Productivity of edible fungi in taiga communities

E A Luginina¹,²* and T L Egoshina¹,²

¹Plant Ecology and Resources Department, Russian Research Institute of Game Management and Fur Farming, ul. Preobrazhenskaya, 79, Kirov 610000 Russia
²Ecology and Zoology Department, Vyatka State Agricultural Academy, Oktyabrsky pr., 133, Kirov 610000 Russia

* E-mail: e.luginina@gmail.com

Abstract. The authors studied edible macrofungi in natural forest communities of middle taiga in Kirov region, Russia. Out of more than 400 macrofungi species known within the area, 5 are rare and being protected, over 20 are used as medicinal, 149 species are considered edible, of which 46 are legally allowed for collection. Local population mostly collects 10-15 species. The largest species variety of economically important macrofungi is found in cowberry and maianthemum-cowberry forest types in which Boletus edulis, B. piniphilus, Leccinum scabrum, L. aurantiacum, L. versipelle, Suillus variegates, Xerocomus subtomentosus, Lactarius rufus, Cantharellus cibarius dominate. Maximum long-term average annual productivity of fruit bodies is marked in young pine lichen forests (127.1 kg/ha), minimum - in mature and overmature bilberry and maianthemum-bilberry spruce forests (24.0 kg/ha). In years of good yield basic dominating species of edible fungi in middle taiga are Suillus granulatus and S. luteus (productivity up to 28-57 kg/ha), Cantharellus cibarius (11-17 kg/ha) and red-cap bolete (up to 21 kg/ha).

1. Introduction

Fungi being the base of heterotrophic block and destructors are important components of ecosystem stability [1, 2]. At the same time many macrofungi, along with other forest food resources [3], are a valuable nutrition product which is traditionally used in Russia as well as in many other countries [4]. But nevertheless productivity of edible fungi remains insufficiently studied.

Kirov region is one of the most important fungi-bearing areas of Russia having diverse edible fungi species of high productivity.

Out of 400 macrofungi species marked in Kirov region, 5 are rare and protected [5], 149 – are edible [6,7], 46 – are legally allowed for collection [8], over 20 – are considered medicinal [9-11]. Local population usually collects and uses 10-15 species of fungi [9,12], the number differs from review to review up to 25 species [13].

The most widespread and having economical importance in middle taiga forest communities of the region are chanterelle (Cantharellus cibarius Fr.), cep (Boletus edulis Fr., B. piniphilus Pilát & Derme), brown birch bolete (Leccinum scabrum (Fr.)S.F.Gray), orange-cap boletus (L. aurantiacum (Bull.) S.F.Gray), granulated boletus (Suillus granulatus (L.: Fr.) Roussel), slippery jack (S. luteus (L.: Fr.) Roussel), velvet bolete (S. variegatus (Szwart: Fr.), yellow-cracked boletus (Xerocomus subtomentosus (L.: Fr.) Quél., O. Kuntze), honey mushroom (Armillaria mellea (Vahl: Fr.) Kumm.), red-hot milky (Lactarius resimus (Fr.)Fr.), ugly milkcap (L. necator (Fr.)Karst.), bearded milkcap (L. pubescens
(Fr.: Krombh.), wooly milkcap \((L. \text{ torminosus}) \) (Fr.) S.F.Gray), saffron milkcap \((L. \text{ deliciosus}) \) (L.: Fr.) S.F.Gray), false saffron milkcap \((L. \text{ deterrimus}) \) Gröger), numerous russules species (genus Russula).

Productivity and peculiarities of growing and fruiting of fungi are being studied in Kirov region for 50 years. The results of previous studies are partly published \([7, 9, 14-18]\). But many aspects of productivity forming of fungi communities remain insufficiently investigated.

This research aims to study characteristics of edible macrofungi fruiting in forest ecosystems of middle taiga in Kirov region.

2. Material and methods

Productivity of studied species is given based on field research from different administrative units within middle taiga zone in Kirov region accomplished in 1991-2018 \([14, 19]\).

Productivity of fungi was determined with common methods \([19-23]\). Census was made regularly (once a week) during the vegetation season from May to October on constant plots 50*50 m and transects 0.2-0.7 km long and 4 m wide.

3. Results and discussion

Peculiarities of climate and environmental conditions and availability of vast areas of the most productive forest habitats assure high productivity and significant species diversity of edible macrofungi in middle taiga of Kirov region. Table 1 presents edible fungi species which form the base of fungi yield in different forest communities within the studied area based on personal field-work and published data \([6, 15-18, 24, 25]\).

Table 1. Composition of dominating edible fungi species in different forest types of middle taiga in Kirov region.

| Forest community type          | Age group       | Dominating fungi species group                                                                 |
|-------------------------------|-----------------|--------------------------------------------------------------------------------------------------|
| Oxalis                        | All ages        | \( \text{Leccinum scabrum, L. aurantiacum, L. versipelle, Armillaria mellea, genus Russula} \)    |
| Cowberry and maianthemum-cowberry | Middle-aged, mature | \( \text{Boletus edulis, B. pinophilus, Leccinum scabrum, L. aurantiacum, L. versipelle, Suillus variegatus, Xerocomus subtomentosus, Lactarius rufus, Cantharellus cibarius} \) |
|                               | Young           | \( \text{Suillus granulatus u S. luteus, Lactarius deliciosus, L. pubescens, L. torminosus, L. flexuosus} \) |
| Bilberry and maianthemum bilberry | All ages        | \( \text{Russula foetens, Lactarius pubescens, L. torminosus, L. resimus, L. trivialis and other milkcap species} \) |
| Mixed-herbs                   | Middle-aged, mature | \( \text{Boletus edulis, B. pinophilus, Lactarius resimus, L. necator, L. vellereus var. vellereus, L. citriolens, Cantharellus cibarius, Armillaria mellea} \) |
|                               | Young           | \( \text{Lactarius deliciosus, L. deterrimus, Suillus luteus} \)                                |
| Linden                        | All ages        | \( \text{Boletus edulis, Leccinum scabrum, Lactarius pubescens, L. torminosus, L. resimus, L. piperatus} \) |
| Lichen, heather-lichen and heather | All ages       | \( \text{Boletus edulis, Leccinum aurantiacum, Suillus variegatus, S. luteus, Russula aeruginea, R. claroflava} \) |
|                               | Young           | \( \text{Lactarius deliciosus, Suillus granulatus, S. luteus} \)                                |

Total production of edible fungi fruit bodies is influenced by year’s conditions, forest type and forest
age [1, 25, 26].

Long-term average of total yield of edible fungi in different types of forest communities with tree stand of different age in middle taiga is given in Table 2.

Table 2. Long-term average of total yield of edible fungi in different types of forest communities in middle taiga of Kirov region (1991 – 2018).

| Forest type | Yield, kg/ha |
|-------------|-------------|
|             | young       | middle-aged | mature and over-mature |
| Bilberry and maianthemum-bilberry spruce forest | 30.0 ± 2.9 | 45.0 ± 5.6 | 24.0 ± 3.0 |
| Cowberry and maianthemum-cowberry spruce forest | 80.1 ± 9.4 | 81.5 ± 10.8 | 57.5 ± 6.1 |
| Oxalis spruce forest | 40.7 ± 4.5 | 50.3 ± 7.3 | 29.8 ± 3.4 |
| Bilberry-maianthemum spruce forest | 37.5 ± 4.3 | 50.0 ± 6.9 | 30.4 ± 2.9 |
| Mixed-herbs spruce forest | 87.2 ± 10.0 | 87.5 ± 12.4 | 67.1 ± 7.0 |
| Bilberry pine forest | 80.1 ± 9.4 | 90.0 ± 11.7 | 132.5 ± 15.8 |
| Maianthemum-bilberry pine forest | 79.3 ± 9.5 | 90.8 ± 12.3 | 132.8 ± 16.2 |
| Cowberry pine forest | 68.1 ± 7.4 | 81.5 ± 9.4 | 120.0 ± 11.8 |
| Maianthemum-cowberry pine forest | 66.4 ± 8.0 | 82.7 ± 8.1 | 119.7 ± 9.8 |
| Lichen pine forest | 127.1 ± 15.4 | 82.5 ± 9.1 | 107.5 ± 11.5 |
| Oxalis pine forest | 65.0 ± 7.2 | 67.5 ± 7.2 | 95.0 ± 10.7 |
| Mixed-herbs pine forest | 128.2 ± 16.8 | 90.5 ± 11.3 | 104.8 ± 10.1 |
| Cowberry and maianthemum-cowberry birch forest | 97.5 ± 11.5 | 85.0 ± 7.9 | 92.5 ± 8.5 |
| Bilberry and maianthemum-bilberry birch forest | 67.0 ± 9.1 | 90.0 ± 12.3 | 97.5 ± 8.3 |
| Oxalis birch forest | 57.5 ± 7.3 | 67.5 ± 8.1 | 80.0 ± 9.1 |
| Linden birch forest | 127.3 ± 15.3 | 105.4 ± 11.0 | 112.5 ± 12.3 |
| Mixed-herbs birch forest | 127.1 ± 18.1 | 105.1 ± 13.5 | 111.9 ± 11.2 |
| Cowberry and maianthemum-cowberry aspen forest | 40.2 ± 5.7 | 55.0 ± 4.9 | 30.4 ± 3.5 |
| Bilberry and maianthemum-bilberry aspen forest | 57.5 ± 8.3 | 65.3 ± 5.9 | 60.0 ± 8.1 |
| Oxalis aspen forest | 30.8 ± 4.2 | 37.5 ± 4.8 | 24.8 ± 3.4 |
| Linden and mixed-herbs aspen forest | 92.5 ± 10.9 | 72.5 ± 8.1 | 65.7 ± 8.7 |

Maximum long-term average sporocarp production of edible fungi was marked in young lichen and mixed-herbs pine forests (127.1 kg/ha and 128.2 kg/ha correspondingly), linden birch forests (127.3 kg/ha) and mixed-herbs birch forests (127.1 kg/ha); minimum - in mature and over-mature bilberry, maianthemum spruce forests (24.0 kg/ha) and oxalis aspen forests (24.8 kg/ha).

Major contribution to total fungi yield within one forest type is made by dominating species. In years
of high yield main dominating species of edible fungi in forests of middle taiga are granulated boletus and slippery jack (produce up to 28-57 kg/ha), chanterelle (11-17 kg/ha) and orange-cap boletus (up to 21 kg/ha). Mass production is typical for cep in some plant communities, e.g. in mature medium-density bilberry spruce forests its yield reaches 35.2 - 46.2 kg/ha (observations of 2010 and 2012). The yield of saffron milkcap in young mixed-herbs spruce forests in some years (2012) varied from 39.8 to 54.3 kg/ha. In years of low and medium yield production of most fungi species in almost all forest types does not exceed 5 – 8 kg/ha.

4. Conclusion
The study of wild growing edible fungi in different plant communities of middle taiga in Kirov region allowed revealing the following:

- Maximum species diversity of dominating edible fungi is marked in cowberry and maianthemum-cowberry forests.
- Maximum long-term average production of edible fungi fruit bodies was marked in young lichen and mixed-herbs pine forests (127.1 kg/ha and 128.2 kg/ha correspondingly), linden birch forests (127.3 kg/ha) and mixed-herbs birch forests (127.1 kg/ha).

References
[1] Burova L G 1986 Ecology of Macrofungi (Moscow: Nauka) p 222
[2] Selen E, Keles A, Acar I and Demirel K 2019 Anatolian Journal od Botany 3(1) 7-12
[3] Egoshina T L 2004 Non forest plant resources and their importance for Russian population Proc. Int. Conf. Food Resources of Wild Nature and Ecological Safety for Population 14-6
[4] Boa E Wild edible fungi A global overview of their use and importance to people Non-Wood Forest Products 17
[5] ed Baranova O G et al. 2014 The Red Book of Kirov Region: Animals, Plants, Fungi pp 335
[6] Luginina E A 2004 Resources of wild growing medicinal and berry plants and fungi in Kirov region Proc. Int. Conf. Food resources of Wild Nature and Ecological Safety for Population 70-1
[7] Kirillov D V, Perevedentseva L G and Egoshina T L 2011 List of Agarics of Kirov Region (Kirov: VNIIÖZ) p 63
[8] Sanitary Rules on Collection, Production and Sales of Fungi 2010 Moscow 67
[9] Luginina E A 2002 Use of resources of wild growing berries, fruits and mushrooms in Kirov regions and peculiarities of their use Proc. Int. Conf. Modern Problems of Nature Management, Game Management and Fur Farming 479-81
[10] Lee Yui, Tu Liguier, Bao Khaiinb, Shirokikh A A, Shirokikh I G, Egoshina T L and Kirillov D V 2009 Medicinal Fungi in Traditional Chinese Medicine and Modern Biotechnologies (Kirov: O-Kratkoye) 320
[11] Egoshina T L, Luginina E A and Kirillov D V 2016 Vestnik of Orenburg State University 4(192) 66-71
[12] Kirillov D V and Egoshina T L 2007 Lesnaye Khozyaistvo 6 29-31
[13] Boa E, Zambonelli A and Bonito G M 2012 Local communities and edible ectomycorrhizal mushrooms Edible Ectomycorrhizal Mushrooms
[14] Egoshina T L and Luginina E A 2014 Izvestia of Samara Scientific Center of the Russian Academy of Sciences 12(1-3) 776-8
[15] Sennikova L S 1989 Resources and economical use of edible fungi in Kirov region Social-Economic Development of Kirov Region 85-7
[16] Skryabina A A and Sennikova L S 1982 Rastitelnye Resursy 18(3) 402-7
[17] Skryabina A A 1999 Yield of edible fungi in Volgo-Vyatsky region in 1960-1998 Ecological Monitoring of Forest Ecosystems (Petrozavodsk) 100
[18] Skryabina A A and Kolupaeva K G 1972 Resources of edible fungi in Kirov region Proc. Conf.
49-52

[19] Egoshina T L, Luginina E A, Melanin S S and Sennikova L S 2004 Resources of edible fungi of Verkhnekamsky district of Kirov region and their use Sci. Session of Russian Academy of Nature Sciences 182-3
[20] Vasilkov B P 1968 Methods of Census of Edible Fungi in USSR Forests (Leningrad: Nauka) p 63
[21] Skryabina A A 2000 Methods of resources characteristics for edible fungi Proc. Conf. Problems of Regional Ecology 8 111-3
[22] Cherkasov A F 1990 Method of resources estimation for wild growing berries and fungi along with forest census in Central Part of Southern Taiga and Northern Mixed Forests of European SFSR (Moscow) 28
[23] Cherkasov A F and Veremyeva S S 1986 Methods of calculation of edible fungi yield based on forest typology Coll. Sci. Papers Problems of Forestry and minor forest production (Pushkino) 90-6
[24] Stavishenko I V and Luginina E A 2015 Mycology and Phytopathology 5(1) 39-47
[25] Stavishenko I V, Luginina E A, Kirillov D V and Egoshina T L 2019 Macromycetes of State Nature Reserve “Bylina” 150
[26] Shubin V I 1990 Macromycetes of Forest Communities of Taiga and Their Use (Leningrad: Nauka) p 197