Monitoring the Biological Productivity of Fungi Macromycetes in the Woodland of Southern Primorye

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Abstract. The dynamics of yields of cap mushrooms of the tubular (Boletaceae) and russula (Russulaceae) families under the conditions of southern Primorye has not yet been studied sufficiently. The terms of fruiting bodies' development and stocks were studied directly in combination with various plant cenoses in which they are formed. The aim of this work is to monitor the biological productivity of fungi-macromycetes in different forest types under the conditions of Southern Primorye. As a result of long-term monitoring of climatic factors, a fairly pronounced relationship between the productivity of mushroom mass and the sum of monthly precipitation has been revealed, which should be taken into account when forecasting the productivity of macromycetes fruiting bodies. Abundant precipitation in late May and early June promotes earlier mass appearance of fungi of families Boletaceae and Russulaceae. The situation is quite different if precipitation is insignificant during this period, in which case the formation of fruit bodies is shifted to later dates, which ultimately leads to a decrease in the biological productivity of fungal mass under the canopy of oak and white birch phytocenoses.

Keywords: Monitoring · Mushroom macromycetes · Productivity · Climatic factors · Forest types

1 Introduction

Commercial harvesting of mushrooms for the population of many regions is a traditional type of forest use, and with the development of market relations in forestry, they can become a significant income source. According to All-Russian Research Institute of Forest Resources [1], the total producing area of mushrooms in the Russian Federation is 81.8 million hectares, including in the Asian part of the country - 64,1 million hectares, European - 17,7 million, the biological stock of mushrooms is 4.3 million tons, including in the Asian part - 3.5 million, European - 800 thousand tons. In the Asian part of Russia, 62% of the stock is in the Far East.

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In the Far East the total number of species of edible mushrooms reaches 150, from which about 50 are rather widespread, and 26 species can be procured in large quantities by organized hunting [2, 3]. Biological reserve of mushrooms tentatively estimated at 500 thousand tons. The productive yield is 150 thousand tons, the share of the estimated collection is about 60 thousand tons, the degree of development of the estimated collection is not more than 1%. The average annual harvest in the 1980s was about 1 thousand tons, of which the Primorsky Krai and Sakhalin Oblast accounted for more than half. In the 1990s, harvesting mushrooms fell to 170 tons. For their own needs, the population collects mushrooms many times more than they are received in preparations [4].

In the southern part of Primorsky Krai, as a result of human activity near cities and numerous settlements, the composition and many other forest taxonomic indicators have changed radically. Coniferous and coniferous-broadleaf stands were replaced by low-quality oak-birch forests formed by the most resistant species to fire damage - Mongolian oak (Quercus mongolica Fisch. ex Ledeb.) and Daurian birch (Betula davurica Pall.) [5]. Derived oak-birch forests not only carry a significant recreational load, but also have large reserves of non-timber products, which are commonly referred to as "secondary use". At present, one of the main secondary uses is the mass hobby of the population to collect mushrooms.

Modern foreign studies of macromycetes, are aimed at studying the structure and factors forming the species diversity, as well as at identifying potentially toxic elements in macromycetes and determining the effect of decomposition of decay on the productivity of fungi [6–11]. Mycologists described 59 fungal species from 34 genera in Georgian oak forests [12]. The dynamics of cap mushroom productivity has not yet been studied sufficiently, so we studied the abundance and stocks of fruit bodies directly in conjunction with various plant cenoses in which they are formed. Hence, the goal of this work is to monitor the biological productivity of macromycetes mushrooms in different forest types under the conditions of Southern Primorye.

2 Research Objects and Methods

In the oak and white-birch forest types of southern Primorsky Krai, edible mushrooms of the tubular (Boletaceae) and russulaceae (Russulaceae) families were the object of study. Under the conditions of southern Primorye, the population most often collects ceps (Boletus edulis Fr.), oakberry (Boletus luridus Fr.), far-eastern obabok (Leccinum extremiorientale (L. Vass.) Sing.), chestnut moss (Xerocomus badius (Fr.) Gilb.), mountain gooseberry (Leccinum scabrum (Fr.) S.F. Gray.), aspen mushroom (Leccinum aurantiacum S.F. Gray.), blue-yellow (Russula cyanoxantha (Schw.) Fr.), edible (Russula vesca Fr.), green (Russula aeruginea Lindbl.) and pink crowberry (Lactarius torminosus (Fr.) S.F. Gray.) and white (L. pubescens Fr.), Lactarius resumes (L. resimus Fr.) and Lactarius Insulsus (L. insulsus (Fr.) Fr.) [13–16].

The productivity of macromycete fungi was studied in the Ussuriysky, Mikhailovsky, Oktyabrsky, and Khorolsky districts that are part of the Khankaisky district of the Prikhanka-Ussuriysky province of Primorsky Krai [17].

During the period of field studies from 2002 to 2018, 18 sample plots (0.25 ha) were laid in dry, fresh, and wet forest conditions. Sample plots were laid according

to the methods generally accepted in taxation and forest management [18–20]. After describing the forest types, we proceeded to determining the yield and calculating the stocks of edible mushrooms according to the methods developed for this purpose [21–23]. Five large 4 × 5 m recording plots were placed in the corners and in the center of each sample area. The fruiting bodies of all mushrooms were cut at the soil level on the registration plots. All the peculiarities of their growth were noted during the collection of mushrooms. The influence of environmental conditions on the growth and productivity of mushrooms in different types of forests was studied in combination with meteorological and biotic environmental factors.

3 Research Results

Characterizing the oak and white birch forests of the study areas, we identified the following groups of forest types: rhododendron-oak (I), Lespedeza (II), hazelnut (III), high grass oak forests with Daurian birch (V), white birch mixed (Bs-V), and fern-grass birch forests (Bb-II). Forest and taxonomic characteristics of forest types on the sample plots are presented in Table 1.

When analyzing meteorological data, it was found that a fairly pronounced relationship is also traced between the productivity of mushroom mass and the amount of monthly precipitation. Abundant precipitation in late May and early June contributes to the earlier mass appearance of fungi of the families Boletaceae and Russulaceae. The situation is quite different if in May and June precipitation is insignificant, in which case there is a shift in the formation of fruits to later dates, which ultimately leads to a decrease in the biological productivity of fungal mass under the canopy of oak and white birch phytocenoses.

With all the diversity of forest and vegetation conditions in the southern part of Primorsky Krai, mushroom massifs gravitate to a greater extent to weakly sloping, elevated slopes of different exposures. The main mushroom areas here are oak and derived white-birch forests, represented by lespedeza, hazel, high-grass, and white-birch mixed types. In the mountainous part of the study areas, mushroom massifs of valuable edible mushroom species are rare and occur in small areas. The total yield of mushrooms is not the same in different forest types. The most productive type is the hazel oak woodland, with an average yield of macromycetes of 120 kg/ha over the long-term observation period, and 98 kg/ha in the hazel oak woodland (Fig. 1).

The biological productivity of macromycetes fungi is the lowest and on average does not exceed 25 kg/ha in high grass oak forest with a well-developed ground cover. In a white birch mixed forest type, the biological productivity of fungi of the Russulaceae family can reach 117 kg/ha in the birch fern-grass forest for not more than 30 kg/ha.

In some years, damage by insect larvae significantly adjusts the economic yield of edible mushrooms. Damageability of mushrooms is closely related to weather conditions and depends on the forest type. The total damage to mushrooms during the period of studies in oak woodlands was 40–45%, in birch woodlands 32–36%. The high degree of damage in oak wood types is explained by the predominance of tubular mushrooms, which are quickly enough affected by insects. The greatest degree of damage was noted

Table 1. Taxation characteristics of the sample areas.

Sample area no	Geographic location, exposure, steepness, altitude	Stand composition	Age, years	Number of trunks, pcs	Crown enclosure	Sum of sectional areas, m^2	Average diameter, cm	Average height, m	Growth class	Reserve, m^3/ha
Rhododendron sedge oak woodland (W –I)										
1	Upper part of the slope south exposition 20–25°, 120 m above sea level	10W, Bo, As	40	750	0.9	11.15	9.0	8.0	V	59.5
Lespedeza oak woodland (W –II)										
2	Upper part of the southern slope 5–10°, 168 m above sea level, N 43°41', E 132°09'	10W, Bm,Bb	60	790	0.7	20.94	16	15	III	174.7
Hazel oak woodland (W–III)										
3	A sloping terrace of southwestern exposition, 76 m above sea level, N 43°41', E 132°07'	8W 2Bb + Ev, La	60	451	0.5	12.65	20	14.2	IV	100
Highly herbaceous oak woodland with Daurian birch (W- V)										
4	Middle part of the southwest slope 2–5°, 120 m above sea level	4W 3Bb 2Ma 1eV	43	1040	0.7	21.37	18.0	16.0	III	192.5
White-birch mixed forest (Bm-V)										
5	Middle part of the gentle southeastern slope, 160 m above sea level, N 43°43', E 132°09'	7Bm 3W + Bb	60	788	0.8	23.94	20	17	III	174.7
Birch fern-grass broadleaf (Bb -11)										

(*continued*)

Table 1. (*continued*)

Sample area no	Geographic location, exposure, steepness, altitude	Stand composition	Age, years	Number of trunks, pcs	Crown enclosure	Sum of sectional areas, m^2	Average diameter, cm	Average height, m	Growth class	Reserve, m^3/ha
6	Middle part of the concave northern slope, 96 m above sea level	6Bm 2W 2Ash	70	643	0.6	16.32	18	16.0	III	135

Note: N - northern latitude; E - eastern longitude; species: W - Mongolian woodland, Bm - Manchurian birch (Betula manshurica Regel.), Bb - black birch (Daurian), Ev - valley elm (Ulmus japonica Rehd. Sarg.), La - Amur linden (Tilia amurensis Rupr.), As - Dode aspen (Populus davidiana Dode), Ma - Amur maackia (Maackia amurensis Rupr. et Maxim.), Ash - ash (Fraxinus rhynchophylla Hance)

in the oak mushroom and mountain ash (up to 70%). In white mushrooms, aspen mushrooms, dunlin, and honeycomb it is 40–50%. The squeaker and chanterelle (Cantarellus cibarius Fr.) are practically undamaged by insects.

Repeated visits of the population and grazing in the forest are accompanied by the emergence of a network of paths and roads as a result there is a thinning of the living ground cover, which subsequently contributes to an increase in fruiting of most macromycetes. The species diversity and number of macromycetes in the more illuminated areas near roads and along edges can be several times greater than in the depth of the forest. On the contrary, intensive atropogenic loads on the same ecotopes, accompanied by destruction of the vegetation cover and compaction of the top soil layer, worsen the fruiting of pileate fungi.

With all the diversity of forest and vegetation conditions in the southern part of Primorsky Krai, mushroom massifs to a greater extent gravitate to weakly sloping, elevated slopes of different exposures. The main fungi areas here are oak and derived white-birch forests, represented by lespedeza, hazel, high-grass, and white-birch mixed types.

4 Conclusions

As a result of long-term climate factors monitoring, a fairly pronounced relationship between the productivity of fungal mass and the sum of monthly precipitation was revealed, which, in our opinion, should be taken into account when predicting the yield of fruit bodies of macromycetes. Abundant precipitation in late May and early June promotes earlier mass appearance of fungi of families Boletaceae and Russulaceae. Quite a different situation is formed if during this period, falls insignificant amount of precipitation, in this case there is a shift of fruit formation to later terms, which ultimately leads to a decrease in the biological productivity of the fungal mass under the canopy of oak and white birch phytocenoses.

a)

b)

Fig. 1. Determination of the macromycetes yield in the experimental plots: a - lespedeza oak woodland; b - hazel oak woodland.

In the southern part of Primorsky Territory the most productive type is the forest oak woodland, with an average yield of macromycetes of 120 kg/ha and 98 kg/ha in the hazel oak woodland over the long-term observation period. In high grass oak forest with well-developed ground cover, biological productivity of macromycetes fungi is the lowest and on average does not exceed 25 kg/ha. The biological productivity of fungi

of the Russulaceae family can reach 117 kg/ha in a white birch mixed forest type and in birch fern-grass forests - not more than 30 kg/ha.

References

1. Strakhov, V.V.: Non-woody forest resources of the Russian Federation. Lesokhozyaystvennaya Informatsiya **3**, 32–47 (1997)
2. Vasil'kov, B.P.: Boletus edulis (one species monograph experience), p. 132. Nauka Publishing House, Moscow (1966)
3. Gukov GV, Komin PA (2020) Shiitake mushroom, Japanese fragrant mushroom (lentinula edodes (derk.) Pegler) in Primorsky territory: Distribution, nutritional and medicinal properties, artificial reproduction, mushroom status. EurAsian Journal of BioSciences 14(1):183–189
4. Sukhomirov GI (2007) Taiga nature management in the Russian Far East. RIOTIP, Khabarovsk, p 384
5. Gukov GV (2005) Problems of recreational role of forests of South Primorye Socio-economic and environmental problems of forest complex. Paper presented at the international scientific and technical conference, USFTU, Ekaterinburg, p 282–284
6. Shiryaev AG, Morozova OV (2020) Latitudinal gradient of diversity of macromycetes and vascular plants in the European part of Russia. Vestnik of Saint Petersburg University Earth Sciences 65(2). DOI:https://doi.org/10.21638/SPBU07.2020.202
7. Rebriev, Y.A., Bulakh, E.M., Sazanova, N.A., Shiryaev, A.G.: New species of macromycetes for regions of the russian far east. Mikol. Fitopatol. **54**(4), 278–287 (2020). https://doi.org/10.31857/S0026364820040091
8. Kujawa, A., Kujawa, K.: Pattern and factors shaping species diversity of macromycetes in ephemeral small habitats in an agricultural landscape in western Poland. Pol. J. Ecol. **67**(3), 206–218 (2019). https://doi.org/10.3161/15052249PJE2019.67.3.004
9. Kautmanová, I., Brachtýr, O., Gbúrová Štubňová, E., Szabóová, D., Šottník, P., Lalinská-Voleková, B.: Potentially toxic elements in macromycetes and plants from areas affected by antimony mining. Biologia **76**(7), 2133–2159 (2021). https://doi.org/10.1007/s11756-021-00788-9
10. Jurkšienė, G., Janušauskaitė, D., Armolaitis, K., Baliuckas, V.: Leaf litterfall decomposition of pedunculate (quercus robur L.) and sessile (Q. petraea [matt.] liebl.) oaks and their hybrids and its impact on soil microbiota. Dendrobiology **78**, 51–62 (2017). https://doi.org/10.12657/denbio.078.006
11. Jirout, J.: The effect of oxygen on fatty acid composition of soil micromycetes. Ecol. Ind. **53**, 125–128 (2015). https://doi.org/10.1016/j.ecolind.2015.01.035
12. Bitsadze, N., Beruashvili, M., Pavliashvili, K., et al.: Main oak species and fungi associated with oak trees described in Georgian mycological herbarium. Annals of Agrarian Science **16**, 432–435 (2018). https://doi.org/10.1016/j.aasci.2018.06.004
13. Gukov, G.V., Rozlomiy, N.G., Kostyrina, T.V., Gridneva, N.V., Zorikov, P.S.: Recreation role of oak forests in Primorsky region. Ecology, Environment and Conservation **21**, 193–196 (2015)
14. Ivanov, A.V., Kasatkin, A.S., Mudrak, V.P., Zamolodchikov, D.G.: Russian Journal of Forest Science **2018**(6), 454–463 (2018). https://doi.org/10.1134/S0024114818060049
15. Komin A, Komin P, Usov V, Gridnev A (2020) Forest resources of the far east, their use and reproduction. E3S Web of Conferences 203. DOI:https://doi.org/10.1051/e3sconf/202020303003
16. Komin AE, Komin PA, Usov VN (2020) Renewal of fraxinus mandshurica rupr. in mixed coniferous-broad leaved forests of the southern far east. International Journal of Pharmaceutical Research 12(4):2297–2301. DOI:https://doi.org/10.31838/ijpr/2020.12.04.317

17. Stepanko A (2010) Agroecological space geosystems of the Russian Far East at the turn of the XX-XXI centuries. Natural Resources and Regional Nature Management 2:64
18. Sukachev, V.N.: Methodological guidelines for the study of forest types, p. 144. Publishing House of the Academy of Sciences of the USSR, Moscow (1961)
19. Anuchin, N.P.: Forest taxation, p. 512. Lesnaya Promishlennost, Moscow (1971)
20. (2002) Methods of studying forest communities. Research Institute of Chemistry of SPbSU, Saint Petersburg, p 240
21. Vasilkov, B.P.: White fungus (experience of a monograph of one species), p. 132. Nauka Publishing House, Moscow (1966)
22. Aniskina AA, Aniskina LS, Lapitskaya (1991) Forestry 5:39
23. Poleshchuk, T.N.: Methodological approaches to determining the timing of development and productivity of edible mushrooms in different ecological and cenotic conditions of Southern Primorye. Bulletin of Krasnogorsk State Agrarian University **4**, 159–162 (2008)