

# Fruiting characteristics of fungi of the genus *Suillus* in the artificial pine plantations of the Kedrovsky coal mine dump (Kemerovo region)

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**Abstract.** The study discusses the fruiting of fungi of the genus *Suillus* in artificial plantations of *Pinus sylvestris* L. on the rock dump at the Kedrovsky coal mine (experimental site) and in the pine forests of the Kuzbass Botanical Garden (control site), located on the territory of Kemerovo. The pine plantations at the experimental sites were distributed according to the degree of forest canopy closure. Three sites with different crown closure were identified: sparse closure (20–30%), moderate closure (50–60%), and high closure (80–90%). Within each site, three zones of crown projection were assigned (sub-crown, near-crown, and external). Field studies were carried out during the summer and autumn of 2019. Two species of macromycetes of the genus *Suillus* are found on the studied sites: *Suillus granulatus* (L.) Roussel and *Suillus luteus* (L.) Roussel. Mushrooms growing in pine plantations on reclaimed overburden dumps start fruiting earlier with longer fruiting than that in pine forests on zonal soils. The highest yields of mushrooms are found in pine stands with sparse closure. In the projection of the tree crown, the number of *Suillus* fungi increases in the direction from the trunk of the tree to the periphery of the crown and beyond (in sparse closures).

## 1 Introduction

Mining of coal and other minerals leads to the destruction of natural biogeocenosis. The transformation of natural ecosystems is particularly pronounced in the Siberian regions with rich coal deposits. In the Kuzbass region, 250.1 and 220.7 million tons of coal were mined in 2019–2020, which accounts for over half of the total Russian coal production. The formed technogenic landscapes become “ecoclinal” with characteristics radically different from the former natural ecosystems. The goal of the restoration of

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post-technogenic landscapes is to create sustainable and sufficiently productive ecosystems with high biological diversity [1].

Higher fungi are one of the key structural components of terrestrial ecosystems, supporting the functioning of the soil-plant system [2]. As heterotrophs and reductants, fungi participate in the decomposition of forest litter, including hard-to-decompose components such as coniferous fall, allowing mineralization and humification processes. It is known that saprotrophic fungi in soil and litter, along with cellulolytic bacteria, are the main agents of cellulose degradation in boreal forests [3, 4]. Higher fungi, in symbiosis with plants, form a complex nitrogen habitat regime that ensures the functioning of the environment under conditions of severe nutrient deficiency. In addition, fungi contribute to the biochemical degradation of lithogenic substrates, which is essential for accumulating sufficient quantities of physical clay fractions and establishing a soil-ecological effect [5].

The existing literature on mycobiota in reclaimed territories addresses only a few aspects of their vital activity [6–11]. The aim of this work was to investigate the fruiting characteristics of fungi of the genus *Suillus* in artificial pine plantations growing on the waste dump of the Kedrovsky coal mine.

## 2 Materials and Methods

The research was carried out in 2019 at two stationary sites. The experimental site was located on the waste dump of the Kedrovsky coal mine of OAO UK Kuzbassrazrezugol, 25 km from Kemerovo. According to the ecological and geographical zoning, the Kedrovsky coal mine is located in the northern forest steppe of the Kuznetsk Basin [12]. The objects of the study are permanent sample plots in pine plantations growing on the planned dump of the Kedrovsky coal mine, without the application of a fertile or potentially fertile layer. The sites without soil ameliorants were selected in order to identify contrasting conditions in comparison with natural landscapes – the root zone of the plots consists of a heterogeneous mass of sedimentary rocks (sandstones and siltstones), with the inclusion of some igneous rocks and loess-like loams. According to previous taxonomic studies [13], the age of the plantations in 2019 was 29 years (age class II). Pine plantations growing on zonal meadow-chernozem soils in the territory of the Kuzbass Botanical Garden, Kemerovo, were selected as a control, since there are no zonal pine forests of similar age and comparable density variability within the city, which are necessary for the research methodology. The age of the trees in the control area was 25 years in 2019. Therefore, the plantations on the dumps are close in age to the forest cultures on the control sites.

At each trial site (experimental and control), visual separation of pine plantations was carried out according to the degree of canopy closure, which allowed three areas to be identified: 1) sparsely closed plantations with a degree of crown closure of 20–30%; 2) moderately closed plantations with a degree of crown closure of 50–60%; and 3) highly closed plantations with a degree of crown closure of 80–90%. According to the main parameters of the ground cover at each of the three sites within the study area, the sub-crown, near-crown (inter-crown), and external projection zones of trees were established [14].

The macromycete fungal community was studied in pine stands (*Pinus silvestris* L.) belonging to the II class of site quality. The field survey was carried out during the summer and autumn period (June to September). The number of fruiting bodies of fungi on the study sites was counted every 7 days.

The Latin names of the fungi and their systematic position are given with reference to the Index Fungorum electronic database [15].

### **3 Results and discussion**

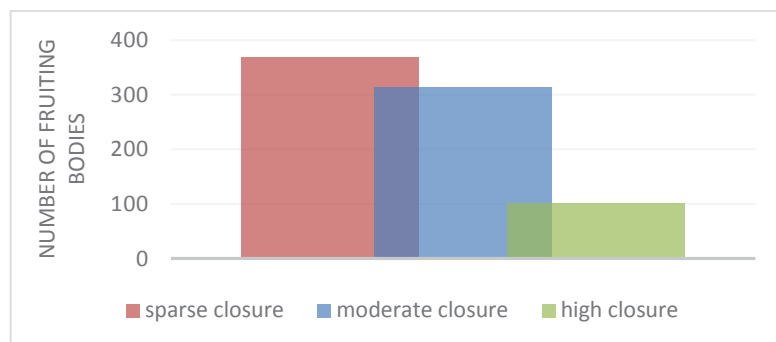
As a result of field observations, two species of macromycetes of the genus *Suillus* were found at the study sites: *Suillus granulatus* (L.) Roussel (granulated bolete) and *Suillus luteus* (L.) Roussel (slippery jack), forming ectomycorrhiza with pine. According to the modern classification, the genus *Suillus* belongs to the division Basidiomycota, class Agaricomycetes, order Boletales, and family Suillaceae.

The comparison of the dates of the onset and the termination of the fruiting of boletus showed a significant difference between the species in the control and experimental sites. It was revealed that the onset of fruiting of a granulated bolete occurred earlier in the conditions of a rock dump. In the control site, carpophores of *Suillus granulatus* appeared 15 days later than in the experimental site. The fruiting of slippery jack on the dump of the Kedrovsky coal mine also occurred earlier (June 27) and lasted one month longer than in pine forests on zonal soils. In the work [8], where the appearance of fruit bodies of *Suillus luteus* in pine stands of the Borodino coal mine dump was examined, the mass onset of fruiting was noted in the first half of summer, which is atypical for the phenology of this species.

A comparison of the yield of *Suillus* fungi at the experimental and control sites revealed a slight prevalence of basidioma in artificial plantations of *Pinus sylvestris* at the coal mine dump. It was found that during the field research period, the number of fruiting bodies of *Suillus* fungi at the experimental site was 8% higher than that at the control site.

Mushrooms are a valuable food product due to their high protein content, as well as the presence of carbohydrates, minerals, and vitamins. All edible mushrooms were classified into four categories according to their nutritional value [16]. According to this classification, granulated bolete and slippery jack belong to the second category. The results show that the pine plantations of the rock dump are rich in valuable edible mushrooms; therefore, the biological resources of the dumps are promising for collecting edible mushrooms.

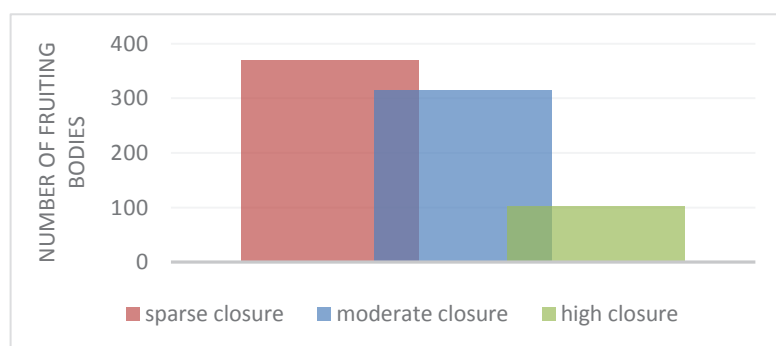
Given the gradation of pine plantations by density, the analysis of the occurrence of *Suillus* fungi at the study sites revealed the dominance in the number of basidioma in sparse stands at the dump of the Kedrovsky coal mine (Fig.1). At the experimental site in a sparse pine forest, the biomass of the collected mushrooms exceeded the control by an average of 18%.



**Fig. 1.** The number of basidioma of *Suillus* (pcs.) fungi in pine plantations with different crown closure on the Kedrovsky coal mine dump

In moderately closed and highly closed pine stands on a reclaimed dump, the yield of *Suillus* fungi decreased by 15% and 72%, respectively, compared with sparse pine plantations. It was noted [17] that the fruiting of ectomycorrhizal fungi is an indicator of their additional carbohydrate production as a result of the increased photosynthetic activity of wood-host plants.

An assessment of the distribution of boletus fruiting bodies in the projection of the crown of the common showed a significant increase in the carpophore number in the direction from the tree trunk to the periphery of the crown and beyond (Fig. 2). The minimum number of fungi was found in the sub-crown zone of the pines, while the near-crown and external zones of the trees were saturated with maximum number of fruiting bodies of *Suillus* fungi. Thus, the number of basidiomata of *Suillus* fungi increased by 27–60% in the near-crown and external zones of pines in different stand types in comparison with the sub-crown zone on the rock dump of the Kedrovsky section.



**Fig. 2.** Distribution of basidioma of *Suillus* fungi (pcs.) at the study sites in sparse pine plantations taking into account the zone of tree crown projection

The pine cover zone is the most humidified due to the redistribution of moisture under the canopy of the stands, which is also indicated by the well-developed moss cover on the litter of this zone.

## 4 Conclusion

This study revealed that two species of fungi of the genus *Suillus*, including granulated bolete and slippery jack, are found on the rock dump of the Kedrovsky coal mine.

In the pine plantations on the reclaimed coal mine dump, the fruiting of granulated bolete and slippery jack commenced earlier, with the mass fruiting of the slippery jack occurring earlier than the phenological norm.

Artificial pine plantations of the Kedrovsky coal mine dump are valuable mushroom lands with a rich supply of edible mushrooms. High saturation of *Suillus* fungi fruiting bodies is characteristic of sparse pine plantations with maximum distribution in the near and external zones of the crown projection.

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