ORIGINAL PAPER

Diversity, taxonomic composition and ecology of Basidiomycetes of Guba district of Azerbaijan

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ABSTRACT
Question: What is the diversity and taxonomic structure of macrofungi in the Guba region of Azerbaijan? How many macrofungi are threatened?
Locations: Guba District, Azerbaijan.
Methods: field surveys, micromorphology studies follow Lodge *et al.* 2004 using a microscope Axio Imager Vert. A1 Carl Zeiss, Germany; identification of species follow Arora 1986, Grunert & Grunert, 2002, Horac 2005.
Nomenclature: index fungorum www.indexfungorum.org, MycoBank www.mycobank.org, World Flora Online www.worldfloraonline.org
Results: The article represents study on the diversity of forest ecosystems of Guba district based on the mushroom specimens collected in 2017–2022. Altogether 144 specimen including those kept at the mycological herbarium were involved to the study. The purpose of this work is to determine the species diversity, taxonomical composition and assignment to ecological groups of basidiomycetes of Guba district, taking into account modern taxonomical and nomenclatural novelties. As a result of study, 91 taxa (90 species and one intraspecific taxon) belonging to the 63 genera, 35 families and seven orders (Agaricales, Boletales, Cantharellales, Geastrales, Hymenochaetales, Russulales, Polyporales) were registered. *Coprinellus domesticus* and *Russula flavisiccans* represents new records for Azerbaijan. The ecological groups of fungi have been studied, species were irrespectively assigned to the saprobionts, symbionts, xylotrophes and parasites. The ecological role of *Cuphophyllus pratensis* and *Gliophorus psittacinus*is unclear, since they are found in moss, and it has been suggested that they can form a symbiosis. The distribution of these species depending on the altitude was also studied; fungal species were mainly noted in the low-mountain zone (51) and relatively less in the middle mountain zone (37). Three species (*Bolbitius titubans*, *Mycena pura*, *Hymenopellis radicata*) were recorded in both zones. Some of them grow along mountain slopes (Macrolepiota procera, Parasola plicatilis) and also occur in meadows. Rare and threatened mushroom species were identified based on IUCN Red List categories.
Conclusions: The study of the macrofungal diversity of the Guba distric expands our knowledge of the fungi of the studied territory, and also creates an opportunity to compare the most mushroom-rich areas of the Greater Caucasus within Azerbaijan in order to document and identify the diversity of fungal species and propose measures for their effective use in future.

KEYWORDS
altitude, ecological groups, genus, herbaria, morphology, mushroom, species, symbiont, threatened

CITATION
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INTRODUCTİON

Fungi are mostly inconspicuous organisms in nature, which means that their importance can be easily overlooked. They play a very important role in addressing major global problems, playing an important role in improving resource efficiency, creating renewable substitutes for products from fossils (De Mattos-Shipley *et al.* 2016, Wijayawardene *et al.* 2022). Since molecular phylogenetics has been used in fungal taxonomy, great progress has been made in species elucidation, and this has been discussed in several recent publications (Hawksworth & Lücking 2017, Zhao *et al.* 2016, 2017, Põlme *et al.* 2021, Kids *et al.* 2023). Macrofungi are heterotrophic organisms belong to the phyla Basidiomycota and Ascomycota and differ from all others in easily observable large fructification (Egbe *et al.* 2013, Kinge *et al.* 2020, Niego *et al.* 2023). Mushrooms are distinguished by great diversity and species richness in terms of phylogenesis and ontogenesis (Guarro *et al.* 1999, Tedersoo *et al.* 2018, Naranjo-Ortiz & Gabaldón 2019).

Fungi contribute to the regulation and improvement of ecosystems by performing vital functions, participating in carbon cycle and establishing symbiotic relationships with a number of other organisms (Brockerhoff *et al.* 2017, Lutzoni *et al.* 2018). One of the most important roles in the ecosystem is that of recyclers, which is biodegradation and decomposition of plant remnants (Riley *et al.* 2014). Macrofungi, also relatively little-studied but useful group of organisms (Hyde *et al.* 2019). Especially some basidiomycetes are a high-quality food source for forest animals and humans and are of great medical importance, which increases their use in various industries (Siddiq *et al.* 2018).

Guba is the second biggest district of the country and locates within the "Shahdagh National Park" in the North-East part of the Greater Caucasus, 600 m above sea level. The diversity of plants in the district has been comprehensively studied since the last century (Aghayeva *et al.* 2018, 2021). Along with plants the fungi, especially, including macromycetes of Guba district were investigated by a number of mycologists since 1950s (Aghayeva 2015, Sadigov 2001, 2007). The purpose of this research is to elucidate the species diversity and taxonomic structure of macrofungi, taking into account modern taxonomic and nomenclature novelties, ecological positions of the species in the growing environment and to determine the list of threatened species.

MATERİAL AND METODS

In total, more than 144 macrofungal specimens were involved in the study, collected from various ecosystems of the Guba district in 2017–2022, including 40 specimens deposited in the mycological herbarium of the Institute of Botany (BAK) in the last century. Specimens were collected from different villages of the district begining from late spring, in summer and autumn, mainly between May and November. GPS coordinates were recorded in the following villages: Ermeki (41.27972° N, 48.50722° E), Gultapa (41.29389° N, 48.47525° E), Ispik (41.30889° N, 48.41806° E), II Nugadi (41.3025° N, 48.56861° E), Kupchal (41.35667° N, 48.4625° E), Kusnatqazma (41.27556° N, 48.3375° E), Gechresh (41.34111° N, 48.41444° E), Grızdahna (41.2375° N, 48.30389° E), Uchkun (41.32972° N, 48.3825° E), Guba city (41.36528° N, 48.52639° E), I Nugadi (41.32972° N, 48.57167° E), Amsar (41.33194° N, 48.53944° E), Susay (41.31083° N, 48.29417° E), Rustov (41.25278° N, 48.58111° E), Xanagah (41.19083° N, 48.52111° E).

In the course of field work and observations, photographs of each specimen were taken, macromorphological characteristics (structure, size, shape of the fruit body, smell, taste, color change when cut, the presence of a volva and a stipe ring, etc.), environmental characteristics, such as temperature, forest type, neighboring plant species, soil type were noted. The micromorphological characteristics (structure, color, size, shape of spores) of the samples were determined (Lodge *et al.* 2004) using a microscope (Axio Imager Vert. A1 Carl Zeiss,

Germany). Identification of species, both field records, macro- and micromorphological features were analyzed based on available literature (Arora 1986, Grunert & Grunert 2002, Horac 2005), and the latest taxonomic and nomenclature novelties were taken into account.

All identified mushrooms were dried and deposited in BAK. The taxonomy and nomenclature of fungi have been adapted to the "Index Fungorum" www.indexfungorum.org, and "MycoBank" www.mycobank.org. The data on plant species were checked in "World Flora Online" www.worldfloraonline.org. In the study, the distribution of fungi depending on altitude above sea level (a.s.l.) was determined by Prilipko (1970).

RESULTS AND DİSCUSSİONS

In total, 91 taxa (90 species and one intraspecific taxon) belonging to 63 genera, 35 families and to seven orders of the Basidiomycota (Agaricales, Boletales, Cantharellales, Geastrales, Hymenochaetales, Russulales, Polyporales) were identified in Guba district (TABLE 1). Among the studied mushrooms, two species represent new record for Azerbaijan.

Coprinellus domesticus **(**Bolton) Vilgalys, Hopple & Jacq. Johnson (FİGURE 1 A–C).

The cap is 3–7 cm, at first it is convex oval, then it takes a wide bell-shaped form; young individuals are honey-ochre in color, and the prominent center is grayish-brown. There are whitish-brown scales or grains on it. As the cap ages, it turns gray but does not melt. The gills are adjacent to the leg or free, dense, white-cream colored, later discolor and blacken. The stem 4–10 × 0.4–1 cm, slightly swollen at the base, white, smooth as silk, hollow, ringless. Spores are 6–9 × 3.5–5 µm, ellipsoidal, smooth, eccentrically porous, with 3-4 oil drops, brown or black. The basidium is 4-spored.

Specimen examined. Guba city, alt. 556 m, 41.36528 ° N, 48.52639 ° E, 30 September 2018; Gultapa village, alt. 787 m, 41.29389 ° N, 48.47525 ° E, 01 October 2018 (BAK1763).

So far, the distribution of three species of the *Coprinellus* genus (*C. disseminates*, *C. micaceus*, *C. xanthothrix*) are known in the country. New inkcup species are found singly or in small groups, in the planted chestnut-walnut forest, in summer and autumn. It is a saprotroph, odor and taste are not distinctive. The features identified by us feats to the description in the literature (Redheadet *et al.* 2001). Mushroom sometimes forms a velvety orange coating called "ozonium" on dead trees.

Russula flavisiccans Bills (FİGURE 1 D–F).

The cap is 5–10 cm, convex at first, becomes flat or shallowly depressed in adults. Dry, very velvety to the touch, but feels dull. As it ripens, fine cracks appear in the center or completely on it; young individuals are reddish-pink or pink in color, but generally orange or yellowish-pink, with central yellowish or cream-colored spots, and the skin peels off with difficulty. The gills close to the stem, dense, short plates sparse or absent, white in young individuals, later cream or yellowish. The stem 3–5 × 1–2.5 cm, equal to the base or slightly narrowed, dry, smooth, whitish, brownish and pale. Spores 6–9 × 7–9 µm, hemispherical, furrowed, white.

Specimen examined. Guba district, Ispik village, alt. 740 m, 41.308889 ° N, 48.418056° E, 26 June 2021 (BAK1764).

Russula is one of the most widespread genera in terms of frequency of occurrence and number of species. Earlier 24 species of *Russula* (*R. albonigra*, *R. alutacea*, *R. aurea*, *R. aurora*, *R. curtipes*, *R. delica*, *R. emetica*, *R. farinipes*, *R. foetens*, *R. heterophylla*, *R. melitode*, *R. melliolens*, *R. minutula*, *R. olivacea*, *R. risigallina*, *R. rosea*, *R. rubra*, *R. sanguinaria*, *R. sanguinea*, *R. turci*, *R. velenovskyi*, *R. violacea*, *R. virescens* were reported in the country.

TABLE 1. Taxonomic structure of studied macromycetes

Order	Family	Genera	Species	%
Agaricales	Agaricaceae	*Agaricus* L.	1	1.1
		Lepiota (Pers.) Gray	2	2.2
		Macrolepiota Singer	3	3.3
	Amanitaceae	*Amanita* Pers.	5	5.5
	Bolbitiaceae	*Bolbitius* Fr.	1	1.1
		Conocybe Fayod	1	1.1
	Cortinariaceae	*Cortinarius* (Pers.) Gray	1	1.1
	Crepidotaceae	*Crepidotus* (Fr.) Staude	1	1.1
	Entolomataceae	*Clitopilus* (Fr. ex Rabenh.) P. Kumm.	1	1.1
		Entoloma (Fr.) P. Kumm.	2	2.2
	Galeropsidaceae	*Panaeolus* (Fr.) Quél.	1	1.1
	Hymenogastraceae	*Galerina* Earle	1	1.1
	Hygrophoraceae	*Cuphophyllus* (Donk) Bon	1	1.1
		Gliophorus Herink	1	1.1
		Hygrophorus Fr.	1	1.1
	Inocybaceae	*Inocybe* (Fr.) Fr.	1	1.1
	Lycoperdaceae	*Apioperdon* (Kreisel & D. Krüger) Vizzini	1	1.1
		Lycoperdon Pers.	2	2.2
	Marasmiaceae	*Marasmius* Fr.	1	1.1
	Mycenaceae	*Mycena* (Pers.) Rousse	3	3.3
	Omphalotaceae	*Rhodocollybia* Singer	1	1.1
	Physalacriaceae	*Hymenopellis* R.H. Petersen	1	1.1
	Pleurotaceae	*Pleurotus* (Fr.) P. Kumm.	1	1.1
	Pluteaceae	*Pluteus* Fr.	1	1.1
		Volvariella Speg.	1	1.1
	Psathyrellaceae	*Coprinellus* P. Karst.	2	2.2
		Coprinopsis P. Karst.	1	1.1
		Parasola Redhead, Vilgalys & Hopple	1	1.1
	Schizophyllaceae	*Schizophyllum* Fr.	1	1.1
	Strophariaceae	*Hypholoma* (Fr.) P. Kumm.	2	2.2
		Pholiota (Fr.) P. Kumm.	1	1.1
		Protostropharia Redhead, Moncalvo & Vilgalys	1	1.1
		Stropharia (Fr.) Quél.	1	1.1
	Tricholomataceae	*Tricholoma* (Fr.) Staude	2	2.2
	Incertae sedis	*Clitocybe* (Fr.) Staude	1	1.1
		Delicatula Fayod	1	1.1
		Lepista (Fr.) W.G. Sm.	1	1.1
		Phaeolepiota Maire ex Konrad & Maubl.	1	1.1
Boletales	Boletaceae	*Boletus* L.	2	2.2
		Hortiboletus Simonini, Vizzini&Gelardi	1	1.1
		Leccinellum Bresinsky&Manfr. Binder	2	2.2
		Rubroboletus Kuan Zhao & Zhu L. Yang	2	2.2
		Xerocomellus Šutara	1	1.1
		Xerocomus Quél.	1	1.1
	Paxillaceae	*Gyrodon* Opat.	1	1.1
		Paxillus Fr.	1	1.1
	Hygrophoropsidaceae	*Hygrophoropsis* (J. Schröt.) Maire ex Martin-Sans	1	1.1
	Suillaceae	*Suillus* Gray	1	1.1
Cantharellales	Hydnaceae	*Hydnum* L.	1	1.1
Geastrales	Geastraceae	*Geastrum* Pers.	1	1.1
Hymenochaetales	Hymenochaetaceae	*Phellinus* Quél.	1	1.1
Polyporales	Fomitopsidaceae	*Daedalea* Pers.	1	1.1
	Ganodermataceae	*Ganoderma* P. Karst.	2	2.2
	Laetiporaceae	*Laetiporus* Murrill	1	1.1
	Polyporaceae	*Cerioporus* Quél.	2	2.2
		Cerrena Gray	1	1.1
		Fomes (Fr.) Fr.	1	1.1
		Lentinus Fr.	1	1.1
		Polyporus P. Micheli ex Adans.	1	1.1
		Trametes Fr.	4	4.4
Russulales	Russulaceae	*Lactarius* Pers.	2	2.2
		Russula Pers.	6	6.5
	Stereaceae	*Stereum* Hill ex Pers.	1	1.1
7	**35**	**63**	**91**	**100%**

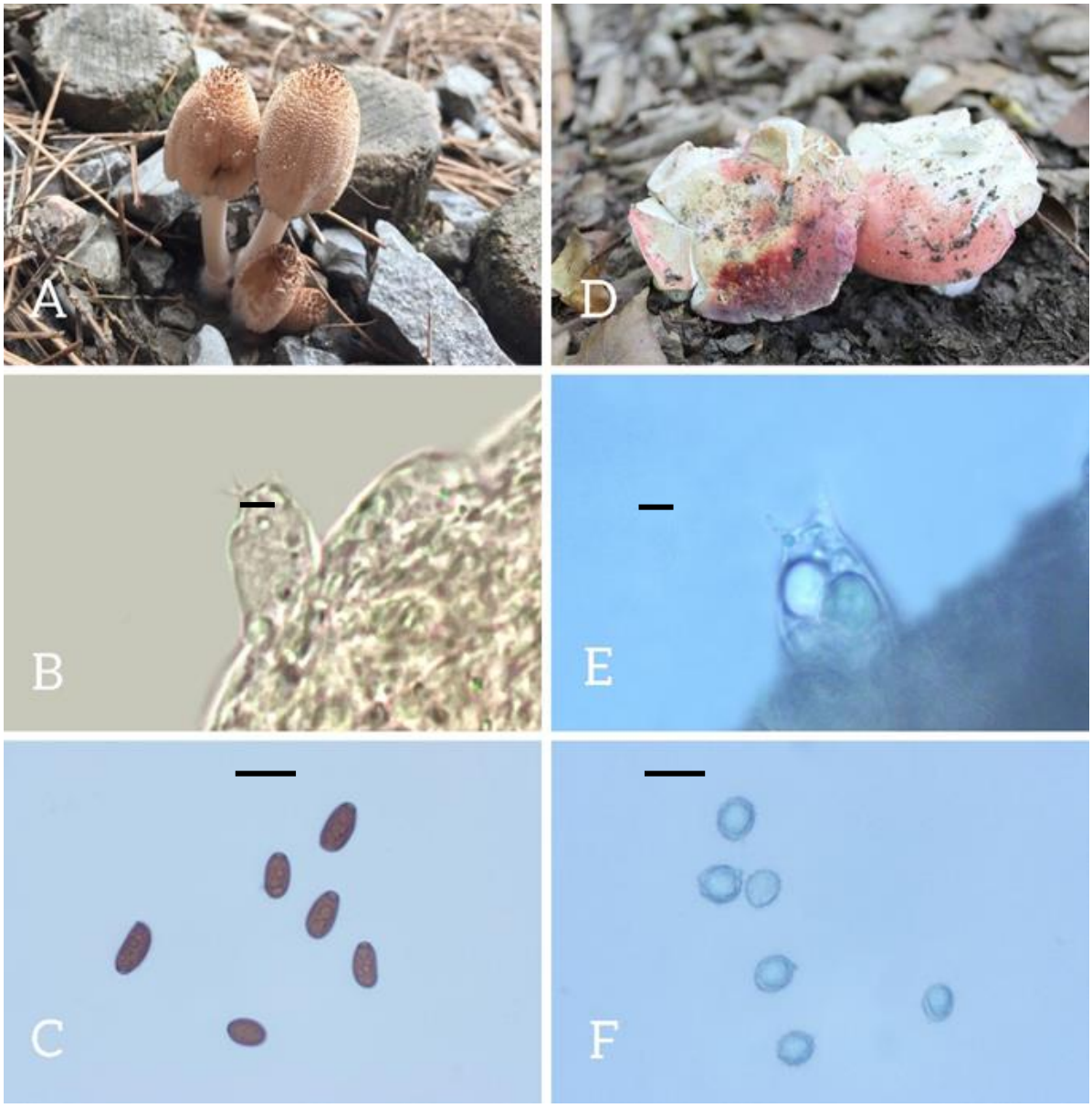

FIGURE 1. New records for Azerbaijan: *Coprinellus domesticus*: A – fruiting body, B – basidium, C – spores; *Russula flavissicans*: D – fruiting body, E – basidium, F – spores. Scale bar = 20 µm.

This group of mushrooms are found singly, scattered, sometimes in groups, in summer and autumn. *R. flavisiccans* forms mycorrhizae in broad-leaved forests, especially with oak. Odor is not distinctive, taste is oily and slightly acrid, and it is mouth-watering. Not edible. The features identified by us feats to the original description (Bills 1989).

Most of the identified species belong to the order Agaricales, which represented with 48 species of the 34 genera and 21 families (Agaricaceae, Amanitaceae, Bolbitiaceae, Cortinariaceae, Crepidotaceae, Entolomataceae, Galeropsidaceae, Hymenogasteraceae, Hygrophoraceae, Inocybaceae, Lycoperdaceae, Marasmiaceae, Mycenaceae, Omphalotaceae, Physalacriaceae, Pleurotaceae, Pluteaceae, Psathyrellaceae, Schizophyllaceae, Strophariaceae, Tricholomataceae). The following genera – *Clitocybe* (*Clitocybe odora*), *Delicatula* (*Delicatula integrella*), *Lepista* (*Lepista nuda*) and *Phaeolepiota* (*Phaeolepiota aurea*) designated Incertae sedis within Agaricales.

Investigated fungi of the family Agaricaceae belong to three genera and six species – *Agaricus bernardii*, *Lepiota brunneoincarnata*, *L. felina*, *Macrolepiota excoriata*, *M. mastoidea*, *M. procera*. The families Amanitaceae (*Amanita bisporigera*, *A. citrina*,

A. excelsa, *A. pantherina*, *A. rubescens*) and Psathyrellaceae (*Coprinellus domesticus*, *C. micaceus*, *Coprinopsis picacea*, *Parasola plicatilis* nclude four species per each, respectively from one and three genera. Strophariaceae were recorded with five species (*Hypholoma fasciculare*, *H. lateritium*, *Pholiota aurivella*, *Protostropharia semiglobata*, *Stropharia aeruginosa* of four genera, Tricholomataceae with two species (*Tricholoma sulphureum*, *T. terreum* of one genus.

The families Entolomataceae and Hygrophoraceae were represented with three species each: *Clitopilus prunulus*, *Entoloma griseocyaneum*, *E. rhodopolium* were determined within Entolomataceae, *Cuphophyllus pratensis*, *Gliophorus psittacinus*, *Hygrophorus chrysodon* within Hygrophoraceae. The family Bolbitiaceae was defined with two species (*Bolbitius titubans*, *Conocybe apala* of two genera, Lycoperdaceae with three species (*Apioperdon pyriforme*, *Lycoperdon perlatum*, *L. pratense*) of two genera and Mycenaceae with three species (*Mycena crocata*, *M. pura*, *M. vitilis*) of single genus and Pluteaceae with two species (*Pluteus cervinus*, *Volvariella bombycina*) of two genera. Some families such as Cortinariaceae (*Cortinarius torvus*), Crepidotaceae (*Crepidotus mollis*), Galeropsidaceae (*Panaeolus papilionaceus*), Hymenogastraceae (*Galerina marginata*), Inocybaceae (*Inocybe geophylla* var. *lilacina*), Marasmiaceae (*Marasmius rotula*), Omphalotaceae (*Rhodocollybia butyracea*), Physalacriaceae (*Hymenopellis radicata*), Pleurotaceae (*Pleurotus ostreatus*), Schizophyllaceae (*Schizophyllum commune*) are represented with single species each.

Boletales was the second biggest order in number of genera (10) and species (13), which included six genera and nine species in Boletaceae (*Boletus edulis*, *B. reticulatus*, *Hortiboletus rubellus*, *Leccinellum griseum*, *L. pseudoscabrum*, *Rubroboletus lupinus*, *R. satanas*, *Xerocomellus chrysenteron*, *Xerocomus subtomentosus*), two genera and two species in Paxillaceae (*Paxillus involutus*, *Gyrodon lividus*). Two families, Hygrophoropsidaceae and Suillaceae, are each represented with single species, *Hygrophoropsis aurantiaca* and *Suillus granulatus*, respectively.

The order Polyporales of the division ranks third in the number of genera (9) and species (14) that include Fomitopsidaceae (*Daedalea quercina*), Ganodermataceae (*Ganoderma lucidum*, *G. applanatum*), Laetiporaceae (*Laetiporus sulphureus*). The family Polyporaceae is rich in number of genera (6) and species (*Cerioporus varius*, *C. squamosus*, *Cerrena unicolor*, *Fomes fomentarius*, *Lentinus tigrinus*, *Polyporus tuberaster*, *Trametes hirsuta*, *T. ochracea*, *T. pubescens* and *T. versicolor*).

The order Russulales includes three genera and nine species in two families, Russulaceae − *Lactarius pubescens*, *L. zonarius*, *Russula emetica*, *R. flavissicans*, *R. foetens*, *R. minutula*, *R. risigallina*, *R. turci* and Stereaceae - *Stereum hirsutum*.

The smallest orders were Cantharellales (*Hydnum repandum*), Geastrales (*Geastrum saccatum*) and Hymenochaetales (*Phellinus igniarius*) represented with one species per each.

Ecology. The climate of the Guba district is dry, mild-hot in summer in the plains, foothills, cold and very humid in the highlands. It varies from 2°C to 26°C in summer and from -4°C to 1°C in winter. Over the past five years, there has been a relative change in climatic conditions, with summers becoming warmer and winters relatively milder. The annual rainfall in the region is about 300 – 1500 mm. Soil type can be mainly divided into grassy mountain-meadow, brown mountain-forest and brown.Most of the district is mountainous, and oak and beech forests are common in the area with a predominance of beech. These forests give way upward to subalpine and alpine meadows (Aghayeva *et al.* 2021, Alimammadova & Aghayeva 2021).

Distribution of fungi depending on altitude was studied. Macrofungi were mainly found in the low-mountain zone (500 (600) – 800 (900) above sea level) and the mid-mountain zone (800 (900) – 1700 above sea level). Some species were recorded in both altitudes (FIGURE 2). These zones are covered by deciduous mixed forests mainly consisting of hornbeam, oak and beech trees.

The identified species were ecologically characterized depending on the substrate or trophic relationships. Macrofungi can be divided into saprobionts, parasites, and symbiotic species including mycorrhiza (Kinge *et al.* 2020). Most terrestrial macrofungi are saprobionts or mycorrhizal symbionts, but a few are plant pathogens. The fungi fruiting on woody substrates are usually either saprobionts or plant pathogens. According to this feature the designated species were divided into four groups: saprobionts (including humus saprobs), symbiotic (including mycorrhizals, moss symbionts), xylotrophes and parasites.

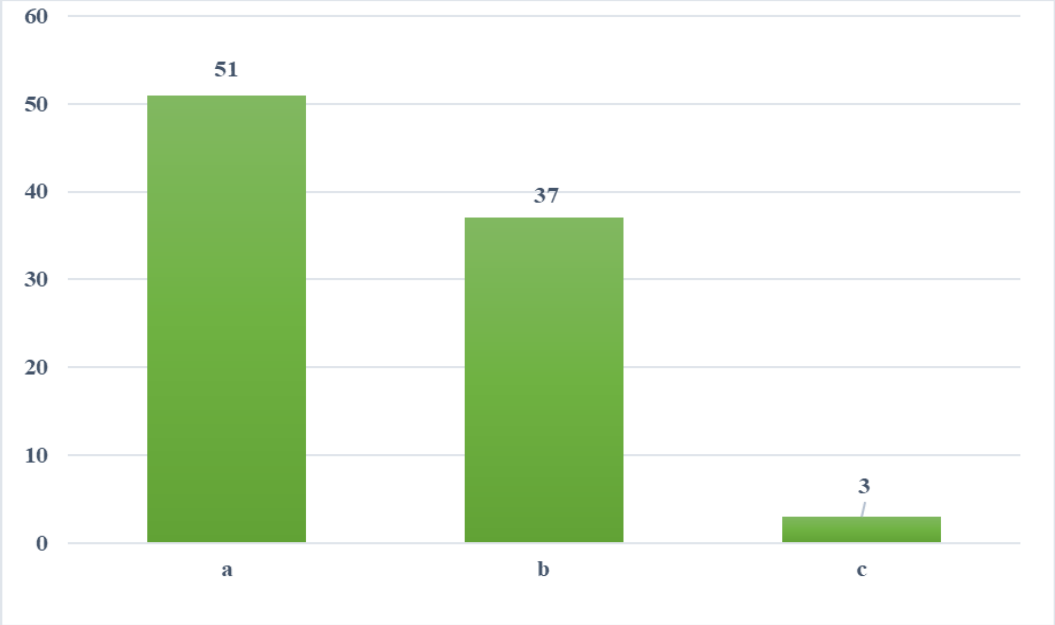

FIGURE 2. Altitude dependence of the number of species of basidiomycetes found in Guba district. a) low mountain zone; b) middle mountain zone; c) species found in both the low and middle mountain zones

Saprobionts include 14 species from 12 genera (*Apioperdon pyriforme, Coprinellus domesticus, C. micaceus, Delicatula integrella, Galerina marginata, Hygrophoropsis aurantiaca, Hymenopellis radicata, Hypholoma fasciculare, H. lateritium, Lentinus tigrinus, Lepiota felina, Marasmius rotula, Pluteus cervinus, Volvariella bombycina*). Also 24 humus saprobs (*Agaricus bernardii, Bolbitius titubans, Conocybe apala, Clitocybe odora, Clitopilus prunulus, Coprinopsis picacea, Entoloma griseocyaneum, Geastrum saccatum, Lepiota brunneoincarnata, Lepista nuda, Lycoperdon perlatum, L. pratense, Macrolepiota excoriata, M. mastoidea, M. procera, Mycena crocata, M. pura, M. vitilis, Panaeolus papilionaceus, Parasola plicatilis, Phaeolepiota aurea, Protostropharia semiglobata, Rhodocollybia butyracea, Stropharia aeruginosa*) belonging to 19 genera included to this group.

The macroevolutionary specialization of fungi for specific symbioses includes a variety of adaptations in relation to environmental and host factors. Mycorrhizal fungi contribute to the health and nutrition of plants by providing them with water and nutrients from the soil and protecting them from pathogens, herbivores, and some abiotic stresses. This group of fungi are also dominate in numbers and represented with species of *Amanita bisporigera, A. citrina, A. excelsa, A. pantherina, A. rubescens, Boletus edulis, B. reticulatus, Cortinarius torvus, Entoloma rhodopolium, Gyrodon lividus, Hortiboletus rubellus, Hydnum repandum, Hygrophorus chrysodon, Inocybe geophylla* var. *lilacina, Lactarius zonarius, L. pubescens, Leccinellum griseum, L. pseudoscabrum, Paxillus involutus, Rubroboletus lupinus, R. satanas, Russula emetica, R. flavisiccans, R. minutula, R. risigallina, R. turci, R. foetens, Suillus granulatus, Tricholoma sulphureum, T. terreum, Xerocomellus chrysenteron, Xerocomus subtomentosus*) belonging to 18 genera were recorded.

Amanita bisporigera, A. citrina forms a symbiosis with *Quercus macranthera, A. pantherina* in deciduous forests, especially with *Acer platanoides* and *A. rubescens* in deciduous forests. *Boletus edulis* and *B. reticulatus* grow around *Q. macranthera* and *A. platanoides*. *Cortinarius torvus* forms a symbiotic relationship in broad-leaved forests, especially with *Q. macranthera, A. platanoides* and *Corylus avellana*. *Gyrodon lividus, Hortiboletus rubellus* forms a mycorrhizal association with *Alnus barbata*. *Hydnum repandum* with *A. platanoides, Hygrophorus chrysodon* with *Pinus eldarica*, *Lactarius zonarius* with *Q. macranthera*, *Lactarius pubescens*with *Betula pendula, Leccinellum griseum, L. pseudoscabrum* with *Fagus orientalis, Paxillus involutus* with *Q. macranthera* and *B. pendula*, *Rubroboletus lupinus, R. satanas* with *F. orientalis* and *Carpinus orientalis, Russula emetica* conifers, especially *P. eldarica, R. flavisiccans* and *R. risigallina* mainly *Q. macranthera*, *R. minutula* with *F. orientalis* and *C. orientalis, R. turci* with *P. eldarica* and *Castanea sativa, R. foetens* in coniferous and broad-leaved forests, *Suillus granulatus* with conifers, *Tricholoma sulphureum* in broad-leaved forests, especially with *A. platanoides*, *T. terreum* with *P. eldarica*, *Xerocomellus chrysenteron* forms mycorrhizae in broad-leaved forests, especially with *A. platanoides*and *Xerocomus subtomentosus* with conifers.

Xylotrophs were identified as *Cerioporus varius, C. squamosus, Cerrena unicolor, Crepidotus mollis, Daedalea quercina, Fomes fomentarius, Ganoderma applanatum, G. lucidum, Laetiporus sulphureus, Phellinus igniarius, Pleurotus ostreatus, Polyporus tuberaster, Schizophyllum commune, Stereum hirsutum, Trametes hirsuta, T. ochracea, T. pubescens, T. versicolor*) belonging to different genera. Some of them can change life strategies depending on the health status of the host. *Pleurotus ostreatus* is frequently found on dying hardwoods and mainly acts saprotrophyclly rather than parasitically. Another widespread plant parasite is *Schizophyllum commune* which causes sap-rot and it is also a week decomposer. This fungus is a wood-rot basidiomycete that preferentially penetrates living plant tissues, including bark and sapwood and also potent mycoparasite of many palnt pathogenic fungi. *Stereum hirsutum* commonly forms on dead limbs and trunks, but pathogen of peech trees. Species of the genus *Trametes* are widespread in Azerbaijan. Only *T. hirsuta* among the species of the genus found in the study area is a parasite that grows on beech trees. *T. ochracea* and *T. pubescens* found on standing and dead wood of deciduous trees. *T. versicolor*is a common saprobiontic wood dweller or week wood parasite on living trees and found all forest types.

Cerioporus squamosus, *G. applanatum* and *G. lucidum* are facultative parasites. *G. lucidum* first grows on living hosts as parasite, then on dead hosts as saprophyte. *Fomes fomentarius* changes life style from parasite to a decomoser. *Laetiporus sulphureus* is generally known as a saprophyte, and partly as a weak parasite. *Phellinus igniarius* and *Polyporus tuberaster* are parasitic and eventually saprobic, restricted to deciduous trees.

Some of the species listed here have been found on one or more different substrates. *Macrolepiota procera* and *Parasola plicatilis* were found in the beech forest floor and grassland, *Bolbitius titubans* on fallen dry branches and in the broadleaf forest floor. *Cuphophyllus pratensis* and *Gliophorus psittacinus* are known to form a symbiosis with mosses.

Three species occuring in the territory were proposed to the third edition of the Red Book of Azerbaijan. These are *Amanita pantherina* (assessed as CR), *Rubroboletus satanas* (CR) and *Ganoderma lucidum* assessed (EN). In addition, through a search of available publications, and the database of the Global Fungal Red List Initiative (https://redlist.info/en/iucn/welcome), found that several species are globally threatened with varying assessment status. Among them *Clitopilus prunulus*, *Lycoperdon perlatum*, *Boletus edulis, Suillus granulatus*, *Hydnum repandum* are piblished with LC and *Entoloma griseocyaneum* with VU assessment status. Three more species – *Macrolepiota procera, Lepista nuda, Pleurotus ostreatus* and *Trametes versicolor* have the status of proposed.

In recent years, there has been a certain increase in interest in mushrooms all over the world, including Azerbaijan (Cerimi *et al.* 2019). Despite research on macrofungi begun in the middle of the 20th century, there is still a large gap in knowledge about the diversity of fungi in the country. In recent years, research has been expanded to identify the diversity of fungi in the Greater Caucasus (Shaki) and the Lesser Caucasus (Geigel National Park) (Mustafabayli *et al.* 2021, Aghayeva *et al.* 2022). The study of the macrofungal diversity of the Guba district expands our knowledge of the fungi of the studied territory, and also creates an opportunity to compare the most mushroom-rich areas of the Greater Caucasus within Azerbaijan in order to document and identify the diversity of fungal species and propose measures for their effective use in future.

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РЕЗЮМЕ

Алімаммадова-Хусуєва, А.А., Агаєва, Д.Н. (2024). Різноманіття, таксономічний склад та екологія базидіоміцетів Губинського району Азербайджану. *Чорноморський ботанічний журнал* 20 (1): 80–90. doi: 10.32999/ksu1990-553X/2024-20-1-4

У статті представлено дослідження різноманітності лісових екосистем Губинського району на основі зразків грибів, зібраних у 2017–2022 роках. Всього до дослідження залучено 144 зразки, включно з тими, що зберігаються в мікологічному гербарії. Метою роботи є визначення видового різноманіття, таксономічного складу та віднесення до екологічних груп базидіальних грибів Губинського району з урахуванням сучасних таксономічних та номенклатурних новинок. У результаті дослідження зареєстровано 91 таксон (90 видів і один внутрішньовидовий таксон), які належать до 63 родів, 35 родин і 7 порядків (Agaricales, Boletales, Cantharellales, Geastrales, Hymenochaetales, Russulales, Polyporales). *Coprinellus domesticus* і *Russula flavisiccans* вперше наведено для Азербайджану. Досліджено екологічні групи грибів, зокрема виділено екологічні групи сапробіонтів, симбіонтів, ксилотрофів і паразитів. Екологічна роль *Cuphophyllus pratensis* і *Gliophorus psittacinusis* неясна, оскільки вони трапляються серед мохів, і було припущено, що вони можуть утворювати симбіоз. Досліджено також поширення цих видів залежно від висоти; види грибів в основному відзначалися в низькогірній зоні (51) і відносно менше в середньогірній (37). В обох зонах зареєстровано три види (*Bolbitius titubans*, *Mycena pura*, *Hymenopellis radicata*). Деякі з них ростуть уздовж гірських схилів (*Macrolepiota procera*, *Parasola plicatilis*), а також трапляються на луках. Рідкісні та зникаючі види грибів були ідентифіковані на основі категорій МСОП.

Ключові слова: висота, екологічні групи, рід, гербарії, морфологія, гриб, вид, симбіонт, зниклий