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Distribution of edible, toxic and medicinal wild mushrooms in Europe and Bulgaria

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Abstract: *The scientific interest in wild mushrooms continuously increases worldwide. In the present review article, the results from some recent investigations by Bulgarian and foreign authors devoted to the current distribution of some edible, toxic and medicinal wild mushroom species in Bulgaria and some European countries are summarized. Some newly-recognized mushrooms are indicated. The examinations of wild mushroom safety under the conditions of environmental contamination deserve special attention, too. The scientists from European countries and Bulgaria have essential contributions to the field of the mushroom identification and distribution.*

Keywords: edible wild mushrooms, toxic wild mushrooms, medicinal wild mushrooms, distribution, Europe, Bulgaria

Introduction

Recently, there is rising interest in wild mushrooms worldwide caused by the necessity of a more profound understanding of their essential features and role in living nature and human society.

In the present review article, some results of publications devoted to the geographical distribution of a variety of edible, toxic and medicinal wild mushroom species in several European countries and in Bulgaria are summarized.

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Distribution of some common and newly-recognized wild mushrooms

The *Strobilomyces* species of family Boletaceae is broadly distributed in Europe and other continents and serves an important ecological function [1]. *Ganoderma lucidum* colonizes mostly oak and beech trees in Central Europe [2]. Five *Ganoderma lingzhi* strains and five *Ganoderma lucidum* ones are recently cultivated in Slovakia.

Hypomyces is a large genus of fungicolous mushrooms, parasitising the fruiting bodies of *Agaricales*, *Boletales*, *Helotiales*, *Pezizales* and *Polyporales*. It currently comprises 147 species widely distributed in France, Germany, Italy, the UK and other countries [3].

Five fungi are recognized on Pantelleria Island, Italy: the saprophytic mushroom *Agaricus arvensis* Schaeff. and the ectomycorrhizal mushrooms *Boletus aereus* Bull., *Cantharellus lutescens* (Pers.) Fr., *Lactarius deliciosus* (L.) Gray and *Suillus collinitus* Kuntze [4]. Three of these species grow exclusively in a pine forest: *Cantharellus lutescens*, *Lactarius deliciosus* and *Suillus collinitus*.

Recently, two parasitic fungi, the *Anthracoidea arenariae* (Syd.) Nannf. of family Anthracoideaceae [5] in North Macedonia and the *Antherospora hortensis* Piątek & M. Lutz of family Floromycetaceae [6] in Greece are observed. In Montenegro, the plant pathogenic mushroom *Arthrocladiella mougeotii* (Léveillé) Vassilkov of family Erysiphaceae is identified [7]. In Serbia, the saprophytic mushrooms *Loweomyces fractipes* (Berk. & M.A. Curtis) Jülich, of family Steccherinaceae [6] and *Clitocybe truncicola* (Peck) Sacc. of family Tricholomataceae [8] are reported.

In Bulgaria, several saprophytic mushrooms such as *Psathyrella typhae* (Kalchbr.) A. Pearson & Dennis of family Psathyrellaceae and *Stropharia halophila* Pacioni [9] and *Pholiota henningsii* (Bres.) P.D. Orton of family Strophariaceae [6] are described. Additionally, the mycorrhizal mushroom *Tricholoma frondosae* Kalamees & Shchukin of family Tricholomataceae is found out in Bulgaria [10].

Edible wild mushroom distribution

Pleurotus eryngii (king Oyster) is one of the most highly prized edible mushrooms [11]. *P. eryngii* var. *ferulae* is distributed in Europe.

During the twentieth century, the chanterelle *Cantharellus cibarius Fr*. is the most popular edible mushroom species in Sweden [12]. In Småland (South Sweden), the chanterelle (*Cantharellus cibarius* Fr.) and the funnel chanterelle (*Craterellus tubaeformis* (Fr.) among five species of three families are usually consumed [13]. In Roztochya (Western Ukraine) and Kortkeros (Komi Republic in North West Russian Federation), two *Boletus* spp., *Polyporus umbellatus* (Pers.), *Grifola frondosa* (Dicks.), *Armillaria spp*. and *Russula spp*. are most popular. *Lactarius spp*. is most often used in Russia, too.

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The following edible mushrooms are identified in Mazovia, a mycophilic region of Poland: *Agaricus arvensis* Schaeff, *Amanita fulva* s.1. Fr., *Armillaria mellea* s.1. (Vahl) P. Kumm., *Armillaria borealis* Marxm. & Korhonen, *Armillaria gallica* Marxm. & Romagn, *Boletus edulis* s.1. Bull., *Boletus reticulatus* Schaeff, *Boletus subtomentosus* s.1. L. and *Gyroporus castaneus* (Bull.) Quél. [14].

In South Tyrol, Northern Italy, Southern Alps, three mushrooms are identified [15]. Two species, *Fomitopsis betulina* Bull. and *Fomitopsis officinalis* Vill. belong to the family of Fomitopsidaceae while a third one, *Auricularia auricula-judae* Bull. id of the family of Auriculariaceae.

The examination of the chemical composition, fatty acids, volatile profile and phenolic compound profiles from five wild edible mushrooms such as *Agaricus bisporus*, *Pleurotus ostreatus*, *Cantharellus cibarius*, *Boletus edulis* and *Lactarius piperatus* from Transylvania, Romania, indicates that their fruiting bodies may be exploited as functional ingredients in the composition of innovative food products [16].

In Marmara region in Turkey, for every 1% increase in consumption of two mushroom species, *Lactarius semisanguifluus* and *Macrolepiota procera var*., meat consumption decreases by 4.39% and 2.97%, respectively [17].

The ecological distribution of the edible and medicinal mushroom *Polyporus umbellatus* in 70 localities in Slovakia is examined and the potential for commercial cultivation of this species is described [18]).

In Bulgaria, there are a total of 200 wild edible mushroom species [19]. Of them, about 20-30 species only are used as food. Some species such as edible boletus, *Boletus edulis* Bull., field mushroom, *Agaricus campestris* L., slippery Jack, *Suillus luteus* Roussel, parasol mushroom, *Macrolepiota procera* S. F. Gray, saffron milky-cap, *Lactarius deliciosus* and Caesar's mushroom, *Amanita caesarea* Pers. are considered best edible mushrooms.

Among 200 randomly selected respondents, 100 males and 100 females, from several towns and villages in the Region of Varna, total of 122 respondents, 64 males and 58 females, give positive answers to the question which edible wild mushrooms these subjects recognize [20]. Men recognize a total of 24 and women do a total of 26 different mushrooms. The edible boletus *Boletus edulis* Bull. is the most commonly recognized edible wild mushroom. Next follow the parasol mushroom *Macrolepiota procera* S. F. Gray, the chanterelle *Cantharellus cibarius* Fr., the agaric *Marasimus oreades* Fr., the culinary-medicinal honey mushroom *Armillariella mellea* P. Kumm, the Caesar's mushroom *Amanita caesarea* Pers., etc. There are statistically significantly more males than females who recognize the forest mushroom *Agaricus silvaticus* Schaeff (t=4.485; $p<0.001$) [20].

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Wild mushroom safety

Environmental contamination represents a serious challenge for human society. That is why numerous contemporary methods for the analysis of edible mushroom contents are more and more widely applied.

Among a group of wild edible and inedible mushroom species such as *Boletus reticulatus*, *Cantharellus cibarius*, *Podoscypha multizonata*, *Marasmius oreades*, *Megacollybia platyphylla*, *Meripilus giganteus*, *Neoboletus erythropus*, *Panellus stipticus*, *Phaeotremella foliacea*, *Russula aurea*, *Agaricus campestris*, *Armillaria ostoyae*, *Bovistella utriformi* and *Pleurotus ostreatus*, which are collected from the Belgrad Forests and the Ilgaz Mountain National Park, Turkey, the last four species present with elevated heavy metal concentrations and should be consumed in a controlled manner [21].

Three edible wild-growing mushroom species such as *Imlera badia*, *Boletus subtomentosus* and *Xerocomellus chrysenteron* sampled during the period between 2014 and 2019 in 60 different environmentally loaded localities in Slovakia present with high mercury content and their consumption represents a serious threat for adults and children [22].

The analysis of the geospatial distribution of two most radiotoxic isotopes of the uranium decay chain in samples of king bolete mushroom *Boletus edulis* and related mushroom species, including *Boletus pinophilus*, *Boletus reticulatus*, *Boletus luridus* and *Boletus impolitus* collected from Poland and Belarus suggests that these mushrooms are comparatively safe for human consumption [23].

The mineral contents in the fruitbodies of the edible mushroom *Leccinum scabrum* from two forested upland sites and one lowland site of different geochemical background in Poland results from a complex interaction of a species' characteristic physiology with local mineral soil geochemistry and with anthropogenic pollution factors [24].

The investigation of the content of 34 elements in four wild-growing edible mushroom species such as *Boletus edulis*, *Imleria badia*, *Leccinum scabrum* and *Macrolepiota procera* collected from Polish forests between 1974 and 2019 reveals that they are a limited source of minerals in the human diet while their frequent and regular consumption is associated with exposure to selected toxic elements and is not recommended [25].

The analysis of the inorganic elemental composition in fruiting bodies of the scaly tooth mushroom *Sarcodon imbricatus* collected from the Wdzydze forests in Central Poland and the Augustowska Primeval forest in Eastern Poland demonstrates concentrations of cadmium, mercury and lead below the established weekly intake tolerance limits [26].

The three-year monitoring of 18 elements in fruiting bodies of five edible mushroom species such as *Calocybe gambosa*, *Entoloma clypeatum*, *Entoloma saepium*, *Amanita rubescens* and *Xerocomellus chrysenteron* collected from an old orchard in South Bohemia, Czech Republic, does not indicate any

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pronounced unfavourable effect on health if these mushroom species are consumed occasionally and do not represent the main component of the diet [27]. Similar results have been obtained concerning four wild growing edible mushroom species such as *Chlorophyllum rhacodes*, *Suillus grevillei*, *Imleria badia* and *Xerocomellus chrysenteron* collected in an unpolluted site in South Bohemia, the Czech Republic [28].

Toxic wild mushroom distribution

Numerous poisonous wild mushrooms have already been identified worldwide. Cortinarius mushrooms are widely reported in Europe where they cause human poisoning and deaths through accidental ingestion of the poisonous species mistaken for the edible ones [29]. The species *Cortinarius orellanus* of the *Cortinarius* genus is typically found in Europe and this mushroom has caused a mass poisoning in Poland in the 1950s [30]. The Cortinarius 'deadly webcap' mushroom species identified in forests of Northern Europe and Scandinavia may be mistaken for other edible mushrooms [31].

In Mazovia, a mycophilic region of Poland, the following mushrooms species are most common among 21 toxic taxa: *Agaricus xanthodermus* Genev., *Amanita muscaria* (L.) Lam., *Amanita pantherina* (DC.) Krombh and *Amanita phalloides* s.1. Vaill. ex Fr. [14].

Some toxic *Morchella* species are responsible for numerous poisonings in France [32]. The wild mushroom fly agaric *Amanita muscaria* that contains four hallucinogens is widely distributed throughout continental Europe and the UK [33].

Gyromitra esculenta, known as a 'false morel', is well-documented as one of the most poisonous mushrooms [34]. This species grows all over the world mostly in coniferous forests in early spring time. It is easily confused with *Morchella esculenta,* known as a 'true morel' and an exclusive culinary product.

The most toxic wild mushrooms in Bulgaria are the species of fly agaric or death-cap *Amanita phalloides*, *Amanita virosa*, *Amanita muscaria* and panther cap, *Amanita pantherina*. [19]. These mushrooms as well as *Inocybe erubescens* belong to the family of Amanitaceae. The deadly fibrecap, *Inocybe erubescens* A. Blytt of the family Inocybaceae is another strongly poisonous wild mushroom in Bulgaria. It is noteworthy that devil's boletus *Boletus satanus* is a toxic duplicate of the popular and widely distributed *Boletus edulis* Bull. [19].

Medicinal wild mushroom distribution

Knowledge of the medical effects of a lot of wild mushrooms is permanently enriched, similar to studies related to the knowledge and distribution of medicinal plants [35].

Morchella conica Pers. is one of six wild edible mushrooms that are widely used in Europe and Asisa not only for their nutritional value but also as a potential source of antidiabetic drugs [36].

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The analysis of the freeze- and hot-air-dried fruiting bodies of five wild-growing edible mushroom species collected in Poland such as *Armillaria mellea*, *Lactarius deliciosus*, *Leccinum aurantiacum*, *Suillus luteus* and *Boletus badius* shows that they increase the antioxidant potential of water-soluble polysaccharides [37].

The geographic and climatic conditions of the collection site of two wild edible mushrooms such as the honey fungus *Armillaria mellea* and the parasol mushroom *Macrolepiota procera* in Portugal influence on mushroom's biomolecule compounds and antioxidant properties [38].

Four macrofungi species with ecological relationship to birch (*Betula* sp.) are collected near the town of Vimperk in the Bohemian Forest, the Czech Republic [39]. Two of them, *Leccinum scabrum* and *Leccinum versipelle* are mycorrhizal while the other two species, *Fomitopsis betulina* and *Inonotus obliquus* are parasitic and are used in alternative medicine.

In Armenia, there are about 200 species of aphyllophoroid mushrooms, including hymenochaetoid fungi of the order *Hymenochaetales* that is represented by 27 species, 14 genera and three families [40]. Of them, 40 species possess medicinal properties. *Phellinus tremulae* is originally reported for Armenian mycobiota.

Among 30 Basidiomycetes strains collected from the mountain and plain forests of Georgia, the split gill medicinal mushroom *Schizophyllum commune* BCC64 of family Agaricomycetes exhibits the highest inhibitory activity against *Escherichia coli* and *Staphylococcus aureus* [41].

Traditional experiences and modern studies demonstrate that medical mushrooms used in European traditions have promising distinct pharmacological potential mediated through defined antitumour, antiinflammatory, antioxidative and antibacterial mechanisms [42].

Similar therapeutic effects are established for other wild mushrooms, too. Some 21 coprinoid mushroom species of former genus *Coprinus Pers*. (Coprinaceae, Agaricomycetes) which are currently divided into four new genera: *Coprinus*, *Coprinopsis*, *Coprinellus* and *Parasola* and distributed in Armenia possess these medicinal and some other properties as well [43]. The acetone extract of the fruiting bodies of the edible peppery milk cap mushroom *Lactarius piperatus* of family Agaricomycetes from Serbia exerts several health promoting effects as it possesses antioxidant, antimicrobial, genoprotective, anticancer and neuroprotective potential [44]. The wild mushroom *Polyporus squamosus* (Huds.) Fr. from Romania can be used as a medicinal ingredient based on its antioxidative, antimicrobial and antiquorum potential [45].

Six medicinal wood-destroying mushrooms commonly found in deciduous and mixed coniferous forests in Central Russia such as *Fomes fomentarius*, *Fomitopsis pinicola*, *Trametes versicolor*, *Trichaptum biforme*, *Inonotus obliquus* and *Coniophora puteana* present with sufficient antiproliferative activity and exert cytotoxic and cell growth-inhibitory effects on leukemia cell lines [46]. Several edible and inedible

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mushrooms growing in the Mediterranean area of France such as *Caloboletus calopus*, *Rubroboletus lupinus*, *Rubroboletus pulchrotinctus*, *Rubroboletus satanas*, *Gyroporus castaneus*, *Suillus luteus* and *Omphalotus olearius* possess antiproliferative activity against the HCT116 colon adenocarcinoma cell line [47].

Hypholoma lateritium is an edible macrofungus with a common distribution in Europe which extracts demonstrate significant activities on proinflammatory protein levels [48].

On the North Black Sea coast, there is little data ethnomycological studies in the available literature, unlike ethnobotanical ones. [49, 50]. Some medicinal wild mushrooms in 11 towns and nine villages on the territory of the North Black Sea coast in Bulgaria are identified, too [51].

Conclusion

Although modern mycological research is less intensive in Europe than in Asia, there are essential contributions to the field of the identification and current distribution of the edible, toxic and medicinal mushrooms by the authors from European countries and Bulgaria as well. Obviously, there are opportunities for more effective interdisciplinary investigations on this hot topic.

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