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Analysis of climatic conditions and macrofungal diversity in the region of Central Balkan National Park, Stara Planina Mts, Bulgaria

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Abstract. This review attempts to summarize the available data on the climatic conditions and macrofungal diversity in the Central Balkan National Park (Stara Planina Mts) region in relation to the clarification of the ongoing climate changes. We provide a preliminary, literature-based checklist of macrofungi occurring in the marked ecological region, supplemented by original observations reported here for the first time. The total number of recorded macromycete species for the analyzed territory is about 338. The species composition, ecological-trophic structure, seasonality, and edibility of the larger mushrooms are briefly discussed. The attached list of identified species includes 47 edible wild mushrooms, as well as 22 larger fungi with conservation significance for the Bulgarian mycota, assessed according to the latest IUCN criteria. According to the Red List of fungi in Bulgaria and the Red Data Book of the Republic of Bulgaria, twelve (12) fungal species are endangered (EN), with three (3) species being of European importance.

Key words: Central Balkan National Park, climate change, fungal conservation, macrofungal diversity.

Introduction

Fungi have a crucial role in ecosystems, contributing to nutrient cycling, plant symbiosis, and biodegradation. However, climate change is altering global environmental conditions, affecting fungal physiology, distribution, pathogenicity, and ecological interactions. Understanding how fungi adapt to these shifts is essential for predicting future biodiversity trends, managing fungal-related plant and human diseases, and harnessing fungal biotechnology for sustainable solutions.

The profound interconnectedness between climate and biodiversity manifests distinctly within forest ecosystems, home to the highly valued wild edible fungi from the genera (*Boletus*, *Cantharellus*, *Cratherellus*, *Hydnum*, *Marasmius*, *Morchella*, *Tricholoma*, etc.), some of which are known as the delicacy mushrooms. Valuable for their culinary and medicinal qualities, some of these fungi also play a crucial ecological role within their habitat, forming symbiotic relationships with host trees and contributing significantly to the forest's nutrient cycle. The escalating impact of climate change on European forests, characterized by alterations in temperature, precipitation patterns, and increased incidence of extreme weather events, has raised concerns over the sustainability of these vital species, as well as for fungal diversity in general.

Natural parks and protected areas, especially those with predominant forest communities, are

suitable habitats for a large number of wild mushrooms, a large part of which are traditionally and annually collected by the population for food.

According to FAO, Bulgaria is one of the leading exporters of mushrooms in the EU – 1260 tons for 2020 (Boa, 2004; Kalač, 2009, 2010). Fresh mushroom consumption in the country exceeds 6 kg per person per year (Ivanova et al., 2020). The collection and purchase of wild edible mushrooms in Bulgaria is well organized in many areas (Bulgarian Food Safety Agency, 2023).

Studies of Bulgarian mycota started more than a century ago (Drumeva-Dimcheva & Gyosheva-Bogoeva, 1993; Denchev & Bakalova, 2002; Denchev et al., 2005; Denchev, 2006) and have increased rapidly during the last decade, but data on protected areas and parks and their habitats are then meagre. More serious studies on the species diversity of larger fungi in some mountains and protected areas of the country have been conducted since 1980, for example Central Balkan Mountain (Fakirova et al., 2002), Rila National Park (Burzakov, 1928; Gyosheva & Denchev, 2000; Gyosheva et al., 2017, 2018; Gyosheva & Stoykov, 2019), Rila Monastery Nature Park (Gyosheva, 2003), Pirin National Park (Denchev et al., 2007), Golo Bardo mountain (Gyosheva, 1991; Gyosheva-Bogoeva, 1984), Rhodope (Denchev et al., 2006), Strandzha (Denchev & Petrova, 2005; Radoukova et al., 2024), etc.

Data on macromycetes in Central Balkan National Park have been published in Hinkova (1965), Hinkova & Draganov (1965), Stoichev & Dimcheva (1982, 1987), Stoichev (1981, 1982, 1983, 1995 a,b), Vanev & Reid (1986), Drumeva-Dimcheva & Gyosheva-Bogoeva (1993), Fakirova & Dimitrova (1999), Stoichev & Gyosheva (2005), Dimitrova & Gyosheva (2009, 2010), Dimitrova (2010, 2011), Gyosheva (2011), Assyov & Denchev (2004, 2011), Denchev et al. (2011a,b), Petrova & Denchev (2011), Assyov et al. (2010, 2012), Management Plan for the Central Balkan National Park, 2016-2025. However, the majority of the published data are related to reporting new species or species confirmed for the first time, collected during short mycological excursions, with more extensive studies of the Central Balkan National Park being conducted only by Fakirova et al. (2000, 2002). In recent years, systematic mycological studies have not been conducted in the area of the Central Balkan National Park.

Climate change causes extreme weather fluctuations, especially more pronounced and frequent droughts and uneven precipitation that often comes in torrents. These causes are behind changes in the species compositions of forests, the spread of pests, and changes in the herbaceous layer of forests (Brázdil & Trnka, 2015; Cacciotti et al., 2021; Procházka et al., 2023). They can also affect the production and species composition of mushrooms. The activity of mycelia decreases, cold-loving types of fungi retreat, and heat-loving and dry-loving fungi spread. In years when there is no rain in the months with the highest activity of mushroom growth, there is a decrease in mushroom production. The dates for mushroom picking are moving to spring, and the mushroom season is longer in autumn. The amount of mushrooms in forests is also affected by the human factor, such that if the harvest is small, fruiting bodies are collected, and they cannot reproduce with spores. However, based on numerous studies, precipitation seems to be the most important factor (Kauserud et al., 2008, 2022; Karavani et al., 2018; Procházka et al., 2023).

Climatic conditions are of fundamental importance for the fruiting of wild mushrooms. For this reason, they are considered a key non-timber forest resource with particularly important socio-economic importance (Boa, 2004; Croitoru, 2007; Dimitrova et al., 2021, 2022). The climate variables have always been over-seen as important factors controlling the appearance of wild mushrooms. The purposeful re-search in this field dates back to at least the middle of the last century, when the first studies tried to find relations between climatic parameters and wild mushrooms production. There are many observations that have shown the relation between the precipitation and mushroom crops, and presently, there could be no doubt that the mushroom productivity is higher in years with higher amounts of rain (Boa, 2004; Croitoru, 2007; Dimitrova et al., 2021, 2022). Current studies use statistics to back up and confirm those observations. The relation between the water availability and mushrooms yield has been shown both for the overall productivity and for that of some particular *Boletus* and *Cantharellus* species. There are some suggestions that not only the precipitation of the current year is important, but also the rainfalls in certain months of the previous year (Kauserud et al., 2012; Karavani et al., 2018; Procházka et al., 2023). Thus, one study demonstrated that in boreal forests of Canada (Procházka et al., 2023), the

rainfall in June of the current year and in May of the previous year are both important for mushroom production. The importance of the water supply was confirmed by different types of experiments, performed in different parts of Europe (Kauserud et al., 2012; Karavani et al., 2018; Procházka et al., 2023). In the frame of a particular study carried out in Spain (MYCOTICON, 2013), artificial drought was induced in holm oak forests. The result was a dramatic (on average over 60%) decrease in the mushroom productivity. According to MYCOTICON (2013), a team of Finnish scientists studied the effect of irrigation on basidiomata production of larger fungi. They found that the additional water supply increased the biomass of the basidiomata of some species, while others were unaffected by this treatment. Temperature (soil, air) was also thought as possibly important factor for the production of basidiomata, and some studies (Bonet et al., 2008, 2010; Martinez-Peña et al., 2012, etc.) have confirmed this relation. However, there are other publications (de-Miguel et al., 2014, etc.), which could not correlate productivity and temperatures. So, at present, this question remains open for discussion (MYCOTICON, 2013). Therefore, understanding which environmental factors and in what proportion influence mushroom productivity is of high practical and scientific priority, especially in the context of climate change (Karavani et al., 2018; Procházka et al., 2023, etc.).

The goal of this review was to present information on climatic conditions and macrofungal diversity in the region of Central Balkan National Park (Stara Planina Mts) described in the literature over the past decades. The analyses are supported by a long series of statistically estimated model parameters from the ERA5 reanalysis and calculated seasonal values for mean air temperature and precipitation. The research will support the processes of better understanding the impact of climate change on fungal diversity, conservation of ecological stability, the culinary industry, and ethnomycology of the region, on which the research project (BG051PO001-3.3.04/17) is focused.

Materials and methods

Study area

Central Balkan National Park is located in the central part of Bulgaria (Fig. 1) and covers the highest part of the Central Stara Planina, including three parts of the Balkan Mountain Range - Zlatishko-Tetevenska Planina (with the highest peak Vezhen, 2,198 m alt.), Troyanska Planina (with the highest peak Kupena, 2,169 m alt.), and Kaloferska Planina (with the highest peak Botev, 2,376 m alt.). Nine (9) reserves are included within the park's boundaries, such as: Boatin, Tsarichina, Kozya Stena, Steneto, Stara Reka, Dzhendema, Severen Dzhendem, Peeshti Skali, Sokolna, as the national park is included in the UN list of national parks and protected areas (Management Plan for the Central Balkan National Park, 2016-2025).

Plant communities in the area

Six vegetation belts are represented in the Central Balkan National Park, either in full or with characteristic elements. They include: (1) a zone of xerothermic oak forests, (2) a zone of xeromesophilic and mesophilic oak and hornbeam forests, (3) a beech zone, (4) a coniferous zone, (5) a belt of subalpine open woodland, juniper and juniper scrub (subalpine zone), and (6) an alpine zone. By phytogeographical affiliation, the park territory belongs to the Central Balkan District of the Illyrian Province of the European Broad-Leaved Forest Region (Georgiev, 1993).

Table 1 lists larger fungi from the Central Balkan National Park according to the analyzed literature sources. The taxa are listed in alphabetical order (Turland et al., 2018). The names of the authors of fungal taxa were abbreviated according to Kirk & Ansell (1992), Kirk (2004), and Index Fungorum (2024). The information in the presented lists includes available data from literature sources regarding the locality and edibility of the species. For each species, the ecological-trophic type was noted, as well as the period of active formation of fruiting bodies. The conservation status of the species was based on the Red List of fungi in Bulgaria (Gyosheva et al., 2006) and the Red Data Book of the Republic of Bulgaria Volume 1 (Peev et al., 2015), using the Red Book categories of IUCN (IUCN 2001, 2003a, b).

Climatic characteristics of the study area

The gradients in the Central Balkan National Park for the main meteorological elements are enhanced and have a well-expressed similar profile at different altitudes, significantly influenced by the mountain range (Velev, 2010). It has been established that for every 100 m the average annual

temperature decreases by 0.51°C-0.56°C, with the northern slopes of Stara Planina having the lowest values in the country (Stanev, 1955; Gocheva, 1982). The largest and up to twice as high as the winter ones are the summer gradients. About the bioclimatic seasons, a study for the country (1961-2000) shows how the gradient changes at the dates of stable transitions through certain temperature limits for every 100 m above sea level (Slavov & Moteva, 2007). The same authors found that the vertical gradient in days is the largest at the winter-spring transition in 0-4 days and the smallest in autumn, about 2 days. The orographic influence is highly significant, and many stations in the Pre-Balkans with lower altitudes report high precipitation amounts, comparable to those measured in the middle and high mountain regions (Velev, 2010). The average annual rainfall is high, ranging from 680 to 1,000 mm. The maximum rainfall is in summer and the minimum in winter.

A detailed analysis of current meteorological studies was performed, compared to previous climate norms and future model expectations. The high-resolution climate reanalysis data from the Copernicus Climate Change Service (C3S) provided through the World Bank's Climate Change Knowledge Portal (CCKP) were also analyzed in support of the study. Monthly values of air temperature in degrees Celsius, precipitation in mm, etc., organized by season, were used. Trends in the data series were assessed using the non-parametric Mann-Kendal test (Mann, 1945; Kendall, 1975), and the slope was assessed using the Sen-slope method (Sen, 1968).

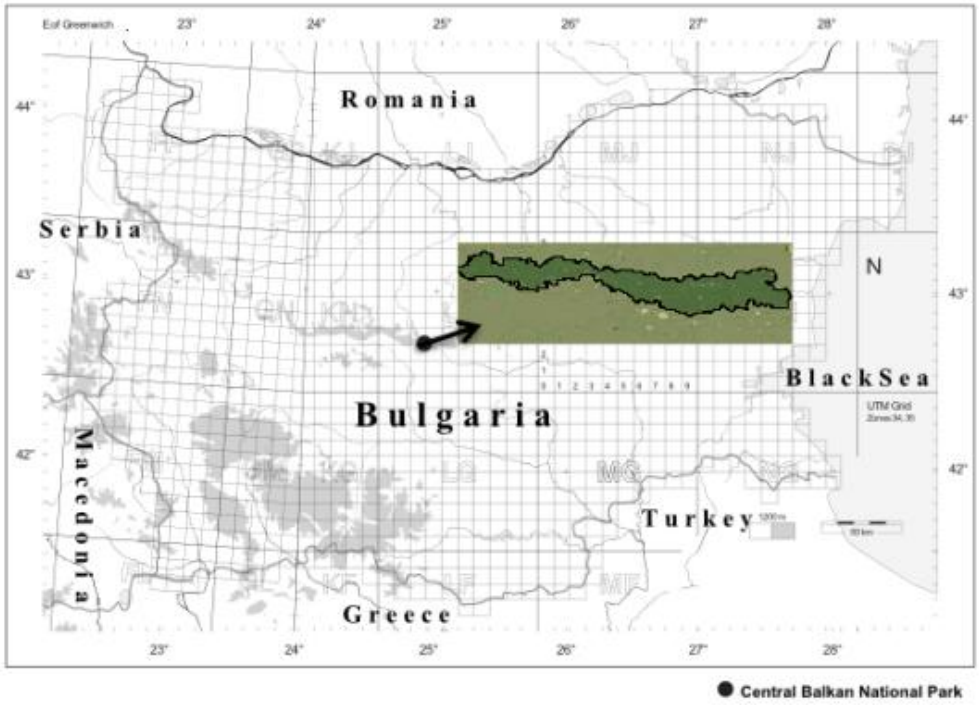

Fig. 1. Map of Bulgaria showing the location of Central Balkan National Park.

Results and Discussion

Species composition of larger fungi in the marked area

The potential number of species in the Bulgarian mycota is estimated at 20 670 (Denchev et al., 2005; Denchev, 2005, 2006, 2011). Denchev & Assyov (2010) indicated 619 taxa for the Stara Planina Mts (western - 268, central – 264, eastern - 364).

According to the analyzed literature sources (Hinkova, 1965; Hinkova & Draganov, 1965; Stoichev & Dimcheva, 1982, 1987; Stoichev, 1981, 1982, 1983, 1995a,b; Vanev & Reid, 1986; Drumeva-Dimcheva & Gyosheva-Bogoeva, 1993; Fakirova & Dimitrova, 1999; Fakirova et al., 2000, 2002), 256 taxa have been established until 2002, and according to the Management Plan for the Central Balkan National Park (2016-2025), 336 taxa of larger fungi have been established from the territory of the Central Balkan National Park (including 6 of the reserves within its boundaries) so far (Table 1). Later, Stoykov et al. (2015) reported two more species of Kozya Stena reserve, bringing the total num-

ber to 338 taxa. These fungi are included in two (2) divisions: Ascomycota – four (4) classes, 7 orders, 14 families, 34 genera, 44 taxa, and Basidiomycota – four (4) classes, 14 orders, 54 families, 114 genera, 294 taxa (Table 1).

The number of mushrooms in some of the reserves on the territory of the park is as follows: Tsarichina reserve – 65 taxa, Kozya Stena reserve – 74 taxa, Steneto reserve – 35 taxa, Stara reka reserve – 52 taxa, Severen Dzhendem reserve – 147 taxa, and for Dzhendema reserve - 29 larger fungi have been published. It remains to be determined how many of these taxa will be reconfirmed for Central Balkan National Park and how many of those reported for the Central Balkan Mountain will be identified for the first time on the territory of the park (Table 1).

In the publications of Fakirova et al. (2000, 2002) and the Management Plan for the Central Balkan National Park (2016-2025), forty-seven (47) species of edible macromycetes were listed for the park (Table 1). The analyzed scientific literature (Fakirova et al., 2002) provides data on larger fungi studied primarily in two types of plant communities: forest (beech and spruce) and grassland (meadows, pastures, etc.). It is stated that the largest number of species was recorded in the beech communities (176, 68.7% of the total number), followed by spruce communities (69, 26.9%) and the smaller number was recorded in the grassland communities (35, 13.7%) (Table 1).

Ecological-trophic structure of larger fungi and their diversity in the plant communities

In the plant communities of Central Balkan National Park, larger fungi belong to 9 ecological-trophic groups (Fakirova et al., 2002). The analysis of the published data for the ecological-trophic groups of fungi showed that the region of Central Balkan National Park include 256 taxa, of which Mr - mycorrhizal fungi are 104 (38.4% of the established species of larger fungi), followed by LeS - wood saprotrophs (72, 26.6%), Hu - humus saprotrophs (53, 19.5%), St - litter saprotrophs (22, 8.1%), LeP - wood parasites (7-2.6%), C - coprotrophs (6, 2.2%), Fd - fallen leaves saprotrophs (3, 1.1%), Br - moss saprotrophs (3, 1.1%) respectively and Ad - needle-debris saprotrophs (1, 0.4%). (Table 1).

Table 1. Checklist of the macromycetes in Central Balkan National Park (Stara Planina Mts), according to Management Plan for the Central Balkan National Park (2016-2025).

Agaricus campestris L.: Fr.: n, v; [7], [9]**;** ***A. silvicola*** (Vitt.) Sacc.: o; [7], [9]**;** ***A. urinascens*** (Jul. Schaeff. F.H. Møeller) Singer var. ***urinascens***: n; [7], [9], [16]; ***Agrocybe erebia*** (Fr.:Fr.) Ktihner ex Singer): c; [7], [18]**;** ***Albatrellus cristatus*** (Schaeff.:Fr.) Kotl & Pozar: n; [7], [9]**;** ***Aleuria aurantia*** (Pers.) Fuckel.: c; [7], [9], [10], [19]**;** ***Amanita battarae*** (Boud.) Bon: c; [7], [18]**;** ***A. muscaria*** (L.:Fr.) Pers.: j, n, l, q; [7], [9]**;** ***A. pantherina*** (DC.:Fr.) Krombh. var. ***pantherina***: n, o, q; [7], [9]**;** ***A. phalloides*** (Vaill.:Fr.) Link: n, o, q; [7], [9]**;** ***A. rubescens*** Pers.:Fr.: l, n, o, q, v; [7], [9]**;** ***A. spissa*** (Fr.) P. Kumm.: q; [7], [18]**;** ***A. vaginata*** (Bull.:Fr.) Lamm.: n, o, q, f; [7], [9]**;** ***A. virosa*** (Fr.) Bertill.: n; [7], [9]**;** ***Ampuloclitocybe clavipes*** (Pers.:Fr.) Redhead: o, q; [7], [9]**;** ***Armillaria mellea*** (Vahl.:Fr.) P. Kumm. s. lat.: j; n; [7], [9]**;** ***Astraeus hygrometricus*** (Pers.:Pers.) Morgan: l; o; [7], [9].

Bjerkandera adusta (Willd.:Fr.) P. Karst.: q; f; [7]**;** ***Bisporella citrina*** (Batsch) Korf & S.E. Carp.: j, c; [5], [7], [8], [18]**;** ***Biscognauxia nummularia*** (Bull.:Fr.) Kuntze: n; [7]**;** ***Bolbitius titubans*** (Bull.:Fr.) Fr. var. ***titubans***: c; [7], [18]**;** ***Boletus aereus*** Bull.:Fr.: n; q; [4], [7], [9]**;** ***B. appendiculatus*** Schaeff.: n; [4], [7], [9]**;** ***B. badius*** (Fr.:Fr.) Fr.: l; q; [4], [7], [9]**;** ***B. chrysenteron*** Bull.: n; q; r; h; [4], [7], [9]**;** ***B. edulis*** Bull.:Fr.: l; n; q; r; [4], [7], [9]**;** ***B. ferrugineus*** Schaeff.: n; [4], [7], [9]**;** ***B. impolitus*** Fr.: l; [4], [7], [9]**;** ***B. luridiformis*** Rostk. var. ***luridiformis***: n; c; [4], [7], [9], [18]; ***B. luridus*** Schaeff.:Fr. var. ***luridus*****:** n; [4], [7], [9]**;** ***B. pinophilus*** Pilat & Dermek: q; [4], [7], [9]**;** ***B. pruinatus*** Fr.&Hok: n; [4], [7], [9]**;** ***B. queletii*** Schnulzer: n; [4], [7], [9]**;** ***B. reticulatus*** Schaeff.(=*B. aestivalis*): l; [4], [7], [9]**;** ***B. rubellus*** Krombh.: n; [4], [7], [9]**;** ***B. truncatus*** Fr. in Fr. Hok: n; [4], [7], [9]**;** ***Bovista nigrescens*** Pers.:Pers.: o, v; [7]**;** ***B. plumbea*** Pers.:Pers.: j, n, o, v; [7]**;**

Calocera cornea (Batsch:Fr.) Fr.: l; q; [7], [9]**;** ***C. viscosa*** (Pers.:Fr.) Fr.: p; q; [7], [9]**;** ***Calvatia utriformis*** (Bull.:Pers.) Jaap: j, n, o, p, v; [7]**;** ***Cainiella johansonii*** (Rehm) E. Müll.: l; [17]**;** ***Cantharellus amethysteus*** (Quel.) Sacc.: i; [2]**;** ***C. cibarius*** Fr.:Fr. var. ***cibarius***: n; o; [7], [9]**;** ***C. friesii*** Quel.: o; g; b; [20], [21]; **(EN); A., B.;** ***Chlorociboria aeruginosa*** (Oeder) Seaver: n; [5], [7], [9]**;** ***Chlorophyllum rhacodes*** (Vittad.) Vellinga: q, f; [7]**;** ***Chondrostereum purpureum*** (Pers.:Fr.) Pouzar: q; [7]**;** ***Chroogomphus rutilus*** (Schaeff.:Fr.) O.K. Mill.: q; c; [7], [9], [18]; ***Chrysomphalina chrysophylla*** (Fr.:Fr.) Clémençon: q; [7], [18]**;** ***Clavaria fumosa*** Pers.:Fr.: n; [7]**;** ***C. fragilis*** Holmsk.:Fr.: n; [7]**;** ***C. rosea*** Dalman:Fr.: n; [7]**;** ***Clavariadelphus pistillaris*** (L.:Fr.) Donk: j; l; q; [7], [9]**; (VU); A., C.;** ***Clavulina cinerea*** (Bull.:Fr.) J.

Schrot.: o; [7], [9]**;** ***C. coralloides*** (L.:Fr.) J. Schrot.: n; [7], [9]**;** ***C. rugosa*** (Bull.:Fr.) J. Schrot.: n; [7], [9]**;** ***Clitocybe dealbata*** (Sow.:Fr.) P. Kumm.: p; [7], [9]**;** ***C. fragrans*** (With.:Fr.) P. Kumm.: q; r; [7], [9]**;** ***C. gibba*** (Pers.:Fr.) P. Kumm.: l; n; o; q; r; [7], [9]**;** ***C. metachroa*** (Fr.:Fr.) P. Kumm.: n; [7], [9]**;** ***C. nebularis*** (Batsch.:Fr.) P. Kumm.: l; q; [7], [9]**;** ***C. odora*** (Bull.:Fr.) P. Kumm.: l; [7], [9]**;** ***C. tornata*** (Fr.:Fr.) P. Kumm.: j; [7], [9]**;** ***Clitopilus prunulus*** (Scop.:Fr.) P. Kumm.: l; [7]**;** ***Coltricia perennis*** (L.:Fr.) Murrill. var. ***perennis***: n; q; [9], [7]**;** ***Coprinellus angulatus*** (Peck) Redhead, Vilgalys, Hopple & Moncalvo: c; [7], [9], [18]; ***C. impatiens*** (Fr.:Fr.) J.E. Lange: q; [7]**;** ***C. micaceus*** (Bull.:Fr.) Vilgalys, Hopple & Jacq. Johnson: j; n; q; [7], [9]**;** ***Coprinopsis nivea*** (Pers.:Fr.) Redhead, Vilgalys & Moncalva: o; [7], [9]**;** ***Cortinarius bulbosus*** (Sowerby:Fr.) Gray: p; [7]**;** ***C. bulliardii*** (Pers.:Fr.) Fr.: n; [7], [20]; **(EN); A., C.;** ***C. cinnabarinus*** Fr.: p; [7]**;** ***C. cinnamomeoluteus*** P.D. Orton: p; [7]**;** ***C. delibitus*** Fr.: q; [7]**;** ***C. evernis*** (Fr.:Fr.) Fr.: o; [7]**;** ***C. gentilis*** (Fr.:Fr.) Fr.: q; [7]**;** ***C. glaucopus*** (Schaeff.:Fr.) Fr.: p; [7]**;** ***C. largus*** Fr.: n; [7]**;** ***C. multiformis*** Fr. var. ***multiformis***: n, q; [7]**;** ***C. obtusus*** (Fr.:Fr.) Fr.: p; [7]**;** ***C. purpurascens*** Fr.: n; [7]**;** ***C. rufoolivaceus*** (Pers.:Fr.) Fr.: n, o; [7]**;** ***C. sanguineus*** (Wulfen:Fr.) Fr.: l; n; q; [7], [9]**;** ***C. saturninus*** (Fr.:Fr.) Fr.: q; [7], [18]**;** ***C. torvus*** (Fr.:Fr.) Fr.: l; n; [7]**;** ***Craterellus cornucopioides*** (L.:Fr.) Pers.: n; [7], [9]**;** ***Crepidotus applanatus*** (Pers.) P. Kumm.: c; [7], [18]**;** ***C. mollis*** (Schaeff.:Fr.) Staude: c; [7], [18]**;** ***Crinipellis scabella*** (Alb. & Schwein.:Fr.) Murrill.: j; [7]**;** ***Crocicreas coronatum*** (Bull. ex Merat) S.E. Carp.; c; [5]**;** ***Crucibulum laeve*** (Huds.:Pers.) Kambly: o; [7]**;** ***Cudonia circinans*** (Pers.:Fr.) Fr.: q; [7], [8]**;** ***Cudoniella rubicundula*** Velen.: q; [7], [18]**;** ***Cyathus olla*** (Batsch:Pers.) Pers.: n; [7]**;** ***C. striatus*** (Huds.:Pers.) Willd.: l; [7]**;** ***Cystoderma amianthinum*** (Scop.:Fr.) Fayod: p; [7]**;** ***C. carcharias*** (Pers.) Fayod: p, q; [7]**;** ***C. granulosum*** (Batsch:Fr.) Fayod: p; [7]**;**
Daldinia concentrica (Bolton:Fr.) Ces. & De Not. s. lat.: n, o; [7]**;** ***Dacrymyces stillatus*** Nees.:Fr.: l; [7], [9]**;** ***Datronia mollis*** (Sommerf.:Fr.) Donk: q; [7]**;** ***Dermea cerasi*** (Pers.) Fr.: n; [7], [8], [19]**;** ***Diatrype disciformis*** (Hoffm.:Fr.) Fr.: l, n, q, r; [7]**;**
Exidia glandulosa (Bull.:Fr.) Fr.: q; [7], [9]**;** ***Entoloma incanum*** (Fr.:Fr.) Hesler: l; [7]; **(VU); A.;**
Fomes fomentarius (L.:Fr.) J.J. Kickx: n; r; [7], [9]**;** ***Fomitopsis pinicola*** (Sw.:Fr.) P. Karst. f. ***pinicola:*** q; [7], [9]**;**
Galerina hypnorum (Schrank:Fr.) Ktihner: p; q; [7], [18]**;** ***G. marginata*** (Batsch:Fr.) Ktihner: p; [7], [9]**;** ***G. pumila*** (Pers.:Fr.) M. Lange ex Singer: l; n; [7], [9]**;** ***Ganoderma applanatum*** (Pers.) Pat.: q; [7], [9]**;** ***G. lucidum*** (Curtis.:Fr.) P. Karst.: o; [7], [9]**;** ***Geastrum fimbriatum*** Fr.: l; r; [7], [9]**;** ***Gloeophyllum sepiarium*** (Wulfen:Fr.) P. Karst.: l; p; [7], [9]**;** ***Gomphidius glutinosus*** (Schaeff.:Fr.) Fr.: q; [7], [9]**;** ***G. maculatus*** (Scop.:Fr.) Fr.: n; [7], [9]**;** ***Gymnophilus joserandii*** Antonin: q; [7], [18]**;** ***G. junonius*** (Fr.:Fr.) P. D. Orton: n; [7], [9]**;** ***Gymnopus acervatus*** (Fr.:Fr.) Murrill: n, o; [7]**;** ***G. confluens*** (Pers.:Fr.) Antonín, Halling & Noordel.: l, n; [7]**;** ***G. dryophilus*** (Bull.:Fr.) Murrill: n, q; [7], [18]**;** ***G. erythropus*** (Pers.:Fr.) Antonín, Halling & Noordel.: o, q; [7]**;** ***G. hariolorum*** **(**Bull.:Fr.) Antonín, Halling & Noordel.: q, f, h; [7]**;** ***G. peronatus*** (Bolton:Fr.) Antonín, Halling & Noordel.: n, q, f, h; [7]**;** ***Gyroporus castaneus*** (Bull.:Fr.) Quel.: n; [7], [9]**;** ***G. cyanescens*** (Bull.:Fr.) Quel.: l; o; q; [7], [9]**;**
Helvella acetabulum (L.) Quél.: l; [7]**;** ***H. crispa*** (Scop.) Fr.: o; [7], [19]**;** ***H. elastica*** Bull.: q; [7], [19]**;** ***H. lacunosa*** Afzel.: o; [7], [19]**;** ***Heterobasidion annosum*** (Fr.:Fr.) Bref.: q; [7]**;** ***Hericium cirrhatum*** (Pers.:Fr.) Nikol.: n; [7], [9]**; (VU); A., C.;** ***H. coralloides*** (Scop.:Fr.) Pers.: i; j; [7], [9], [21]; **(NT); A., C.;** ***H. erinaceus*** (Bul.:Fr.) Pers.: l; n; [11], [26]; **(EN); A., B., F.;** ***Heyderia abietis*** (Fr.:Fr.) Link: q; t; [8], [18]**;** ***Humaria hemisphaerica*** (F.H. Wigg.) Gillet: n; [7], [8], [9], [19]**;** ***Hydnum repandum*** L.:Fr. f. ***repandum:;*** n; p; r; [7], [9]**;** ***H. rufescens*** Pers.:Fr.: n; o; r; [7], [9]**;** ***Hygrocybe cantharellus*** (Schwein.:Fr.) Murrill: n; [7]**;** ***H. coccinea*** (Scop.:Fr.) P. Kumm.: n; [7]**;** ***H. conica*** (Schaeff.:Fr.) P. Kumm. var. ***conica*****:** n, o; [7]**;** ***H. persistens*** (Britzelm.) Singer var. ***persistens***; n; [7]**;** ***H. pratensis*** (Schaeff.:Fr.) Murrill: j, n, p, q; [7]**;** ***H. punicea*** (Fr.:Fr.) P. Kumm.: j, q; [7], [20]; **(EN); A., B.;** ***H. subglobispora*** (Orton) Moser: j; [7]**;** ***Hygrophorus agathosmus*** (Fr.) Fr.: p; [7]**;** ***H. chrysodon*** (Batsch:Fr.) Fr.: l; [7]**;** ***H. cossus*** (Sowerby) Fr.: l; [7]**;** ***H. eburneus*** (Bull.:Fr.) Fr.: l, q; [7]**;** ***H. hypothejus*** (Fr.:Fr.) Fr.: p; [7]**;** ***H. marzuolus*** (Fr.:Fr.) Bres.: n; [7]**;** ***Hymenoscyphus rokebyensis*** (Svrcek) Mateus: n; [7], [9]**;** ***H. scutela*** (Pers.:Fr.) W. Phillips: c; [5], [7], [9],[18]**;** ***Hypholoma capnoides*** (Fr.:Fr.) P. Kumm: n; q; [7], [18]**;** ***H. fasciculare*** (Huds.:Fr.) P. Kumm.: j; l; o; p; q; [7], [9]**;** ***H. lateritium*** (Schaeff.:Fr.) P. Kumm.: n; q; r, c; [7], [18]**;** ***Hypoxylon fragiforme*** (Pers.:Fr.) Kickx: n; q; r; h; [7], [9]**;**
Inocybe bongardii (Weinm.) Quél. var. ***bongardii***: q; [7]**;** ***I. geophylla*** (Pers.:Fr.) P. Kumm. var. ***geophylla***: c; [18], [7]**;** ***I. petiginosa*** (Fr.:Fr.) Gillet: n; [7]**;** ***I. rimosa*** (Bull.:Fr.) P. Kumm.: n; q; [7], [18]**;** ***Ischnoderma benzoinum*** (Wahlenb.:Fr.) P. Karst.: o; m; [7], [26]**;**
Kretzscmaria deusta (Hoffm.:Fr.) P.M.D. Martin; n: q; h; [7], [9]**;** ***Kuehneromyces mutabilis*** (Schaeff.:Fr.) Singer & A. H. Sm.: l; n; o; [7], [9]**;**

Laccaria amethystina Cooke: l, n, o, p, q; [7]**;** ***L. laccata*** (Scop.:Fr.) Cooke: l, n, o, p, q; [7]**;** ***Lachnum bicolor*** (Bull.:Fr.) P. Karst. var. ***rubi*** (Bres.) Dennis: q; [7], [18]**;** ***Lactarius aurantiacus*** (Pers.:Fr.) Gray: p; [7], [9]**;** ***L. blennius*** (Fr.:Fr.) Fr.: l; n; o; q; h; [7], [9]**;** ***L. deterrimus*** Groger: q; [7], [9]**;** ***L. pallidus*** (Pers.:Fr.) Fr.: q; r; [7], [9]**;** ***L. picinus*** Fr.: q; r; [7], [9]**;** ***L. piperatus*** (L.:Fr.) Pers.: l; n; q; h; [7], [9]**;** ***L. rufus*** (Scop.:Fr.) Fr.: q; [7], [9]**;** ***L. spinosulus*** Quel.: n; [7], [9], [20]; **(EN); A., B.;** ***L. vellereus*** (Fr.:Fr.) Fr.: l; n; q; c; [7], [9], [18]**;** ***L. volemus*** (Fr.:Fr.) Fr.: l; n; o; q; [7], [9]**;** ***Lasiosphaeria ovina*** (Pers.) Ces.: q; [7], [18]**;** ***Leccinum pseudoscabrum*** (Kallenb.) Sutara (=*L. carpini*): l; o; [3], [7], [9]**;** ***L. scabrum*** (Bull.:Fr.) Gray: j; n; [3], [7], [9]**;** ***Lentinellus cochleatus*** (Pers.ex Hoffm.:Fr.) P. Karst.: l; [7], [9]**;** ***Lentinus strigosus*** (Schwein. :Fr.) Fr.: c; [7], [9], [18]**;** ***Leotia lubrica*** (Scop.) Pers.: l; [5], [6], [7]; **(EN); A., B.;** ***Lepiota aspera*** (Pers.:Fr.) Quél.: n; [7]**;** ***L. brunneoincarnata*** Chodat & C. Martin: l; [7]**;** ***L. cristata*** (Bolton:Fr.) P. Kumm.: l; [7]**;** ***L. subincarnata*** J.E. Lange: n; [7]**;** ***Lepista flaccida*** (Sowerby:Fr.) Pat.: j; [7], [9]**;** ***Leucopaxillus giganteus*** (Sowerby:Fr.) Singer.: l; n; [7], [9]**;** ***Limacella guttata*** **(**Pers.:Fr.) Konrad & Maubl.: q; [7], [18]**; (VU); A.;** ***Lyophyllum connatum*** (Schumach.:Fr.) Singer: q; [7]**;** ***L. decastes*** (Fr.:Fr.) Singer: n; [7]**;** ***Lycoperdon echinatum*** Pers.:Pers.: l; [7]**;** ***L. perlatum*** Pers.:Pers.: j, n, o, p, v. [7]**;**

Macrolepiota procera (Scop.:Fr.) Singer: n, u; [7]**;** ***Macrotyphula fistulosa*** (Holmsk.:Fr.) R.H. Petersen: n; [7], [9]**; (VU); A., B., C;** ***Marasmius oreades*** (Bolton:Fr.) Fr.: n; [7]**;** ***M. rotula*** (Scop.:Fr.) Fr.: q, f; [7]**;** ***M. wynnei*** Berk. & Broome: j; [7]**;** ***Megacollybia platyphylla*** (Pers.:Fr.) Kotl. & Pouzar: l, q; [7]**;** ***Melanoleuca melaleuca*** (Pers.:Fr.) Murrill: q; [7], [9]**;** ***Mollisia atrata*** (Pers.) P. Karst.: n; [7], [8]**;** ***Mycena acicula*** (Schaeff.) P. Kumm.: q; r, [7]**;** ***M. aetites*** (Fr.) Quel.: q; [7], [18]**;** ***M. crocata*** (Schrad.:Fr.) P. Kumm: q; r; h; [7], [9]**;** ***M. epipterygia*** (Scop.:Fr.) Gray var. *epipterygia:* q; [7]**;** ***M. epipterygia*** var. ***viscosa*** (Maire) Ricken: q; h; [7], [9]**;** ***M. filopes*** (Bull.:Fr.) P. Kumm.: q; [7]**;** ***M. flavescens*** Velen: c; [7], [18]**;** ***M. galericulata*** (Scop.:Fr.) Gray: n; q; [7], [9]**;** ***M. galopus*** (Pers.:Fr.)P. Kumm.var. ***galopus***: n; [7], [9]**;** ***M. inclinata*** (Fr.) Quel.: q; h; [7]**;** ***M. pelianthina*** (Fr.:Fr.) Quel.: q; [7]**;** ***M. polygramma*** (Bull.:Fr.) Gray: l; q; [7], [9]**;** ***M. pura*** (Pers.:Fr.) P. Kumm. f. *pura*: n; o; p; q; [7], [18]**;** ***M. rorida*** (Fr.:Fr.) Quel.: c; [7], [18]**;** ***M. sanguinolenta*** (Alb.& Scwein.:Fr.) P. Kumm.: q; [7], [9]**;** ***Mycetinis scorodonius*** (Fr.:Fr.) A.W. Wilson: j, n, l, o, q; [7], [18]**;**

Nectria cinnabarina (Tode:Fr.) Fr.: c; [7], [18]**;** ***Neottiella rutilans*** (Fr.) Dennis: n; [7], [8], [9], [19]**;** ***Neubulgaria pura*** (Pers.:Fr.) Petr.: l, n; [5], [7]; ***Nomania serpens*** (Pers.:Fr.) Gray: q, f; [7]**;**

Orbilia auricolor Bloxam: q; [7], [18]**;** ***Otidea alutacea*** (Pers.) Massee: l; [7], [8], [19]; **(VU); A.;** ***Ossicaulis lignatilis*** (Pers.:Fr.) Redhead & Ginns: l; [7], [13]**;** ***Oudemansiella mucida*** (Schrad.:Fr.) Hohn.: l; n; q; h; [7], [9], [18]**;**

Panaeolus semiovatus (Sowerby:Fr.) S. Lundell & Nannf. var. ***semiovatus:*** n; [7], [9]**;** ***P. sphinctrinus*** (Fr.) Quel.: n; [7], [9]**;** ***P. subbalteatus*** (Berk.&Broome) Sac.: n; [7], [9]**;** ***Panellus serotinus*** (Pers.ex Hoff.:Fr.) Ktihner: n; k; d; [7], [10]**;** ***P. stipticus*** (Bull.:Fr.) P. Karst.: q; h; [7], [18]**;** ***Panus conchatus*** (Bull.:Fr.) Fr.: n; [7], [9]**;** ***Parasola plicatilis*** (Curtis:Fr.) Redhead, Vilgalys & Hopple: q; [7]**;** ***Paxillus involutus*** (Batsch:Fr.) Fr.: o; [7], [9]**;** ***Peziza echinospora*** P. Karst.: n, o; [7], [19]**;** ***P. micropus*** Pers.: l, n; [7]**;** ***P. repanda*** Pers.: c; [7], [18], [19]**;** ***P. vesiculosa*** Bull.: n; [7]**;** ***Phallus impudicus*** L.:Fr. f. ***impudicus***: o; q; [7], [9]**;** ***Phellinus conchatus*** (Pers.:Fr.) Quel.: c; [7], [15]**;** ***Ph. nigrolimitatus*** (Romell) Bordot&Galzin: o; [7], [14]**; (NT); A.;** ***Ph. viticola*** (Schwein.:Fr.) Donk: q; [7], [15], [16], [25], [28]; **(EN); A., B.;** ***Phlebia tremellosa*** (Schard.:Fr.) Burds. & Nakasone: n; [7], [9], [24]; [***Pholiota adiposa*** (Batsch:Fr.) P. Kumm.: l; q; [7], [9]**;** ***Ph. flammans*** (Batsch:Fr.) P. Kumm.: q; [7], [22]**;** ***Ph. squarrosa*** (Weigel:Fr.) P. Kumm.; q; [7], [9]**;** ***Phylloporus pelletieri*** (Lev.) Quel.: i; s; [3], [7], [14], [21], [23]; **(EN) Aii (*of European significance*); A., B., D., E.**; ***Piptoporus betulinus*** (Bull.:Fr.) P. Karst.: j; [7], [9]**;** ***Pleurotus cornucopiae*** (Paulet.) Rolland: l; h; [7], [9]**;** ***P. ostreatus*** (Jacq.:Fr.) P. Kumm.: o; [7], [9]**;** ***Pluteus cervinus*** (Schaeff.) P. Kumm.: l; o; i; q, h; [7], [9]**;** ***P. phlebiphorus*** (Ditmar:Fr.) P. Kumm.: c; [7], [18]; ***P. plautus*** (Weinm.) Gillet: l; n; [7], [9]**;** ***P. satur*** Ktihner & Romagn.: c; [7], [18]; ***P. umbrosus*** (Pers.:Fr.) P. Kumm.: n; [7], [9]**;** ***Podoscypha multizonata*** (Berk.& Broome) Pat.: l; [7], [9]**; (EN) Aii (*of European significance*); C., F.**; ***Polyporus badius*** (Pers.) Scwein.: n; o; q; [7], [9]**;** ***P. brumalis*** (Pers.:Fr.) Fr.: j; [7], [9]**;** ***P. ciliatus*** Fr.:Fr.: n; o; q; [7]; ***P. leptocephalus*** (Jacq.:Fr.) Fr.: l; n; r; m; [7], [9], [14]; ***P. squamosus*** (Huds.:Fr.) Fr.: n; o; q; [7], [9]**;** ***Postia stiptica*** (Pers.:Fr.) Julich: n; q; [7], [9]**;** ***Protomerulius caryae*** (Swain.) Ryvarden: t; [27]; ***Psathyrella candolleana*** (Fr.:Fr.) Maire: j; n; o, c; [7], [18]; ***Pseudocraterellus undulatus*** (Pers.:Fr.) Rauschert: l; n; [7], [9]**;** ***Pseudohydnum gelatinosum*** (Scop.:Fr.) P. Karst.: l; [7]; ***Psilocybe semilanceata*** (Fr.) P. Kumm.: n; [7], [9]**;** ***Pycnoporus cinnabarinus*** (Jacq.:Fr.) P.Karst.: q, h; [7], [9]**;**

Ramaria flava (Schaeff.:Fr.) Quel.: q; [7], [9]**;** ***R. formosa*** (Pers.:Fr.) Quel.: n; [7], [9]**;** ***Rhodocollybia butyracea*** f. ***asema*** (Fr.:Fr.) Antonín, Halling & Noordel.; q, f; [7]**;** ***Rh. butyracea*** (Bul.:Fr) Lennox f. ***butyracea***: n, p; [7]**;** ***Rh. maculata*** (Alb. & Schwein.:Fr.) Singer: q; [7]**;** ***Rickenella fibula*** (Bull.:Fr.)

Raithelh.: p; [7], [9]**;** ***Rozites caperatus*** (Pers.:Fr.) P. Karst.: n; [7], [20]; **(EN); A., B., C., D.;** ***Russula alutacea*** (Fr.:Fr.) Fr.: q; [7], [9]**;** ***R. atropurpurea*** (Krombh.) Britzelm.: l; [7], [9]**;** ***R. claroflava*** Grove: l; n; o; [7], [9]**;** ***R. cyanoxantha*** (Schaeff.) Fr.: l; n; o; q; [7], [9]**;** ***R. delica*** Fr.s.lat.: j; l; [7], [9], [13]**;** ***R. fellea*** (Fr.:Fr.) Fr.: q; h; [7]**;** ***R. fragilis*** (Pers. :Fr.) Fr.: o; q; [7], [9]**;** ***R. grisea*** (Pers.) Fr.: n; [7]**;** ***R. integra*** (L.) Fr. f. ***integra***: q; [7]**;** ***R. integra*** f. ***pseudoolivascens*** (Singer) P.A.Moreau, Carteret: q; [18], [7]**;** ***R. luteotacta*** Rea: n, c; [7], [18]**;** ***R. mustelina*** Fr.: p; [7], [9]**;** ***R. ochroleuca*** (Pers.) Fr.: q; r; [7], [9]**;** ***R. olivacea*** (Schaeff.) Fr.: j; [7], [9]**;** ***R. pectinatoides*** Peck: c; [7], [18]**;** ***R. rosea*** Pers.: l; n; q; r; c; [7], [9], [18]**;** ***R. sardonia*** Fr.: q; [7], [9]**;** ***R. vesca*** Fr.: o; [7], [9]**;** ***R. virescens*** (Schaeff.) Fr.: n; o; c; [7], [9], [18]**;** ***R. xerampelina*** (Schaeff.) Fr.: l; [7], [9]**;** ***Rutstroemia elatina*** (Alb. & Schwein.) Rehm: q; [7], [18], [19]**;**

Sarcodon imbricatus (L.:Fr.) P. Karst.: p; [7], [9]**;** ***Sarcosphaera coronaria*** (Jacq.) Rehm.: o; [7], [12]; **(VU) Aii (*of European significance*); A., B., D., F.;** ***Schizophyllum commune*** Fr.:Fr.: l; n; [7], [9]**;** ***Schizopora paradoxa*** (Schrad.:Fr.) Donk;: q; [7]**;** ***Scleroderma citrinum*** Pers.:Pers.: n; o; [7], [9]**;** ***S. verrucosum*** (Bull.:Pers.) Pers.: h; [7], [9]**;** ***Scutellinia cejpii*** (Velen.) Svrček: n; [7], [8]**;** ***S. crucipila*** (Cooke & W. Phillips) J. Moravec: o; [7], [8], [19]**;** ***S. scutellata*** (L.) Lambotte: j, c; [7]**;** ***Setulipes androsaceus*** (L.:Fr.) Antonin: l, q; [7]**;** ***Simocybe centunculus*** (Fr.:Fr.) P. Karst.: c; [7], [18]**;** ***Spathularia flavida*** Pers.:Fr.: l, a, e; [2], [6], [7]; **(NT); A.;** ***Stereum hirsutum*** (Willd.:Fr.) Gray: q; [7], [9]**;** ***S. rugosum*** (Pers.:Fr.) Fr.: q; r; h; [7]**;** ***Strobilomyces strobilaceus*** (Scop.:Fr.) Berk.: i; l; n; o; [1], [3], [7], [9]**; (VU); A., C.;** ***Stropharia aeruginosa*** (Curtis:Fr.) Quel.: n; h; [7], [9]**;** ***S. semiglobata*** (Batsch:Fr.) Quel.: n; o; [7], [9]**;** ***Suillus greviellei*** (Klotzch:Fr.) Singer: a, e; [21]**;** ***S. luteus*** (L.:Fr.) Roussel: p; [3], [7], [9]**;**

Telephora palmata (Scop.:Fr.) Fr.: q; [7], [9]**;** ***Th. terresteris*** Ehrh.:Fr.: o; q; [7], [9]**;** ***Trametes gibbosa*** (Pers.:Fr.) Fr.: n; [7], [9]**;** ***T. hirsuta*** (Wulfen:Fr.) Pilat f. ***hirsute***: q; [7]**;** ***T. versicolor*** (L.:Fr.) Lloyd: j; n; o; r; [7], [9]**;** ***Tremella mesenterica*** Retz.:Fr.: l; [7], [9]**;** ***Tricharina gilva*** (Berk. ex Cooke) Eckblad: o; [7], [8], [19]; ***Tricholoma alborunneum*** (Pers.:Fr.) P. Kumm.: q; [7], [9]**;** ***T. equestre*** (L.:Fr.) P. Kumm. var. ***equestre***: q; [7], [9]**;** ***T. saponaceum*** (Fr.:Fr.) P. Kumm.: q; [7], [9]**;** ***T. sulphureum*** (Bull.:Fr.) P. Kumm.: q; [7], [18]**;** ***T. vaccinum*** (Schaeff.:Fr.) P. Kumm.: p; [7], [9]**;** ***T. virogatum*** (Fr.:Fr.) P. Kumm.: n; [7], [9]**;** ***Tricholomopsis rutilans*** (Schaeff.Fr.) Singer: q; [7], [18]**;** ***Tubaria furfuracea*** (Pers.:Fr.) Gillet: c; [7], [18]**;** ***Tylopilus pseudoscaber*** Secr.ex A.H. Smith et Thiers: q; [3], [7], [22]; **(VU); A.;** ***Tyromyces chioneus*** (Fr.:Fr.) P. Karst: q; [7], [9]**;**

Vascellum pratense (Pers.:Pers.) Kreisel: n; [7]**;**

Xeromphalina campanella (Batsch:Fr.) Ktihner & Maire: n; q; [7], [18]**;** ***Xerula radicata*** (Relhan:Fr.) Dorfelt: j; n; q, h; r; [7], [9]**;** ***Xylaria hypoxylon*** (L.:Fr.) Grev.: n, q, r; [7], [13]**;** ***Xylaria polymorpha*** (Pers.:Fr.) Grev.: n, f; [7].

Symbols used:

Locality: a. above Haidushka Pesen hut; **b.** above Karlovo town; **c.** above Ribaritsa village; **d.** above Tuzha village; **e.** above Chiflika village; **f.** around Benkovski hut; **g.** around Hubavetzh hut, **h.** Benkovski hut; **i.** Boatin reserve; **j.** Dzhendema reserve; **k**. Grumotevichnata gora; **l.** Kozya Stena reserve; **m.** Mazalat hut; **n.** Severen Dzhendem reserve; **o.** Stara Reka reserve; **p.** Steneto reserve; **q.** Tsarichina reserve; **r.** under Ambaritsa hut; **s.** under Balkanski rozi hut; **t.** under Vezhen peak; **u.** many places; v. everywhere;

Literary sources: Assyov et al., 2011 **[1]**; Assyov et al., 2012 **[2];** Assyov & Denchev, 2004 **[3];** Dimitrova & Gyosheva, 2010 **[4]**; Dimitrova, 2010 **[5]**; Dimitrova, 2011 **[6]**; Fakirova et al., 2002 **[7]**; Fakirova & Dimitrova, 1999 **[8]**; Fakirova et al., 2000 **[9]**; Hinkova, 1965 **[10]**; Burzakov, 1928 **[11]**; Petrova & Denchev, 2011 **[12]**; Stoichev & Dimcheva, 1982 **[13]**; Stoichev, 1981 **[14]**; Stoichev, 1983 **[15**]; Stoichev, 1995a **[16]**; Stoykov et al., 2015 **[17]**; Vanev & Reid, 1986 **[18**]; Dimitrova & Gyosheva, 2009 **[19]**; Gyosheva, 2011 **[20]**; Assyov et al., 2010 **[21];** Stojchev & Dimcheva, 1987 **[22];** Assyov & Denchev, 2011 **[23];** Hinkova, 1961 **[24];** Stoichev, 1995b **[25];** Stoichev, 1982 **[26];** Stoichev & Gyosheva, 2005 **[27];** Denchev et al., 2011a,b **[28]**

Conservation status: EN; VU; NI; **A.** Red List of fungi in Bulgaria **B.** Red Data Book of the Republic of Bulgaria; **C.** Red List of the Central Balkan National Park Plan; **D.** Annex N1 to the Berne Convention; **E.** Biodiversity Act of Bulgaria; **F.** National Biodiversity Monitoring System NBMDS.

Seasonality of mushrooms in the market region

The analyzed scientific literature (Fakirova et al., 2000, 2002) does not provide sufficient data on the seasonality and phenological timing of fruiting of the identified taxa, therefore we can assume about their seasonality according to Arnolds (1981, 1992), Phillips (1981, 2006), Hinkova (1954), Drumeva-Dimcheva & Gyosheva-Bogoeva (1993), Mueller et al. (2004), Drumeva-Dimcheva et al. (2010), Drumeva-Dimcheva & Gyosheva-Bogoeva (2016), Assyov et al. (2012), Assyov (2012, 2014), Vazha-

rov (2013), https://manatarka.org/, etc. The lar-gest part of macromycetous fungi (256 taxa, accor-ding to Fakirova et al., 2002) in the Central Balkan National Park actively fruit mainly during sum-mer-autumn (125 species) and spring-autumn (116 species) seasons. Typically, the early spring has 6 spe-cies and the autumn has 9 species, respectively.

Edible wild mushrooms fruiting in the territory of the Central Balkan National Park

Some authors, such as Drumeva-Dimcheva & Gyosheva-Bogoeva (1993), Denchev & Bakalova (2002), etc., found a total of 2072 macromycetes in Bulgaria, of which 200 species are edible. This determines the species diversity of edible mushrooms in the studied area as relatively high. Which of them were used in the life of the local popularation and in what way may be subject to subsequent ethnomycological studies in the region.

The analyzed literature sources, such as Fakirova et al. (2000, 2002), Denchev & Assyov (2010), Management Plan for the Central Balkan National Park (2016-2025), determined 47 species of economically important edible wild macromycetes so far on the territory of the park, which are divided into two large groups: (1) Economically valuable edible mushrooms that are harvested for comercial purposes: *Boletus aereus*, *B. edulis*, B. *pinophillus*, *Boletus reticulatus* (Syn. *Boletus aestivalis*), *Cantharellus cibarius*, *Craterellus cornucopioides*, *Hydnum repandum*, *Macrolepiota procera*, *Marasmius oreades*, *Pleurotus ostreatus*, etc.; (2) Edible mushrooms that are collected for personal use: *Agaricus campestris*, *Armillaria mellea*, *Boletus badius*, *Bovista nigrescens*, *Bovista plumbea*, *Calvatia utriformis*, *Chlorophyllum rhacodes*, *Chroogomphus rutilus*, *Clitocybe nebularis* (Syn. *Lepista nebularis*), *Clitopilus prunulus*, *Gomphidius glutinosus*, *Gyroporus castaneus*, *G. cyanescens*, *Hygrocybe pratensis*, *Lactarius piperatus*, *L. volemus*, *Leccinum scabrum*, *L. pseudoscarbum*, *Lycoperdon perlatum*, *Ramaria flava*, *Russula cyanoxantha*, *R. virescens*, *Sarcodon imbricatus*, *Suillus luteus*, *Tricholoma equestre* (Syn. *Tricholoma flavovirens*).

Little-known species of no particular economic importance that are rarely collected are: *Amanita rubescens*, *Clitocybe gibba*, *Clitocybe odora*, *Hygrophorus eburneus*, *Kuechneromyces mutabilis*, *Lycoperdon pyriforme*, *Lyophyllum decastes*, *Polyporus squamosus*, *Russula olivacea*, *R. vesca*, *Tricholomopsis rutilans*, and *Xerocomellus chrysenteron* (Syn. *Boletus chrysenteron*).

Species of conservation significance

Twenty-two (22) species of larger fungi with conservation status included in the Red List of fungi in Bulgaria (Gyosheva et al., 2006) and Red Data Book of the Republic of Bulgaria (Peev, 2015) fruit in the analyzed zone, Central Balkan National Park, so far. Of them 22 species from the Red List of fungi in Bulgaria (Gyosheva et al., 2006). They are listed in the following categories: Endangered (EN) – 9 species: *Cantharellus friesii*, *Cortinarius bulliardii*, *Hericium erinaceus*, *Hygrocybe punicea*, *Lactarius spinosulus*, *Leotia lubrica*, *Phellinus viticola*, *Phylloporus pelletieri*, *Rozites caperatus*; Near Threatened (NT) – 3 species: *Hericium coralloides*, *Phellinus nigrolimatatus*, *Spathularia flavida*; Vulnerable (VU) – 9 species: *Clavariodelphus pistilaris*, *Entoloma incanum*, *Hericium cirrhatum*, *Limacella guttata*, *Macrotyphula fistulosa*, *Otidea alutacea*, *Sarcosphaera coronaria*, *Strobilomyces strobilaceus*, *Tylopilus pseudoscaber*. Twelve (12) species from the categories Endangered (EN) and Vulnerable (VU) are included in the Red Data Book of the Republic of Bulgaria (Peev et al., 2015) (Table 1).

Seven (7) species (*Clavariodelphus pistilaris*, *Hericium cirrhatum*, *H. coralloides*, *Macrotyphula fistulosa*, *Podoscypha multizonata*, *Rozites caperatus*, and *Strobilomyces strobilaceus*) are included in the Red List of the Central Balkan National Park, Plan '01. Three (3) species (*Phylloporus pelletieri*, *Rozites caperatus*, and *Sarcosphaera coronaria*) are included in the Annex N1 to the Berne Convention (Dahlberg & Croneborg, 2003). One (1) species (*Phylloporus pelletieri*) is included in Appendix 2, Part 35a, Biological Diversity Act (Denchev et al., 2015). Three (3) species (*Phylloporus pelletieri*, *Podoscypha multizonata*, and *Sarcosphaera coronaria*) have an European endangered status (Category Aii according to IUCN). Three (3) species (*Hericium erinaceus*, *Podoscypha multizonata*, and *Sarcosphaera coronaria*) are included in the National Biodiversity Monitoring System (NBMS) and are monitored (Denchev et al., 2015) (Table 1).

Whether some of these species were collected and used by people in the marked areas, i.e., what is the degree of anthropogenic threat to them, could be the subject of further research and analysis among the local population.

The Management Plan of the Central Balkan National Park (2016-2025) contains a proposal to change the conservation status of the species *Spathularia flavida* Pers. : Fr. from Near Threatened (NT) to Endangered (EN) in the next update of the Red List of Mushrooms in the Central Balkan National Park. At the same time, the types of mushrooms that should be subject to special measures and to be included in the updated management plan of Central Balkan National Park belong to both important groups: (1) Conservation significant species from the Red List of fungi and the Red Data Book of Bulgaria; (2) Economically valuable edible fungi that are collected from the park for personal needs and commercial purposes, such as *Boletus aereus*, *B. reticulatus*, *Cantharellus cibarius*, *C. lutescens*, *Craterellus cornucopioides*, *Morchella esculentha*, *M. conica*, etc.

Analysis of climate variables related to the mushroom growth and fruiting of larger fungi in the territory of Central Balkan National Park

The fruiting of wild mushrooms is associated with complex interrelationships between climatic conditions and mushroom growth.

The analysis of the literature data shows that the ideal climatic conditions for wild mushrooms involve a balance between climatic factors, such as air temperature, air humidity, substrate/soil temperature, substrate/soil moisture, and precipitation (Hinkova, 1954; Arnolds, 1981, 1992; Phillips, 1981, 2006; Gyosheva-Bogoeva & Drumeva-Dimcheva, 1993; Mueller et al., 2004; Karavani et al., 2018; Procházka et al., 2023). Therefore, an air temperature range of 10°C to 21°C and relative air humidity above 70% - 90%, as well as soil temperature (12°C-26°C) and soil moisture (75% - 80%), create ideal conditions for many species of fungi.

Summary of available literature:

The established air temperature trends in the country correlate well with the reported global warming trends (IPCC, 2021). Warming is observed in all seasons during the period 1991-2020. The increase in summer temperatures by +0.16°C/10 years is determined by the statistically significant warming trend in June, July, and August (+0.15, +0.12, and +0.18°C/10 years, respectively). Autumn temperatures do not follow a clear trend during the period under review, but since the beginning of the century, they have also been increasing. The transition from a colder to a warmer and/or drier climate has affected about 36% of the country's territory, and the relative change in mountain climate subtypes shows a significant decrease (by 60-70%) in areas with alpine climate (Malcheva & Bocheva, 2023). In the regions with a continental climate, winter is the coldest, with a decrease in altitude of 0.3-0.4°C/100 m (Malcheva et al., 2023). The average temperature for July is lower in the highlands of Western Bulgaria (19-20°C), and in the mountains it decreases with altitude by about 0.7°C/100 m. The average temperature in April is 10-13°C. In the mountainous regions, the temperature decreases by an average of 0.6-0.7°C/100 m. The average temperature for July is lower in the highlands of Western Bulgaria (19-20°C). The average temperature in October is lowest in the highlands of Western Bulgaria (10-12°C). Unlike the average annual air temperature, the annual amount of precipitation did not change significantly during the period 1991–2020 for the country as a whole due to the different signs of change in individual regions. According to Malcheva et al. (2023), precipitation decreased significantly in the high parts of the mountains (up to 30%). In the Moderately Continental climatic subregion, winter precipitation is the smallest (18-20% of the annual amount). They vary from 190 to 200 mm in mountainous regions. In spring, precipitation in regions with a continental regime increases to 25-27% of the annual amount, and in summer, they are about 30-35% of it. In seasonal amounts of precipitation, except autumn, the differences between the two periods for a large part of the country are about ±10%. Winter precipitation decreases in the high parts of the Balkan Mountains by over 20%. Summer precipitation decreases in the high parts of the mountains by 10-15% and more. Autumn is the season with the highest increase in precipitation for the period 1991–2020 (on average over 15%), with the exception of the high parts of the mountains. A likely reason for the decrease in seasonal precipitation amounts in winter, spring, and summer is the reduced frequency of the precipitation type circulation during these seasons. The significant decrease in the anticyclonic type in autumn can be associated with the increase in the seasonal precipitation amount.

Model data analysis:

Compared to mushrooms grown under controlled conditions, the temperature and humidity

requirements for fruiting of a large proportion of wild mushrooms are not well studied or are changing with new climatic realities. The distribution of the species composition of mushrooms by season suggests that 49% of them find favorable conditions for development in the temperature range defined by the dates of a stable temperature transition above 5 in spring to 5 in autumn. For many mushroom species, the optimal temperature for spore germination is moderate, ranging from 20 to 28°C (Guo & Xu, 2025).

Warming is more pronounced in the winter and summer seasons, and less so in the spring and autumn, and in the four seasons studied, the trend for the period 1981-2020 is statistically significant. These model data do not show a significant change in the amount of precipitation. However, the spring and summer trends are negative, towards a decrease, and the winter and autumn trends are positive, towards an increase. In conclusion, given the fact that a large part of the reviewed publications show a decrease in precipitation in mountainous regions in various places in the country by up to 30%, the studies should continue and be supported by monitoring in the immediate vicinity of the research sites.

Given their seasonal development, Fig. 2 and Fig. 3 present the main climate-forming variables - average air temperature and precipitation for the climatic seasons winter, spring, summer, and autumn.

The distribution of precipitation by season (Fig. 2) and the average seasonal air temperature for the period (Fig. 3), 1981-2020, is shown by reanalysis of EPA 5 in the region. The selected region covers a larger area and is relatively representative of the main habitats occupied by deciduous forest vegetation in the Central Balkan National Park. Model data show that for the period 1981-2020, the average temperature for the winter, spring, summer, and autumn seasons is respectively: 0.5°C; 10.6°C; 20.5°C, and 11.2°C. Autumn and spring have similar values, but as can be seen from the data, spring is slightly cooler. Summer is also relatively cold with average temperatures around and slightly above 20.0°C. The average annual air temperature for the period is 10.7°C. The region receives annual precipitation of around 886 mm or above. Precipitation shows maximums in the spring-summer period (551 mm) with the lowest amount in winter (163 mm). The combination of cool and humid weather during the warm half of the year suggests a variety of wild mushrooms and the presence of protected species in the country and Europe.

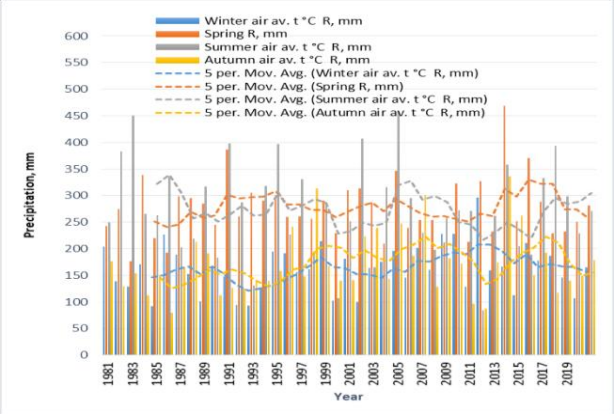

Fig. 2. Distribution of the amount of precipitation by season for the period 1981-2020, EPA 5 reanalysis in the region.

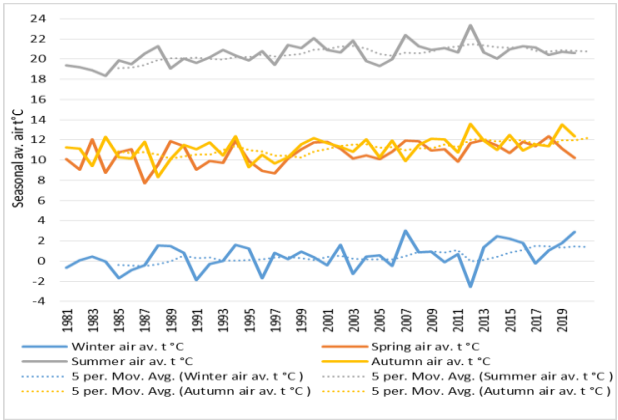

Fig. 3. The average seasonal air temperature for the period 1981-2020, EPA 5 reanalysis in the region.

As can be seen in Table 2, warming is more pronounced in the winter and summer seasons, and less pronounced in the spring and autumn. In the four seasons studied, the trend for the period 1981-2020 is statistically significant. These model data do not show a significant change in the amount of precipitation. However, the spring and summer trends are negative, towards a decrease, and the winter and autumn trends are positive, towards an increase. In conclusion, given the fact that a large part of the reviewed publications show a decrease in precipitation in mountainous

regions in various places in the country by up to 30%, the studies should continue and be supported by monitoring in the immediate vicinity of the research sites.

Table 2. Statistical assessment of trends for the period 1981-2020 by season.

	Mann-Kendall trend			Sen's slope estimate		
Time series	**First year**	**Last Year**	**n**	**Test Z**	**Signific.**	**Q**
Winter ∑R, mm	1981	2020	40	1.06	ns	0.63
Spring ∑R, mm	1981	2020	40	-0.03	ns	-0.09
Summer ∑R, mm	1981	2020	40	-0.62	ns	-0.87
Autumn ∑R, mm	1981	2020	40	1.08	ns	0.69
Winter av T° C	1981	2020	40	2.76	**	0.05
Spring av T° C	1981	2020	40	2.48	*	0.04
Summer av T° C	1981	2020	40	3.25	**	0.04
Autumn av T° C	1981	2020	40	2.57	*	0.04

The average annual and multi-annual values of the following environmental parameters have been calculated for the period 1981-2020: the average annual air humidity (Fig. 4) is 72%, and the average annual soil surface humidity (Fig. 5) is 0.55 m^3/m^3.

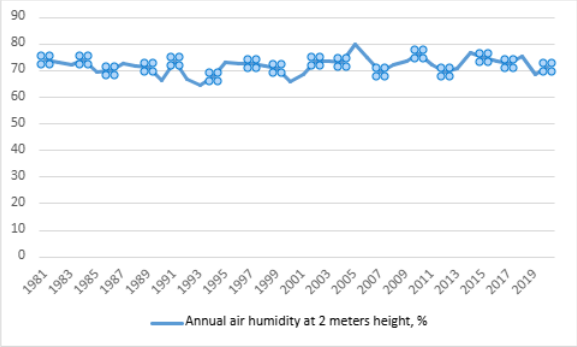

Fig. 4. The average annual air humidity (%) for the period 1981–2020.

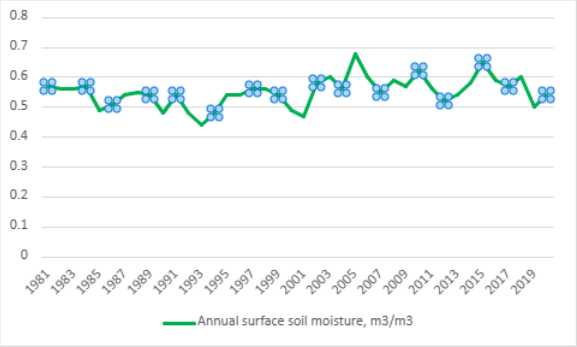

Fig. 5. The average annual soil surface humidity (m^3/m^3) for the period 1981-2020.

Conclusions

The analysis of climatic conditions and macrofungal diversity in the Central Balkan National Park region, Stara Planina, Bulgaria, conducted in this work, shows that there is an increase in air temperature by seasons, which is a prerequisite for extending the fruiting period of macromycete mushrooms in the region. The established species composition of macromycetes and, in particular economically valuable edible mushrooms, shows a relatively high diversity. The formation of fruiting bodies by macromycetes and the duration of their fruiting period is directly dependent on the microclimatic conditions of the specific habitat region. The combination of specific abiotic factors in the Central Balkan National Park region (Stara Planina Mts) and their impact on the productivity of edible mushrooms requires specific field studies. This would be important from both an ecological and an economic point of view. On the one hand, new finds are expected for the territory, which would enrich the mycological data for the country as a whole, and on the other hand, the resource of edible wild mushrooms will be specified as a potential source of food and income for the local population.

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