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IMPACT OF COLLECTING MUSHROOMS FROM THE SPONTANEOUS FLORA ON FOREST ECOSYSTEMS IN ROMANIA

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Abstract

Mushrooms from spontaneous flora are among the most important non-wood forest products, more than 3000 species being consumed worldwide and more than 100 being of great importance in medicine, fighting against several diseases. In Romania, there is a long tradition of collecting/picking edible mushrooms from the spontaneous flora, but concrete data regarding the impact of mushrooms collecting on forest ecosystems is lacking. For estimating the quantities of edible mushrooms that could be harvest from spontaneous forest flora managed by the National Forest Administration in 2016, the following were taken into account: the reports recently done by the specialists of National Institute for Research and Development in Forestry "Marin Drăcea"-INCDS; the database of INCDS regarding the non-wood forest products; the current forest fund administrated by the National Forest Administration; the information contained in scientific papers or resulted from research projects. The largest amounts of edible mushrooms that are harvested from the Forestry Departments managed by National Forest Administration belong to the following species: Boletus sp., Cantharellus cibarius Fr. (chanterelle) and Armillaria mellea (Vahl) P. Kumm. (honey fungus). The most significant impact of mushrooms collecting occurs in the terrestrial flora and fauna. In order to assure a low impact on environment, the activity of harvesting edible mushrooms will have to respect the principle of sustainable management of forestry resources, i.e. the harvesting should be made so as not to disturb the regenerative capacity and biodiversity especially in the case of endangered species or in fragile ecosystems. If the activity of harvesting edible mushrooms is supervised by the forest authorities who have experience in organizing such activities and in compliance with all the recommendations, there is no possibility of occurrence of situations with negative effects on biodiversity or on the abundance of mushroom species.

Key words*: mushroom, collecting, impact, spontaneous flora.*

INTRODUCTION

The mushrooms are relatively simple plants (*Thallophyta*), being grouped in Phylum of Fungi, which is divided into five classes that include the microscopic fungi (micromicetes) and mushrooms with large fruiting bodies (macromicetes) (Eliade and Toma, 1977).
They are among the most important non-wood forest products, more than 3000 species are consumed worldwide and more than 100 are of great importance in medicine, fighting against cancer and other chronic diseases (Chang and Miles, 2008). For these reasons, the Food and Agriculture Organization of the United Nations (FAO-UN) promotes their use in order to contribute to sustainable forest management worldwide by assuring also the biodiversity conservation and by improving incomes and food security of future generations (FAO, 1991). Since ancient times, mushrooms were considered gourmet ingredients across the world, especially for their unique flavor, being evaluated by mankind as a culinary miracle (Dincă and Dincă, 2011). Latin poet Horace (65-8 BC.) believes that "it is easier to despise gold and silver than to give up a dish of mushrooms" (Tudor, 2010). The mushrooms are considered a delicacy with great nutritional and functional values, being of great interest because of their organoleptic properties, medicinal and economic significance (Chang and Miles, 2008; Ergönül et al., 2013). However, it cannot easily distinguish between edible and medicinal mushrooms because many of the common edible species have therapeutic properties and also the ones used for medical purposes are edible (Guillamón et al., 2010).

According to recent studies, edible mushrooms are becoming increasingly important for their nutritional, sensory and pharmacological characteristics (Ergönül et al., 2013).
With respect to their chemical composition, mushrooms could become an alternative source of new antimicrobial compounds, mainly secondary metabolites, such as terpenes, steroids, anthraquinones, derivatives of benzoic acid, and the quinolones, but also of primary metabolites, such as oxalic acid, peptides and proteins (Valverde et al., 2014).
Mushrooms could also be an excellent source of various nutrients that could be used directly in the human diet and health promotion for all synergistic effects of bioactive compounds (Román et al., 2006; Barros et al., 2007; Vaz et al., 2010).
The nutritional value of edible fungi is due to their high content of protein, fiber, vitamins and minerals and low level of fat (Mattila et al., 2001; Barros et al., 2008). They are very useful for vegetarian diets because they provide all essential amino acids for adults' requirements, having higher protein content than most vegetables (Barros et al., 2008).
Most edible mushrooms fructify in summer and fall, having higher frequency and production in hilly and mountain regions (Chang and Miles, 2008). During a year, in chronological order, the first mushrooms that appear at the end of winter are the representatives of Genus *Peziza* Dill. ex Fries. They are followed by the fungi of Genus *Morchella* Dill. ex Fries, at the beginning of spring, followed by the representatives of Genera *Tricholoma* Fries, *Amanita* Pers., *Entoloma* (Fr.) P.Kumm., that appear in May. In the summer, several mushroom of Genera *Russula* Pers., *Lactarius* Pers., *Cantharellus* Adans. ex Fr. and *Boletus* L. appear, and in the autumn, in September, October the large majority of fungi are developing, disappearing later with the advent of the first frost (Eliade and Toma, 1977).
Mushrooms are multiannual and the fructifications generally have a short development phase. When conditions are favorable, the fructification lasts several days. Sometimes, depending on the environmental conditions, the fructification can begin directly with a great production which is maintaining for 2-4 days, then it gradually decreasing until disappearing. Sometimes, the fruiting begins with small production which then increases abruptly interrupting, or with a moderate production throughout the period of fructification (Chang and Miles, 2008). Ecological optimum of edible mushrooms is very limited, this feature representing the main cause of the high variability of productions in space and time (Wasser, 2011).
Besides their nutritional and medicinal properties, mushrooms have important functions in the forest ecosystem. They decompose organic matter and the mycorrhizal fungi improve nutrient acquisition, stress tolerance and resistance to pathogens of the host trees (Smith and Read, 1997).
They largely determine the evolution of the substance and the transport processes of radionuclides in forest ecosystems. Fungi play a key role in mobilizing, uptaking and translocation of nutrients and substantially contribute to long-term maintenance of radiocesium in forest soil organic horizons (Steiner et al., 2002).
Therefore, within the ecosystem, the mushrooms have the following functions (Tainter and Baker, 1996; Berg and McClaugherty, 2008; Smith and Read, 2008):

- humification and mineralization of organic waste (both plant and animal origin) of biota;
- solubilization of poorly soluble minerals from mineral substrate and supplying the plants with them;
- supply superior plants with nitrogen compounds from the decomposition of organic matter;
- structuring the soil by agglutination of organic and / or mineral particles;
- structuring the organic deposits by binding micelles (that have a radial or linear development), which helps protecting the soil surface and creates a specific ecological niches at the litter layer;
- converting the organic material from the soil surface into humus with different qualities.

The mushrooms are preferred by many animal species, without being their exclusive feed. The animals that are currently eating mushrooms are the following: the wild boar (*Sus scrofa* L.), the brown bear (*Ursus arctos* L.), the European

badger (*Meles meles* L.), the red squirrel (*Sciurus vulgaris* L.), the European hedgehog (*Erinaceus europaeus* L.), the spur-thighed tortoise (*Testudo graeca* L.) and several snail species, such as *Orcula dolium* Draparnaud and *Limax cinereoniger* Wolf etc. Also, they constitute vital support for various animal and plant parasites, defined as hyperparasites (Hanski, 1989).

In the spontaneous flora of Romania, the edible mushrooms have a high distribution range, being present in all forest ecosystems, from plain to mountain regions, where the site conditions are favorable for their development. Together with forest fruit, medicinal plants and game, mushrooms represent one of the most important non-wood forest products for Romania.

The spread of edible mushrooms is subject to the existence of the forest environment and forest related ecological niches, such as glades, forests edge etc. Within the whole distribution range there are areas with different potential and intensities of fructification, being conditioned by the microclimate, type of vegetation, anthropogenic pressure and exploitation.

In Romania, as in the case of other countries worldwide, there is a long tradition of collecting/picking edible mushrooms from the spontaneous flora, but concrete data regarding the impact of mushrooms collecting on forest ecosystems is lacking. Therefore, the aim of this paper is to estimate the quantities of mushrooms that could be harvested by the Local Forestry Departments within National Forest Administration Romsilva and the potential impact of mushroom harvesting on the environment.

MATERIALS AND METHODS

The harvesting of edible mushrooms is a seasonal activity, concentrated along the growing season (April to October, depending on the species biology and optimal harvesting period), being primarily dependent on the fructification intensity.

According to recent statistics, in Romania, in the period 2009-2015, the average annual quantity of the harvested edible mushrooms from the spontaneous flora was 636 tones and varied between 521 (year 2014) and 808 (year 2012) tones (MMAP, 2016a). Every year, National Forest Administration Romsilva, by taking into consideration the fructification, is harvesting between 400 and 500 tons of edible mushrooms from spontaneous flora (Crăciunescu et al., 2015). In Romania, the harvesting of the edible mushroom is done across the forest fund, administrated both by approximately 140 private forest districts and by around 330 state forest districts of National Forest Administration Romsilva. The latter ones are organized at county level into Local Forestry Departments (ro. *Direcție Silvică*), namely: Alba (AB), Arad (AR), Argeş (AG), Bacău (BC), Bihor (BH), Bistriţa-Năsăud (BN), Botoşani (BT), Braşov (BV), Brăila (BR), Buzău (BZ), Caraş Severin (CS), Călărași (CL), Cluj (CJ), Constanța (CT), Covasna (CV), Dâmboviţa (DB), Dolj (DJ), Galați (GL), Giurgiu (GR), Gorj (GJ), Hunedoara (HD), Harghita (HR), Ialomiţa (IL), Iași (IS), Ilfov (IF), Maramureș (MM), Mehedinţi (MH), Mureş (MS), Neamţ (NT), Olt (OT), Prahova (PH), Satu Mare (SM), Sălaj (SJ), Sibiu (SI), Suceava (SV), Teleorman (TR), Timiş (TM), Tulcea (TL), Vâlcea (VL), Vaslui (VS) and Vrancea (VN) (forestry fund constituted of forests, forests edges, meadows, wooded pastures, meadows etc.).

The access to areas with edible mushrooms is done by previously created roads for other purposes (e.g. exploitation, connection between communities, access to enclaves, transhumance or old paths).

The harvesting of edible mushrooms does not require special arrangements within the forestry fund, such as deforestation or reducing in any way the forest area. It involves especially a judicious placement of the points of collection (and acquisition), the necessary workforce and the needed accommodation, as the case.

The main phases of harvesting activity are:

a. Evaluation of the fructification within the known harvesting areas and also within the lands where new areas with fructification were identified;

b. Organizing the points or centers of collection (storage spaces, equipped with scales and packaging for short or long storage, bedding, forms, acquisition funds, sanitary authorization, posting of identifying and harvesting instructions of mushrooms);

c. Manual harvesting (**collecting / picking**) of mushrooms (by twisting and easily tearing), packaging in baskets and moving to collection points where the reception is done. The harvesting of mushrooms is done during the morning, after the dew disappears, on dry weather, or if they require a preservation for a few days, the optimal harvesting time is mid-day, but not in the heat, because then they lose their flavor.
On rainy days, it is not advisable to harvest mushrooms because they will be filled with water; they will crush and will not be suitable for preservation, increasing in this way their percentage of perishability;
d. The reception of mushrooms takes place at the collecting points and consists in taking the baskets with mushrooms, weighing, and placing them on the reception table, where good, healthy and clean mushrooms are put. Impurities and sick and poisonous mushrooms are left into the basket in order to be reweighted, and the difference determine the received amount;
e. Temporary storage is done in boxes in cool, dark and ventilated basements, by vertically stacking;
f. The sending of products to valorification centers must be done as quickly as possible and must assure protection conditions against qualitative depreciation.
Recently, in December 2016, on the website of the Ministry of Environment, Waters and Forests was posted, for public consultation, a project of a Ministerial Order regarding the instructions for harvesting and purchasing the non-wood forest products, including mushrooms, specific to national forest fund (MMAP, 2016b). This regulation is stipulated by Article 58 paragraph (5) of the Law 46/2008 republished – Forest Code.
According to this project of Ministerial Order, the activity of harvesting the non-wood forest products, including mushrooms, shall be conducted only by the owner or forest district with individuals authorized by the forestry district that is administrating the forestry fund or providing forestry services.
In this way, it is expected to have an inventory at national level regarding the points of harvesting and the harvested quantities for each species. This would be also a very useful tool for assuring the principles of sustainable development.
For estimating the quantities of edible mushrooms that could be harvest from spontaneous forest flora managed by the National Forest Administration in 2016, the following were taken into account: the reports recently done by the specialists of National Institute for Research and Development in Forestry "Marin Drăcea" - INCDS; the database of INCDS regarding the non-wood forest products; the current forest fund administrated by the National Forest Administration; the information contained in scientific papers or resulted from research projects.
The database of the non-wood forest products was done by consultation the information from the forest management plans elaborated in the last decade (in order to take into consideration the current area of forestry fund).
In these works, there is a chapter entitled *Better utilization of other forest products than wood* that consists of concrete (values) and approximate data (indication of species that could be harvested), which are based on the experience of field staff in the area and the records from the forest districts regarding the harvests of previous years (game harvested, salmonids production, the products of spontaneous and cultivated, medicinal and aromatic plants, production of berries and edible mushrooms).
The corresponding values for forest districts areas that were inventoried were multiplied by a coefficient corresponding to the current total area managed by Forestry Department.
The coefficient has determined by taking into consideration the ration between total area of forested land existing at Forestry Department level and area of selected forest districts within the same Forestry Department. Usually, the area of four forests district for each Forestry Department was taken into account. This method of calculation provides (in the absence of in-depth local studies on these resources) a relatively real database of edible mushrooms from the national forestry fund.

RESULTS AND DISCUSSIONS

It is noted from Figure 1 that the largest amounts of edible mushrooms that are harvested from the Forestry Departments managed

by National Forest Administration belong to the following species: *Boletus* sp., *Cantharellus cibarius* Fr. (chanterelle) and *Armillaria mellea* (Vahl) P.Kumm. (honey fungus).

The honey fungus is harvest in significant quantities almost in all counties across Romania, but mainly in Maramureș, Suceava, Bacău, Mureș, Neamț counties. In the case of honey fungus, the fructification is strong in hilly and mountain regions and weaker in plain areas.

The largest amounts of harvested chanterelle and *Boletus* sp. are located, like in the case of honey fungus, in Suceava and Maramureș counties.

The results in the case of Suceava County confirm the data regarding harvested quantities in the period 1963-1972, according to which the 1918 tones of mushroom were collected, mainly honey fungus and chanterelle (Ichim, 1994).

In addition, in much smaller quantities are also harvested: *Tuber aestivum* Chatin (summer truffle) (Dincă and Dincă, 2012), *Choiromyces meandriformis* Vittad. (Transylvanian Big White Truffle), *Morchella* sp. (True morels), *Amanita caesarea* (Scop.) Pers. (Caesar's mushroom), *Russula alutacea* (Fr.) Fr, *Russula vesca* Fr. (bare-toothed Russula), *Russula virescens* (Schaeff.) Fr. (green-cracking russula), *Russula cyanoxantha* (Schaeff.) Fr. (charcoal burner), *Pleurotus ostreatus* (Jacq. Ex Fr.) P. Kumm (oyster mushroom), *Lactarius deliciosus* (L. ex Fr.) S.F.Gray (saffron milk cap), *Agaricus silvaticus* Schaeff. (Scaly Wood Mushroom), *Ramaria* sp. Fr. ex Bonord. and *Marasmius oreades* (Bolton) Fr (Scotch bonnet).

It should also be mentioned that according to the Ministerial Order no. 246/2006 regarding the list of edible mushrooms from spontaneous flora for which the harvesting and acquisition is allowed, there are 35 species in this situation (MAPDR, 2006).

This list is intended to grow to 108 species if the project of the Ministerial Order (MMAP, 2016b) will be adopted.

Currently more and more European countries are introducing lists of mushroom species allowed for commercial use (Kotowski, 2016).

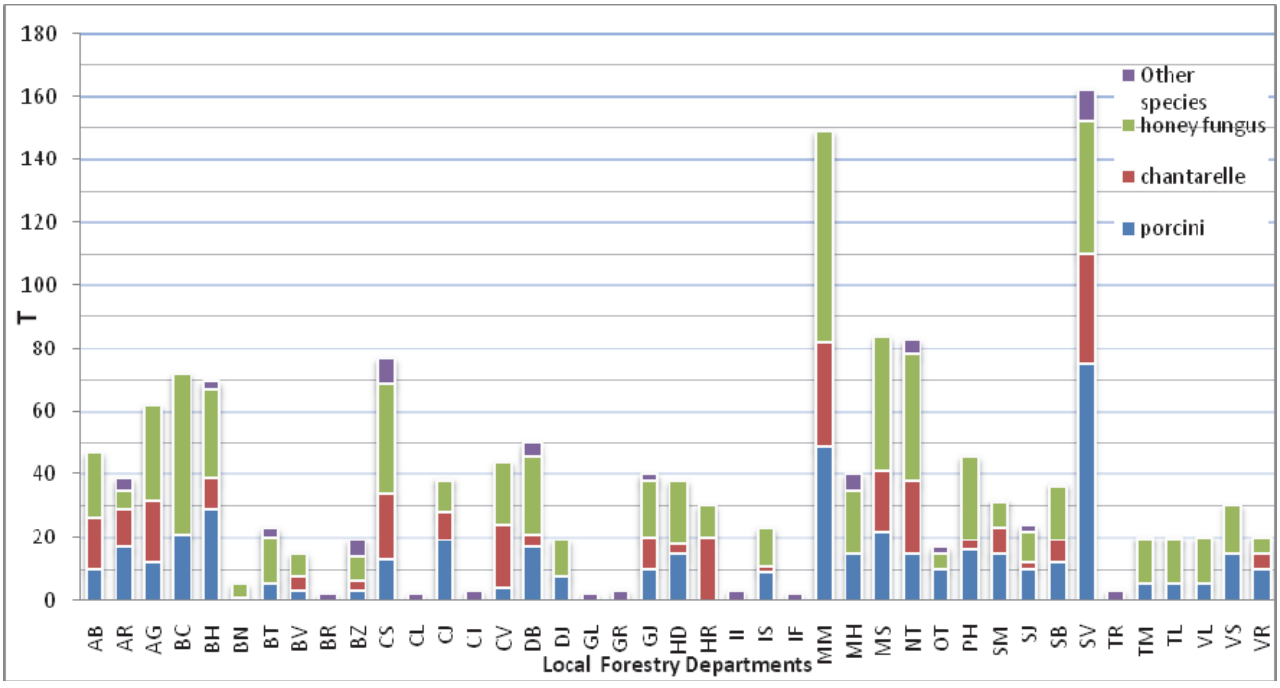

Figure 1. Estimated quantities that could be harvested in 2016 by the Local Forestry Departments of the National Forest Administration Romsilva

The potential impact of mushroom harvesting on forest ecosystems and measures to reduce it

The harvesting of mushrooms, being a direct human intervention into the forest ecosystem, could result in some degree of disturbance of food chains. However, according to several small-scale studies of the impact of mushroom

harvesting, it was concluded that careful harvesting does not reduce fruiting (Diamandis and Perlerou, 2001). But since the majority of the commercially valuable mushrooms are mycorrhizal, it should be taken into consideration that mushroom harvesting with high intensities could affect forest health and productivity (Moore and Chiu, 2001).

Mushrooms are among the food varieties of the omnivorous animals, that provide proteins and lipids (the mushrooms' content in the two components being about 10%), other sources (herbs) being very poor in such substances.

However, none of the animal species populating from our forests is exclusively feeding with wild mushrooms from spontaneous flora.

Since the formation of fructification bodies of fungi species occurs over a big period of time (several weeks to a month or more) and the diversity of the sites creates a strong differentiation regarding the momentum in which the mushrooms are forming, there is a possibility that the animal species which consume mushrooms, to seek and find places where they grow.

As regards the effect on mycorrhiza there are no studies showing that there is a significant disorder in nutrition processes.

It is possible that the spore-forming process to be affected to some extent, but it is diminished by the differentiated maturing periods.

The most significant impact of mushroom harvesting occurs in the terrestrial flora and fauna.

The **impact on the flora** consists of: impairment of biodiversity (disappearance of individuals with consequences of genetic variability both at the species level and at biocenotic level); reduction of regenerative capacity (by harvesting the mature spore-bearing fungi and destruction of mycelium through soil compaction); the disappearance of a species from its distribution range, that may entail changes in the local ecosystem structure (independent from natural changes); destruction of individual during collection.

The **impact on the fauna** consists of: disorder the animal species that have their habitat in places where the mushrooms are collected, during harvesting campaign or even in reducing, in some cases, the their food source.

The **impact on soil** is mechanical and consists in the disturbance of the topsoil, i.e. the organic layer. Biochemical processes that are carried out in soil are mildly affected.

During harvesting, the superficial layer of the soil is compacted and the mushroom mycelium is crushed.

In some areas, especially in underdeveloped rural areas, some species of fungi (e.g. *Russula cyanoxantha*, *Pleurotus ostreatus, Cantharellus cibarius, Armillaria mellea*) are traditionally consumed by the local population. Therefore their harvest in large quantities may have negative impacts on the lives and habits of the populations concerned.

The environmental impact will be minimal if the organization of the harvest is well done and if the places of harvest are well known (the old and the new harvesting areas) and if a preliminary evaluation of all interrelations existing within the ecosystem will be done in order to assess the consequences as a result of disappearance of food sources, unbalancing the links in the food chains.

CONCLUSIONS

In order to assure a low impact on environment, the activity of harvesting edible mushrooms will have to respect the principle of sustainable management of forestry resources, i.e. the harvesting should be made so as not to disturb the regenerative capacity and biodiversity especially in the case of endangered species or in fragile ecosystems.

The activity of harvesting mushrooms could become also an important source for income for the forest land owner or for the forest district that has the area of harvesting in administration. In this way, by increasing the intensity of harvesting, but in the limits implied by the principle of sustainable development, the forest land owner or the forest district, as the case, will decrease the pressure on trees.

Given the wide variation in the fructification phenology of mushroom species in Romania and the inability to anticipate and to forecast the annual fructification, a repeated sampling is needed, such as the sampling that takes place in spring and autumn to determine when fructification will occur and with what intensity.

Thanks to the repeated assessments the harvesting potential on vegetation layers and

administrative units (counties, Forestry Departments) are well known for the main species of edible mushrooms.

If the activity of harvesting edible mushrooms is supervised by the forest authorities who have experience in organizing such activities and in compliance with all the recommendations, there is no or very low possibility of occurrence of situations with negative effects on biodiversity or on the abundance of mushroom species.

Even if Romania is characterized as a country with great potential for harvesting large quantities of edible mushrooms, an alternative to reduce the harvested quantities, hence the pressure on the forest ecosystems is the intensive cultivation of species of great interest, especially for food industry.

Last but not least, a very useful tool will be a national registry of quantities harvested for the main mushroom species which will be easy to be done if the Project of Ministerial Order for approving the Instruction regarding the harvesting and acquisition of non-wood forest products specific to national forestry fund will be adopted.

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