikhe, Gori Municipality, 600 m a.s.l., N41.9593 E44.2414,

05.06.2019, A. Jorjadze, TBI5022794; on calcareous soil, Taribana, Chachuna Sanctuary, Dedoplistskaro Municipality, 460 m a.s.l., N41.3187 E 45.9896, 05.11.2019, A. Jorjadze, TBI5022801; on sandy soil, steppe community, near David Gareji Monastery, Sagarejo Municipality, 600 m a.s.l., N45.3766 E41.4532, 11.11.2019, A. Jorjadze, TBI5022807.

Geographic distribution: Algeria, Armenia, Azerbaijan, Egypt, France, Hungary, India, Iran, Israel, Jordania, Kazakhstan, Kyrgyzstan, Mali, Mauretania, Morocco, Russia, Somalia, Soudan, Spain, Tunesia, Turkmenistan, Ukraine, Yemen; North Africa, Eastern Africa, North America [9, 23, 30, 33, 34].

Gastrosporiaceae Pilát

***Gastrosporium simplex* Mattir., Mém. R. Accad. Sci. Torino, Ser. 2 53: 361 (1903) (Fig. 1h)**

Fruitbody hypogeous, chalky white, spherical or ellipsoid, pearl-like, 0.8-1.4 cm diam., with white

Fig. 1 a – *Disciseda bovista,* b – *D. candida*, c – *Chlorophyllum agaricoides*, d – *Mycenastrum corium,* e – *Tulostoma brumale*, f – *T. fimbriatum,* g – *T. volvulatum,* h – *Gastrosporium simplex*, i – *Geastrum campestre*, j – *G. coronatum*, k – *G. floriforme,* l – *G. minimum*

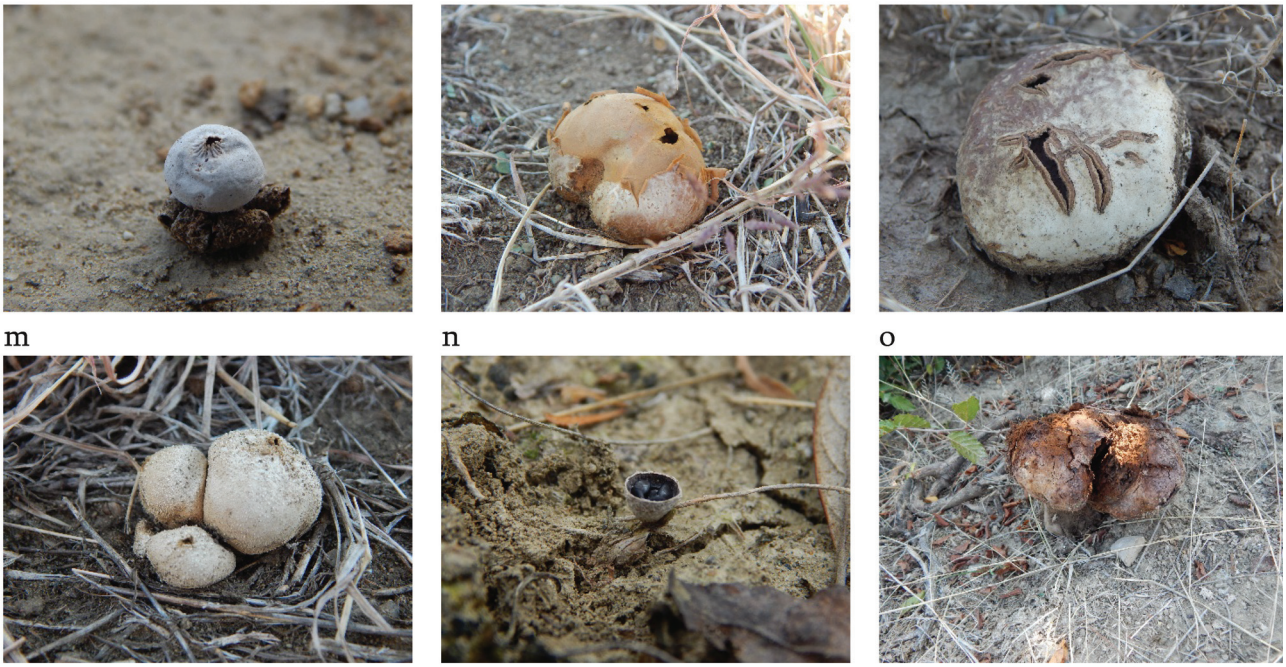

Fig. 1 (cont.) m – *Geastrum xerophilum,* n – *Calvatia candida*, o – *C. cyathiformis*, p – *Lycoperdon perlatum,* q – *Cyathus stercoreus*, r – *Pisolithus arhizus*

mycelial cord 5-12 cm long and 1 mm thick, subgleba absent, growth solitary or in small groups. Exoperidium chalky white, flocculent, covered by with calcium oxalate crystals. Endoperidium at first pale ochreous and cartilaginous, then grey and membranous, cracking at maturity. Gleba whitish grey and soft, then pale ochraceous and powdery, without capillitium. Spores spherical or ellipsoid 3.6-5.2 × 4-5 µm, pale ochraceous, finely verrucose.

Habitat: Underground carpophore found among roots of various herbaceous plant species. Ground surface covered with mosses *(Pleurochaete squarrosa* (Brid.) Lindb.) and lichens *(Cladonia rangiformis Hoffm.*). Near *Paliurus spina-christi* shrub.

Material examined: Steppe community, near David Gareji Monastery, Tapobi, Sagarejo Municipality, 600 m a.s.l., N45.3766 E41.4532, 11.11.2019, A. Jorjadze, TBI5022805.

Geographical distribution: Argentina, Austria, Bulgaria, Czech Republic, France, Germany, Great Britain, Italy, Kazakhstan, Pakistan, Poland, Slovakia, Spain, Sweden, Switzerland, Ukraine [9, 23, 33, 35, 36].

Notes: G. simplex grows in well ventilated and sunny places, where ground surface temperature reaches 45°C. On calcicolous soils. Associated with various grasses: Stipa L., Festuca L., Bromus L., Sesleria Scop., Agropyron Gaertn., Artemisia L., Carex L. and others [23, 36-38].

Geastraceae Corda

***Geastrum campestre* Morgan, Am. Nat. 21: 1027 (1887) (Fig. 1i)**

Material examined: On sandy soil, under *Rhamnus pallasii*, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.97182 E44.20432, 25.09.2019, A. Jorjadze, TBI5022784; steppe community made up of *Bothriochloa ischaemum*, Gareji dryland, Sagarejo Municipality, 600 m a.s.l., N45.3766 E41.4532, 11.11.2019, A. Jorjadze, TBI5022825.

Geographic distribution: Armenia, Australia, Austria, Czech Republic, Denmark, France, Germany, Great Britain, Hungary, Japan, Kazakhstan, Lithuania, Norway, Romania, Russia, Slovakia, Spain, Sweden, The Netherlands, Ukraine; South Africa, North America [9, 23, 30, 32, 33, 39].

***Geastrum coronatum* Pers., Syn. meth. fung. (Göttingen) 1: 132 (1801) (Fig. 1j)**

Material examined: Among mosses, under *Rhamnus pallasii*, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022818.

Geographic distribution: Armenia, Austria, Bulgaria, Czech Republic, Denmark, Estonia, France, Germany, Great Britain, Greece, Hungary, Kazakhstan, Kyrgyzstan, Lithuania, New Zealand, Norway, Poland, Portugal, Romania, Slovakia, Spain, Swe-

den, The Netherlands, Ukraine; North America, Central America, Australia, Africa [9, 23, 30, 32, 33, 39].

***Geastrum floriforme* Vittad., Monogr. Lycoperd. (Torino): 167 (23 of prepr.) (1842) (Fig. 1k)**

Fruitbody at first spherical 1-1.5 cm wide, slightly concave at base, greyish, at maturity exoperidium splits into 6-9 unequal rays, expanded fruiting body 2-4 cm diam., lobes strongly hygroscopic, upper surface of rays glabrous and brown, in dry conditions the rays curl around the fruitbody covering it. Endoperidium sessile, globose to depressed globose, 0.5-1.5 cm diam., grey-brown; peristome indeterminate, with uneven fibrillose edge. Gleba dark brown, powdered. Spores globose, brownish, warted, 5.5-6 μm.

Habitat: On sandy soil, with dry mosses.

Material examined: Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022813.

Geographical distribution: Argentina, Armenia, Australia, Austria, China, Czech Republic, Denmark, Finland, England, France, Germany, Great Britain, Italy, Kazakhstan, Mexico, New Zealand, Poland, Portugal, Romania, Russia, Slovakia, Spain, Sweden, The Netherlands, Ukraine, United States; Southern Africa [9, 23, 30, 33, 40, 41].

Notes: *G. floriforme* morphologically similar to *G. corollinum*. However, *G. floriforme* basidiocarps are hypogeous when unexpanded, have indistinctly delimited peristomes and mycelial layer is encrusted with sand or plant debris. *G. floriforme* differs from *G. hungaricum* by its indistinctly delimited peristome, smooth endoperidial surfaces, and larger basidiospores. *G. kotlabae* can be segregated due to its plicate peristome and verrucose endoperidium [41-43].

***Geastrum minimum* Schwein., Schr. naturf. Ges. Leipzig 1: 58 [32 of repr.] (1822) (Fig. 1l)**

Material examined: On soil, steppe community, near artificial lake, near David Gareji Monastery, Sagarejo Municipality, 620 m a.s.l., 41.4570, 45.3710, 14.10.2019, A. Jorjadze, TBI5022815; on soil, steppe community, Gareji dryland, Sagarejo Municipality, 770 m a.s.l., N41.4874 E45.3277, 07.11.2019, A. Jorjadze, TBI5022804.

Geographic distribution: Australia, Austria, Belgium, Congo, Czech Republic, Denmark, Estonia, Finland, France, Germany, Great Britain, India, Iran, Israel, Italy, Japan, Kazakhstan, Latvia, Lithuania, New Zealand, Nigeria, Norway, Pakistan, Portugal, Romania, Slovakia, South African Rep., Spain, Sweden, Switzerland, The Netherlands, Ukraine; North America, Central America, South America [9, 23, 32, 33, 41].

***Geastrum nanum Pers.*, J. Bot. (Desvaux) 2: 27 (1809)**

Material examined: On sandy soil, open area, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 25.09.2019, A. Jorjadze, TBI5022783.

Geographic distribution: Australia, Austria, Belgium, Great Britain, Czech Republic, Denmark, Estonia, Finland, France, Germany, India, Ireland, Italy, Kazakhstan, Kenya, Latvia, Lithuania, Norway, Poland, Romania, Russia, Slovakia, South African Rep. Spain, Sweden, Tanzania, The Netherlands, Ukraine; Southern Africa, Eastern Africa, North America, Central America, South America (9, 23, 32, 33, 34, 40).

***Geastrum xerophilum* Long ex Desjardin, Pacific Sci. 65(4): 493 (2011) (Fig. 1m)**

Fruitbody at first spherical, at maturity exoperidium splits into 6-7 non-hygroscopic rays rolling up under endoperidium. Fully expanded fruitbody 15-20 mm diam. and 7-10 mm tall. Rays greyish brown, surface encrusted with sand. Endoperidium globose, 10 mm diam., stalked, pallid-grey, surface furfuraceous, then glabrous. Peristome conical, 1 mm tall, not delimited, sulcate. Gleba brown. Spores globose, warted, 5-6 μm diameter.

Habitat: On sandy soil.

Material examined: Open area, Uplistsikhe, near old cemetery, Gori Municipality, 615 m a.s.l., N41.9718 E44.2043, 06.10.2020, A. Jorjadze, TBI50225240.

Geographic distribution: Brazil, Hawaii, Mexico, Spain, United States [41].

Notes: Geastrum xerophilum, a species typical of xerophytic environments, occurs in semi-arid climate with low irregular rainfall and high temperature and evapotranspiration. The species is morphologically similar to *G. campestre* Morgan, which differs in its hygroscopic rays, delimited peristome, and larger spores (6.5-8.0 μm diam.) [44].

Lycoperdaceae Chevall

***Calvatia candida* (Rostk.) Hollós, Term. Füz. 25: 112 (1902) (Fig. 1n)**

Material examined: On sandy soil, steppe community, Gareji dryland, Sagarejo Municipality, 800 m a.s.l., N45.3182 E41.4747, 14.10.2019, A. Jorjadze, TBI5022795; on sandy soil, steppe commu-

nity, Gareji dryland, Sagarejo Municipality, 600 m a.s.l., N45.3766 E41.4532, 11.11.2019, A. Jorjadze, TBI5022791.

Geographic distribution: Armenia, Australia, Czech Republic, Germany, Hungary, India, Iran, Italy, Kazakhstan, Kyrgyzstan, Lithuania, Poland, Portugal, Romania, Russia, Slovakia, South African Rep., Sweden, The Netherlands, Ukraine; North America, South America [9, 23, 30, 32, 33, 45].

***Calvatia cyathiformis* (Bosc) Morgan, J. Cincinnati Soc. Nat. Hist. 12(4): 168 (1890) (Fig. 1o)**

Material examined: On sandy soil, steppe community, Gareji dryland, Sagarejo Municipality, 800 m a.s.l., N45.3182 E41.4747, 14.10.2019, A. Jorjadze, TBI5022822.

Geographic distribution: Africa, Armenia, China, Cuba, Japan, India, Lithuania, Ukraine, United States; East Africa, South America [26, 30, 32-34, 45, 46].

***Lycoperdon perlatum* Pers., Observ. mycol. (Lipsiae) 1: 4 (1796) (Fig. 1p)**

Material examined: On soil, steppe community, near artificial lake, near David Gareji Monastery, Sagarejo Municipality, 620 m a.s.l., 41.4570, 45.3710, 07.10.2019, A. Jorjadze, TBI5022782.

Geographic distribution: Armenia, Australia, Austria, Azerbaidjan, Belgium, British, Bulgaria, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Iran, Ireland, Italy, Kazakhstan, Kyrgyzstan, Lithuania, Luxembourg, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovenia, South African Rep., Spain, Sweden, Switzerland, The Netherlands, Ukraine, United States, Yugoslavia; South America, Tasmania [9, 23, 26, 30, 32, 33].

Nidulariaceae Dumort

***Cyathus stercoreus* (Schwein.) De Toni, in Berlese, De Toni & Fischer, Syll. fung. (Abellini) 7(1): 40 (1888) (Fig. 1q)**

Fruitbody narrowly bell-shaped, 7 mm tall, 4 mm diam., narrows downward to 1mm diam., on the outside hairy, gray to brownish white, internally surface smooth, lead black. Peridioles lead black, smooth, lenticular, 2 mm diam., peridioles attached to peridium with white epiphragm. Spores globose to subglobose, 22-30 μm diam., smooth, thick-walled 4 μm thick.

Habitat: On manured and sandy soil, straw.

Material examined: Kotsakhuri dry gorge, southern macro-slope of the Kvernakebi Range, Kaspi Municipality, 600 m a.s.l., N41.9602 E44.3801, 01.12.2019, A. Jorjadze, TBI5022803.

Geographic distribution: Africa, Armenia, Australia, Austria, British, China, Corse, Cuba, Czech Republic, Denmark, France, Germany, Greece, India, Iran, Israel, Italy, Kazakhstan, Lithuania, New Zealand, Norway, Portugal, Romania, Russia, Slovakia, South African Rep., Spain, Sweden, Switzerland, The Netherlands, Ukraine, Zimbabwe; North America, South America [9, 23, 30, 32, 33].

Sclerodermataceae Corda

Pisolithus arhizus (Scop.) Rauschert, Z. Pilzk. 25(2): 50 (1959) (Fig. 1r)

Material examined: On eroded soil, meadow, area of about 5 m radius around *Rhamnus pallassi*, *Paliurus spina-christi*, *Carpinus orientalis* Mill. scrub, Kotsakhuri dry gorge, southern macro-slope of the Kvernakebi Range, Kaspi Municipality, 600 m a.s.l., N41.9602 E44.3801, 14.09.2019, A. Jorjadze, TBI5022781; on soil, under *Carpinus orientalis*, Kotsakhuri dry gorge, southern macro-slope of the Kvernakebi Range, Kaspi Municipality, 600 m a.s.l., N41.9602 E44.3801, 10.10.2019, A. Jorjadze, TBI5022789.

Geographic distribution: Austria, Belgium, British, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Israel, Italy, Mauritius, Norway, Pakistan, Poland, Portugal, Russia, Thailand; South African Rep., Spain, Sweden, The Netherlands, Ukraine, Zambia [9, 33, 47, 48].

Acknowledgement

We would like to thank Shota Rustaveli National Science Foundation for financial support of our research within the framework of the grant project FR-18-14169 “Dryland cryptogams of Georgia: diversity, conservation and potential as bioindicators of desertification”.

References

[1] P.M. Kirk, P.F. Cannon, D.W. Minter, J.A. Stalpers, Dictionary of the Fungi, Tenth ed., CABI, Wallingford, 2008.

[2] J. Voronov, Collection of data on mycoflora of the Caucasus, Trudy Tiflisskogo Botanicheskogo Sada 13(2) (1915) 1 – 200 (in Russian).

[3] H.K. Haussknecht, Overview of the cryptogams

collected by Prof. Dr. Haussknecht in the Orient, Hedwigia 10 (1871) 17-27 (in German).
[4] J. Voronov, Collection of data on mycoflora of the Caucasus 2, Trudy Tiflisskogo Botanicheskogo Sada 2(3) (1922) 1 – 186 (in Russian).
[5] N.N. Voronikhin, Materials for the fungal flora of the Caucasus, Izvestiya Akademii Nauk SSSR, Petrograd, 1923 (in Russian).
[6] N. Voronikhin, Materials for the flora of fungi of the Caucasus, Trudy Botanicheskogo Muzeya, 21 (1927) 87 – 252 (in Russian).
[7] R. Singer, Mushrooms from the Caucasus – A contribution to the flora of the southwest central Caucasus, Beihefte zum Botanischen Centralblatt 46(2) (1929) 71-113 (in German).
[8] B.P. Vasilkov, On some interesting and new species of Gasteromycetes in the USSR, Trudy Botanicheskogo Instituta Akademii Nauk SSSR 2(9) (1954) 447 – 464 (in Russian).
[9] H. Kreisel, Checklist of the gasteral and secotioid Basidiomycetes of Europe, Africa, and the Middle East, Österr. Z. Pilzk. 10 (2001) 213 – 313.
[10] A. Jorjadze, Species of macro-fungi new for Georgia, Bull. Georgian Acad. Sci. 166(1) (2002) 94-96.
[11] A. Jorjadze, New records of Geastrum Persoon (Gasteromycetes) for Georgia, Proc. Georgian Acad. Sci. Ser. Biol. B 3-4 (2009) 14 – 17.
[12] M. Gvritishvili, Z. Tskitishvili, On finding of macromycete Myriostoma coliforme (Dicks.) Corda in Tbilisi Botanic Garden (TBG), Proc. Tbilisi Botanic Garden 94 (2004) 177 – 178.
[13] I.G. Nakhutsrishvili, Data for study of Georgia's Gasteromycetes, Proc. of the South Caucasian conference on spore-producing plants (1972) 23-235 (in Russian).
[14] I.G. Nakhutsrishvili, Flora of spore-producing plants of Georgia (A conspectus), Metsniereba, Tbilisi, 1986 (in Russian).
[15] N. Ketskhoveli, Georgia's vegetation cover, Metsniereba, Tbilisi, 1960 (in Georgian).
[16] G. Nakhutsrishvili, Vegetation of Georgia, Springer, Cham, 2013.
[17] D. Ukleba, Kvernakebi, in: I. Abashidze (Ed.), Georgian Soviet Encyclopedia, vol. 5, Tbilisi, 1980, p. 494 (in Georgian).
[18] L. Maruashvili, Iori Upland, in: Abashidze I. (Ed.), Georgian Soviet Encyclopedia, vol. 5, Tbilisi, 1980, pp. 95-96 (in Georgian).
[19] L. Maruashvili, Georgia's physical geography, Tsodna, Tbilisi, 1964 (in Georgian).
[20] E. Elizbarashvili, Georgia's climatic resources, Hydrometeorological Institute of Georgia, Tbilisi, 2007 (in Georgian).
[21] M.B. Ellis, P.J. Ellis, Fungi without Gills (Hymenomycetes and Gasteromycetes). An identification Handbook, Chapman and Hall, London, 1990.
[22] P.E. Sossin, The Handbook of the Gasteromycetes of the USSR, Nauka, Leningrad, 1973 (in Russian).
[23] S.R. Shvartsman, N.M. Filimonova, Flora of spore-producing plants of Kazakhstan, vol. 6: Gasteromycetes, Nauka, Alma-Ata, 1970 (in Russian).
[24] O.K. Miller, H.H. Miller, Gasteromycetes: morphological and developmental features, with keys to the orders, families, and genera, Mad River Press, Eureka, CA, 1988.
[25] D.N. Pegler, B.M. Spooner, T.W.K. Young, British Truffles: A revision of British hypogeous fungi, Royal Botanic Gardens, Kew, 1993.
[26] S.T. Bates, R.W. Roberson, D.E. Desjardin, Arizona gasteroid fungi I: Lycoperdaceae (Agaricales, Basidiomycota), Fungal Divers. 37 (2009) 153-207.
[27] Index Fungorum. http://www.indexfungorum.org/Index.htm, 2020 (accessed 15.11.2020).
[28] M. Davlianidze, Ts. Gviniashvili, M. Mukbaniani, L. Jinjolia-Imnadze, T. Jugheli, Nomenclatural checklist of flora of Georgia, Universali, Tbilisi, 2018.
[29] F. Kuhar, V. Castiglia, J.C. Zamora, L. Papinutti, New records and notes on gasteroid fungi of arid regions in Argentina, Sydowia 64(2) (2012) 233-244.
[30] S. Nanagulyan, L. Osipyan, Conspectus of mushrooms of Armenia. Gasteromycetes (Appendix to Armenian Biodiversity Strategy and Action Plan), Erevan, 2000.
[31] A. Vizzini, L. Panno, Disciseda bovista, recently collected from northern Italy, and Lycoperdon defossum, a synonym of D. candida, Mycotaxon 113 (2010) 129-136.
[32] M. Mazelaitis, Lietuvos TSR Gasteromicetai, Mokslas, Vilnius, 1982.
[33] M. Zerova, P. Sosin, G. Rojenko, Handbook of the Fungi of Ukraine, vol. 5(2), Naukova Dumka, Kiev, 1979.
[34] D.M. Dring, R. Rayner, Some Gasteromycetes from Eastern Africa, J. East Afr. Nat. Hist. Soc. Natl. Mus. 26 (1967) 5-46.
[35] L. Domínguez, M. Castellano, First report of

Gastrosporium simplex (Gasteromycetes) from South America, Mycotaxon 64 (1997) 443-448.
[36] M. Stasińska, Gastrosporium simplex (Fungi, Hymenogastrales) new localities in Pomerania (NW Poland), Pol. Bot. J. 47(1) (2002) 71-74.
[37] A. Pilat, On the genus Gastrosporium Mattirolo (Gasteromycetes), Bull. Soc. Mycol. France 50 (1934) 37-49 (in French).
[38] A. Tomaszewska, J. Łuszczyński, Ł. Lechowicz, M. Chrapek, Selected rare and protected macro-fungi (Agaricomycetes) as bioindicators of communities of xerothermic vegetation in the Nida Basin, Acta Mycol. 50(1) (2015) 1058(1-12).
[39] M. Jeppson, R.H. Nilsson, E. Larsson, European earthstars in Geastraceae (Geastrales, Phallomycetidae) – a systematic approach using morphology and molecular sequence data, System. Biodivers. 11(4) (2013) 437 – 465.
[40] J.C. Coetzee, A. Eicer, A. van Wyk, Taxonomic notes on Geastraceae, Tulostomataceae, Nidulariaceae and Sphaerobolaceae (Gasteromycetes) sense Bottomley, in southern Africa, Bothalia 27(2) (1997) 117-123.
[41] J.O. Sousa, L.A. Morais, Y.M. Nascimento, I.G. Baseia, Updates on the geographic distribution of three Geastrum species from Brazilian semi-arid region, Mycosphere 5(3) (2014) 467-474.
[42] T. Kasuya, K. Hosaka, H. Sakamoto, A. Uchida, T. Hoshino, M. Kakishima, New records of Geastrum from Japanese sand dunes, Mycotaxon 118 (2011) 1-15.
[43] S. Sunhede, Geastraceae (Basidiomycotina). Morphology, ecology, and systematics with special emphasis on the North European species, Synopsis Fungorum 1, Fungoflora, Oslo, 1989.
[44] B. Silva, J.O. Sousa, I.G. Baseia, Discovery of Geastrum xerophilum from the Neotropics, Mycotaxon 118 (2011) 355-359.
[45] R.K. Verma, S.N. Mishra, V. Pandro, A.K. Thakur, Diversity and distribution of Calvatia species in India: A new record from Central India, Int. J. Curr. Microbiol. Appl. Sci. 7(9) (2018) 2540-2551.
[46] F. Kotlaba, P. Zehnalek, Sixteen gasteromycetes collected in Cuba 50 years ago, Czech Mycol. 70(2) (2018) 185-209.
[47] N. Yousaf, M. Fiaz, H. Ahmad, A.N. Khalid, Gasteroid mycota of district Mansehra, Khyber Pakhtunkhwa, Pakistan, Int. J. Agric. Biol. 16(3) (2014) 571-577.
[48] D. Phanichapol, Some Gasteromycetes from Northern Thailand, Thai. For. Bull. 16 (1986) 233-236.