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## Monitoring of protected fungal species in Samursky national park

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**Abstract:** New locations of three xylotrophic basidiomycete species (*Fistulina hepatica*, *Ganoderma lucidum*, *Volvariella bombycina*), rare and protected in the Republic of Dagestan (2020), were revealed in the forest ecosystems of Samursky National Park as a result of field research carried out in 2022. Among them, the species *Ganoderma lucidum* is also protected at the federal level and it is included in the Red Data Book of the Russian Federation (2008). The Latin name, current taxonomic position, brief morphological characteristics of the basidiomata, description of recorded local populations, as well as data on occupied woody substrata and forest habitat patches are given for each species. Factors limiting the population numbers of the species and recommended conservation efforts are discussed.

**Keywords:** basidial macromycetes, biodiversity, Caucasus, xylotrophic fungi, Dagestan, protected areas, fungal conservation, rare species.

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## Мониторинг охраняемых видов грибов на территории национального парка «Самурский»

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**Резюме:** В результате полевых исследований, проведенных в 2022 году, в лесных экосистемах национального парка «Самурский» выявлены новые местонахождения трёх редких и охраняемых в Республике Дагестан видов ксилотрофных базидиомицетов (*Fistulina hepatica*, *Ganoderma lucidum*, *Volvariella bombycina*). Из них вид *Ganoderma lucidum* также охраняется на федеральном уровне и включен в Красную книгу Российской Федерации (2008). Для каждого вида приводится латинское название, современное таксономическое положение, краткая морфологическая характеристика базидиом, описание выявленных локальных популяций, а также сведения о занимаемых древесных субстратах и участках лесных местообитаний. Обсуждаются факторы, лимитирующие численность вида, и рекомендуемые меры охраны.

**Ключевые слова:** базидиальные макромицеты, биоразнообразие, Кавказ, ксилотрофные грибы, Дагестан, ООПТ, охрана грибов, редкие виды.

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## Introduction

Monitoring the known occurrences of rare and protected species, as well as finding new locations, is an essential requirement for maintaining the Red Data Books, both at national and regional levels, as well as for conservation activities in general. When monitoring rare and endangered species, the presence (or absence) of the species and its abundance are recorded as the first and most important parameters, as well as the biological and ecological characteristics of the populations (Aleksanov et al., 2021).

As for fungi, direct monitoring of total population size, including the total number of mature individuals of a species capable of reproducing, is not applicable in contrast to the majority of plants and animals. For practical purposes of fungal conservation, the concept of a functional individual has been introduced. This term for wood-inhabiting fungi corresponds to all conspecific sporocarps living on a single tree, log or other discrete unit of substrate (Dahlberg, Mueller, 2011). In Russia, this approach was used, for example, to estimate the abundance of xylotrophic fungi of the West Siberian Plain. It was proposed that the number of woody substrates on which a particular species develops should be taken into account as an estimate of fungal numbers (Mukhin, 1993).

Currently, the Red Data Book of the Republic of Dagestan includes 10 species of non-lichinized fungi, including one ascomycete species, one agaric, six aphylophoroid and two gasteroid species (Krasnaya..., 2020). Among them, three species (*Fistulina hepatica*, *Ganoderma lucidum*, *Volvariella bombycina*) are known from the territory of Samursky National Park. A total number of aphylophoroid fungi species known for this protected area is 95 species (Bagdasarova, 1965; Viner, 2017; Volobuev, 2020; Volobuev, 2021).

In 2022, as a result of the mycological survey new data on distribution and ecology of protected fungal species have been obtained. The aim of this paper is to describe the local populations and ecological characteristics of fungal species, red-listing in the Republic of Dagestan and recorded in Samursky National Park.

## Material and methods

Field inventory studies were carried out by the authors in September 2022 in forest ecosys-

tems of Samursky National Park within the “Delta Samura” site. Deciduous forests investigated included areas dominated by *Carpinus betulus* L. and *Quercus robur* subsp. *pedunculiflora* (K. Koch) Menitsky with herbs, e.g. *Euphorbia amygdaloides* L., and liana forests dominated by *Alnus* spp. and *Populus* spp. (Yarovenko et al., 2004).

Basidiomata of protected species were recorded using an Apple iPhone 11 digital camera. The geographical coordinates and altitudes of studied localities were fixed by the Garmin 64st GPS-navigator.

Morphological identification of fungi was performed using Boekhout (1990) and Bernichia & Gorjón (2020).

Taxonomy is given according to Sun et al. (2019) and Wijayawardene et al. (2022).

Estimation of population size follows to Dahlberg & Mueller (2011), namely, a total number of mature individuals of lignicolous fungi are calculated as a number of functional units (trunk, log, stem, twigs, etc.) with basidiomata multiplied by two.

## Results and discussion

*Fistulina hepatica* (Schaeff.) With. (*Fistulinaceae*, *Agaricales*). This species, known as “beefsteak fungus”, belongs to the genus *Fistulina* Bull., currently including twelve species worldwide (Zhou et al., 2022). Among them, *F. hepatica* together with three other species (*F. americana*, *F. orientalis*, and *F. subhepatica*) are distributed in the Northern Hemisphere.

BASIDIOMATA annual, juicy and fleshy when fresh, attached directly to the woody substrate by the base of the tongue-shaped cap or by a short lateral stipe. Pileus are solitary or clustered in 2–3, 10–20 cm in diameter and 2–6 cm thick, covered with orange-red to blood-liver coloured radial-striped cuticle with tiny papillae. The young basidiomata have a yellowish-burgundy texture, impregnated with reddish exudate, with pale veins on the cut, becoming dense, coarsely fibrous with age. Hymenophore tubular, with the tubes not fused laterally with each other and remaining loose, cylindrical, whitish or pale yellow, turning brown when pressed (Fig. 1).

LOCAL POPULATIONS. Magaramkentsky District, Samursky National Park:

1) vicinity of Bilbil-Kazmalyar settlement, 41.82069–41.82279 °N, 48.52637–48.53254 °E, 18.6–28.6 m a.s.l., 16 September 2022; 11 trees with 15 basidiomata recorded, the estimated population size is 30 mature individuals;

2) 41.88189 °N, 48.51799 °E, –34.1 m a.s.l., 19 September 2022; one tree with a single basidioma registered, the estimated population size is two mature individuals.

**SUBSTRATA AND HABITATS.** All basidiomata of *Fistulina hepatica* were revealed on living trees of *Quercus robur* subsp. *pedunculiflora* (K. Koch) Menitsky in herbaceous hornbeam forest with oak, herbaceous oak forest, herbaceous oak forest with poplar, hornbeam forest

with ash and milkweed, hornbeam forest with oak and milkweed.

**LIMITING FACTORS.** The species is associated with old-growth broadleaved forests with old oak trees. The limiting factors are forest management, including silvicultural activities, logging of oaks, as well as recreational pressure.

**RECOMMENDED CONSERVATION ACTIONS.** It is necessary to prohibit any type of logging of old oak trees and fragments of broad-leaved forests with oak, to prohibit removal of oak large dead wood, to monitor the state of the discovered populations and to search for new occurrences of the species. The species has the threat category – 3. Vulnerable species (Krasnaya..., 2020).



**Fig. 1.** Basidiomata of *Fistulina hepatica*: a – young basidiomata; b – mature basidioma; c, d – senescent basidiomata. Photos by S. V. Volobuev.

**Рис. 1.** Базидиомы *Fistulina hepatica*: а – молодые базидиомы; б – зрелая базидиома; в, г – стареющие базидиомы. Фотографии С. В. Волобуева.

***Ganoderma lucidum*** (Curtis) P. Karst. (*Ganodermataceae*, *Polyporales*). This is a type species of the genus *Ganoderma*, being known as a “mushroom of immortality” due to its wide implementation in traditional Chinese medicine (Bernicchia, Gorjón, 2020).

**BASIDIOMATA** annual, less frequently 2–3-year-old, consisting of a cap and a well-developed lateral stipe covered with a shiny crust. Cap is semicircular, fan-shaped or kidney-shaped, flattened, 3–25 cm in diameter and up to 4 cm thick, the margin flat, sometimes

wavy. Cap surface is initially reddish, then reddish-brown to purplish-brown, with age almost black, concentric-veined, and covered with a glossy resinous crust. Context is spongy-fibrous, indistinctly zoned, cream-coloured at first and then wood-coloured. Hymenophore is tubular, the pores are rounded, 3–5 per 1 mm, the pore surface is whitish-creamy to brownish. Stipe is cylindrical, straight or curved, 1–2 cm thick and up to 15 cm long, hard, covered with a shiny crust of the same colour as the cap surface (Fig. 2).



**Fig. 2.** Basidioma of *Ganoderma lucidum* at the base of living hornbeam. Photo by S. V. Volobuev.

**Рис. 2.** Базидиома *Ganoderma lucidum* у основания живого граба. Фото С. В. Волобуева.

**LOCAL POPULATIONS.** Magaramkentsky District, Samursky National Park, vicinity of Bilbil-Kazmalyar settlement, 41.81707 °N, 48.53055 °E, 49.4 m a.s.l., 16 September 2022; one tree with three basidiomata recorded, the estimated population size is six mature individuals; 41.81976 °N, 48.53184 °E, 30.3 m a.s.l., 16 September 2022; one tree with one basidioma recorded, the estimated population size is two mature individuals.

**SUBSTRATA AND HABITATS.** All basidiomata of *Ganoderma lucidum* were collected on living trees of *Carpinus betulus* L. in hornbeam forest with oak and milkweed and in hornbeam forest with milkweed.

**LIMITING FACTORS.** The species prefers old-growth broadleaved forests with stable high and moderate moisture levels. It requires for large woody substrate (dead trunks, old stumps) of deciduous species. Limiting factors are economic exploitation of areas, including logging

of forests, building of linear infrastructure and collecting of basidiomata.

**RECOMMENDED CONSERVATION ACTIONS.** There is a requirement to prohibit all logging of old trees, especially broad-leaved trees, and to forbid the removal of large-size deadwood. The monitoring of the current population state, the search for new occurrences of the species and the isolation and maintenance of strains in pure culture collections of fungi are recommended. The species is listed in the Red Data Book of the Russian Federation (Bondartseva, Zmitrovich, 2008) with the status category 3b. In the Red Data Book of the Republic of Dagestan *G. lucidum* has the threat category – 2. Vulnerable species (Krasnaya..., 2020).

***Volvariella bombycina*** (Schaeff.) Singer (*Pluteaceae*, *Agaricales*). This lignicolous fungus, named as “silky rosegill” because of its remarkable pileus surface, usually grow in cracks of bark, old hollows, on fallen or standing dead trunks of various deciduous trees (Szczepkowski et al., 2013).

**BASIDIOMATA** annual, large, consisting of stipe and cap with a lamellar hymenophore. Cap is up to 20 cm in diameter, initially ovoid, tightly flattened at the edges to the stipe, white, later becoming bell-shaped to flattened-convex, pale yellow to yellowish-creamy. Cap surface is silky-fibrous, tufted to densely fluffy. Context is white, brittle and odourless. Lamellae are loose, thin, frequent, white to greyish pink. Stipe is up to 15–20 cm high and up to 2 cm in diameter, smooth, white, cylindrical, widened at the base and surrounded by a loose, fibrous-membranous, white to creamy-yellowish volva (Fig. 3).

**LOCAL POPULATIONS.** Magaramkentsky District, Samursky National Park, 41.89439 °N, 48.49659 °E, –40.5 m a.s.l., 19 September 2022; one tree with three basidiomata recorded, the estimated population size is six mature individuals.

**SUBSTRATA AND HABITATS.** Basidiomata of *Volvariella bombycina* were found on dry standing tree of *Populus* sp. in herbaceous poplar forest.

**LIMITING FACTORS.** The species needs to large woody substrates – trunks of living and dead broadleaved trees. Limiting factors are forestry activities, including logging and removal of woody debris.



**Fig. 3.** Basidioma of *Volvariella bombycina* at old hollow of dry standing poplar. Photo by S. V. Volobuev.

**Рис. 3.** Базидиома *Volvariella bombycina* в старом дупле сухостойного тополя. Фото С. В. Волобуева.

**RECOMMENDED CONSERVATION ACTIONS.** It is important to prohibit logging of large trees of broad-leaved species and removal of large dead wood, to monitor the state of the revealed and search for new occurrences of the species, and to keep the fungal strains in pure cultures collections. In the Red Data Book of the Republic of Dagestan *V. bombycina* has the threat category – 4. Near threatened species (Krasnaya..., 2020).

The data obtained allowed us to expand our current knowledge on the distribution and ecology of rare fungal species in the territory of Samursky National Park. The results of these monitoring studies will be used for further work on compiling a red list of species required to be protected in the Republic of Dagestan, and general tasks of fungal conservation.

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