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Parameters of Cantharellus cibarius Fr. ecological range fragment and resilience to human impact in taiga and sub taiga forest communities

E A Luginina¹ and A A Sorokina

Plant Ecology and Resources Dept., Russian Research Institute of Game Management and Fur Farming, Kirov, Russia

¹E-mail: e.luginina@gmail.com

Abstract. The paper present results of analyses of plant communities with Cantharellus cibarius Fr. in southern taiga and sub-taiga forests within Kirov region. Golden chanterelle occurs mostly in pure pine forests and pine forests mixed with spruce and birch, of green-moss, lichen and cowberry types; in young to maturing stands; crown density low or medium. Species richness of herbaceous-shrub storey in the studied communities varied from 5 to 29. Ecological preferences of C. cibarius habitat fragment, defined with Ellenberg's (1974) scales, allow to characterise the species as the following: temperate climate species, shade-resistant, rarely found in conditions of total shading; mesophyte regarding soil humidity, prefers acidic soils with low nitrogen, but, as an exception, marked on neutral soils rich in nitrogen. Differences in the species ecological preferences in conditions of southern taiga and sub-taiga are insignificant. Hemeroby index varied from 0.05 to 0.33 for studied communities. Average share of species tolerant to human impact was 13.23%, and the share of anthropo-phobic species – 86.77%. These data characterise C. cibarius as the species capable of tolerating moderate human impact in southern taiga subzone, but being less tolerant to human impact in sub-taiga areas and coniferous-broadleaved forests.

1. Introduction

Fungi are an essential component of boreal forest heterotrophic complex accomplishing destruction processes [1, 2], and are also of significant economical importance as medicinal and nutritional raw material sources [3–5].

Kirov region is traditionally included in the list of main fungi-bearing areas in Russia, notable for diversity of growing fungi species and their high productivity. Abundance of fungi is primarily driven by climatic conditions and occurrence of large areas of various forest habitats [6].

Studies of macromycetes in the region mostly try to reveal the productivity parameters of edible fungi [7–9]. Species diversity investigation of the last decade allowed to enlist 300 species of agarics within the region [10]. The level of species diversity is maximum for southern taiga sub zone where total 377 species were registered [11, 12]. Standard acts permit organized collection of 45 macromycetes species marked in Kirov region [13, 6].

Golden chanterelle (*Cantharellus cibarius* Fr.), family *Cantharellaceae* [14] is found in dry coniferous (mostly pine), deciduous and mixed forest stands within the region, preferring sparse areas, forest openings, footpaths and forest outskirts [6].

Fruiting bodies of *C. cibarius* is a high-demand food and medicinal raw material [15,16] and contain the complex of biologically active compounds: polysaccharides, organic acids, steroids, triterpenes, phenols, and etc., which determine antimicrobial, anti-diabetic, anticancer, anti-oxidizing activity of the fungi's extract [17, 18].

Despite the named features, resource parameters of golden chanterelle remain insufficiently studied. Fragmented data are published on fructification parameters of the species in Kirov region [19; 6, 20], Republic of Karelia [21] and some other taiga areas in Russia, and in separate regions of Privolzhskyi and North-Western Federal Districts [22, 23]. Data on the species resources in other countries are also scattered: USA [24], Mexico [25], Spain [26], Sweden [27], and Finland [28]. The decrease of chanterelle productivity during the last 50 years was being marked in Netherlands [29], which, according to the authors, is determined by accrescent air pollution.

The study aims to define ecological-coenotic confinement and tolerance to human impact of plant communities with *C. cibarius*.

2. Materials and methods

Plant communities with *C. cibarius* were being studied in 2000-2017 in southern taiga and sub taiga zones of Kirov region.

Ecological preferences were estimated with Ellenberg's (1974) [30] and Tsyganov's (1983) [31] ecological scales, which included light intensity, thermoclimatic parameters, continentality, soil humidity, acidity and richness [32].

Resilience of *C. cibarius* towards human impact was characterized by the plant community composition and hemeroby concept [32], which is widely used to estimate resilience of species [33], plant communities [34, 35], and landscapes [36], locally [34] and on vast territories [37, 38, 39].

Jalas's modification of hemeroby scale [32] includes 7 levels:

a – a-hemerob (natuerlich) – species of natural communities, not tolerating human impact;

o – oligo-hemerob (natunah) – species from communities close to natural, tolerating slight irregular interventions;

m – meso-hemerob (halbnatuerlich) – species of semi-natural communities, resilient to sporadical human interventions;

 $b - \beta$ -eu-hemerob (naturfern) – species of far-from-natural communities, resilient to human impact;

 $c - \alpha$ -eu-hemerob (naturfern) – ruderal species of natural and anthropogenic communities, tolerating intense regular disturbances;

p – poly-hemerob (naturfermd) – specialized ruderal intensive species;

t – meta-hemerob (kuenstlich) – species of destroyed ecosystems on the edge of extermination [33].
 Community's hemeroby index shows the ratio of species having *b-c-p-t*-components in hemeroby spectrum and species with *a-o-m*-components [40]. The value of hemeroby parameters indicate the level of resilience to human impact: the larger the hemeroby index value is, the more capable the species is of tolerating human intervention.

3. Results and discussion

Characteristics of 21 plant communities with *C. cibarius* studied in southern taiga and sub-taiga forests of Kirov region are shown in table 1.

Average species abundance in the lower forest synfolium (LFS) of the studied southern taiga plant communities is 13, varying from 6 to 29 species, total projective cover of LFS reached 37% (15-70%) (table 1). Dominating species are presented by *Vaccinium vitis-idaea*, *Vaccinium myrtillus*, *Arctostaphylos uva-ursi*, *Rubus saxatilis*, *Pyrola rotundifolia*, *Deschampsia cespitosa*, *Fragaria vesca*, *Campanula rotundifolia*, and *Chamaenerion angustifolium*.

Average species abundance of the studied coniferous-deciduous sub zone plant communities LFS is 10, varying from 5 to 14 species, total projective cover of LFS reached 38% (20-60%). Dominating species are *Vaccinium vitis-idaea*, *Vaccinium myrtillus*, *Milium effusum*, *Rubus saxatilis*, *Calamagrostis neglecta*, and *Carex caryophyllea*.

# PC ^a	Forest community type	Forest stand composition ^b	Tree stand age, years	Crown density	N of specie s in LFS ^c	Projectiv e cover of LFS, %
1	Birch-spruce-pine forest with aspen	4B4S2P+As	60–80	0.4	18	_
2	Birch-pine forest	5P5B+S	80–100	0.7	29	70
3	Green-moss pine forest	5P3B2S	70	0.6	15	35
4	Lichen pine forest	8P2B	25	0.6	12	35
5	Lichen-green-moss pine forest	10P	60–70	0.6	8	15
6	Lichen-green-moss pine forest	10P+S	100-120	0.3	11	20
7	Lichen-green-moss pine forest	10P+B	60–80	0.5	9	15
8	Green-moss pine forest	6P4S	50-60	0.4	8	35
9	Cowberry pine forest (with patches of mosses and lichen)	10P+S	60	0.4	12	-
10	Herbaceous-cowberry-lichen pine forest	10P	12–15	0.3	6	25
11	Green-moss pine forest with cowberry patches	8P2B	15–18	0.4	13	30
12	Bilberry-cowberry pine-birch forest	6P4B	30–35	0.6–0.7	15	40
13	Cowberry spruce-pine forest	7P2S1B	60	0.7	11	50
14	Cowberry pine forest	10P	50	0.6	13	50
15	2-3 years old cut-over from cowberry- green-moss pine forest with birch	-	_	_	13	60
16	Cowberry pine forest	10P	45–50	0.5	14	20
17	Cowberry pine forest with spruce	5P3B2S	40–45	0.5	12	45
18	Bilberry-cowberry pine forest	7P2S1B	20–25	0.5–0.6	6	35
19	Sphagnum-cowberry birch forest	10B+S	12–15	0.3	5	_
20	Lichen-green-moss pine forest with cowberry patches	10P	30	0.5	10	30
21	Green-moss spruce forest	9S+B	40	0.2–0.3	10	60

Table 1. Attributes of studied plant communities with C. cibarius in southern and sub-taiga forests of Kirov region.

^aPC - plant community.

^bNote: As - aspen; B - birch; P - pine; S - spruce.

^cLFS - lower forest synfolium

Analyses of ecological range of the communities with C. *cibarius* using Ellenberg's scales revealed that in southern taiga sub zone the species prefers semi-shady to shady conditions 5.6 ± 0.6 (in the

range of 4.7 to 6.5), rarely growing in less than 20% light intensity conditions (6th step of the scale). Average point relative to warmth was 4.9 ± 0.3 (4.5 to 5.6), indicating that the species falls into the temperate climate group (5th step of the scale) - semi-cold-resistant (figure 1).



Figure 1. Fragment of the ecological range of plant communities with C. cibarius in southern taiga sub zone (by Ellenberg's scales (1974), where: L - light/shadingscale, point; T - thermoclimatic scale, point; K - climate continentality scale, point; F - soil humidity scale, point; R soil acidity scale, point; N - nitrogen richness scale, point.



Figure 2. Fragment of the ecological range of plant communities with *C. cibarius* in sub taiga zone (by Ellenberg's scales (1974), where: L - light/shading scale, point; T thermoclimatic scale, point; K - climate continentality scale, point; F - soil humidity scale, point; R - soil acidity scale, point; N nitrogen richness scale, point.

By the climate continentality scale the species grows in conditions from faintly sub-oceanic to faintly sub-continental 4.6 ± 0.5 (5th step of the scale). Analyses of the group of edaphic ecological factors showed that average soil humidity parameter in the species habitats was 4.7 ± 0.7 (5th step of the scale) - the species prefers slightly moist soils. The parameter's values varied from 3.9 (dry to slightly moist habitats) to 5.9 (slightly moist to humid soils) indicating that the species has low plasticity towards this factor. *C. cibarius* prefers acid to moderately acid soils 3.5 ± 0.7 (4th step of the scale) but the range of the values was wide in different communities - from 2.5 (prefers more acidic soils) to 4.8 (indicators of moderately acidic soils). Soil nitrogen richness appears less significant for the species - average 2.9 ± 0.6 (indicators of nutrient-poor soils, occurring on nitrogen rich soil as an exception) (3rd step of the scale).

Analyses of plant communities with *C. cibarius* in sub taiga zone revealed average point of shade/lightening scale in all studied habitats - 5.1 ± 0.6 (5th step of the scale), that allows attributing the species to shade-tolerant, rarely found in conditions of full illumination or significant shading with less than 10% light intensity. By thermoclimatic parameter golden chanterelle is a species of temperate climate 4.9 ± 0.2 (5th step of the scale), variation from 4.5 to 5 points (figure 2).

Average climate continentality parameter in the sub zone of coniferous-deciduous forests is close to the value for southern taiga sub zone 4.6 ± 0.5 (from faintly sub-oceanic to faintly sub-continental), ranging from 4.0 to 5.3 (figure 2). Communities with the species prefer fairly moist soils of moderate humidity 4.6 ± 0.6 (5th step of the scale), which is typical for mesophytic vegetation. Parameter varied from 4.0 to 5.3. Average point of soil reaction was 3.1 ± 0.8 (3rd step of the scale), indicating that the species prefers acidic soils, but is rarely found on neutral soil as an exception. Soil acidity parameter varied from 2.0 to 4.2. The species prefers mostly nitrogen-poor soils 2.9 ± 0.4 (3rd step of the scale), but sometimes found on nitrogen-rich ones.

Species of the studied communities of southern taiga are presented by mostly highly- and moderately-sensitive to human impact (o - 82.6%, m - 86.6%, b - 23.5%). In the majority of studied habitats species insensitive to human impact were not marked (p - 1.2%). Only 2% of the species are not resilient to any human impact (a - a-hemerobs). Species tolerating regular and intense

disturbances ($c - \alpha$ -eu-hemerobs) occupy 2.4%. Meta-hemerobic species (t) were not revealed, as well as the species of totally destructed ecosystems and artificial communities (figure 3). Hemeroby index for studied communities varied from 0.05 to 0.33. Average share of species resilient to human impact was 13.23%, and anthropo-phobic species - 86.77%.

As a result, we can characterize C. *cibarius* as a species capable of tolerating moderate human intervention in southern taiga sub zone.





Figure 3. Hemeroby spectrum of communities with *C. cibarius* in southern taiga sub zone of Kirov region. X-axis – Share of species, %; Y-axis – hemeroby levels.

Figure 4. Hemeroby spectre of communities with *C. cibarius* in coniferous-deciduous forests of Kirov region. X-axis – Share of species, %; Y-axis – hemeroby levels.

In sub taiga zone of Kirov region communities with *C. cibarius* are mostly resented by oligo- and meso-hemerobs (o - 91.31%, m - 92.5%), i.e. species highly sensitive to human impact. 12.1% are β -eu-hemerobs (*b*) resilient to intense impacts. Species insensitive to human intervention: α -eu-hemerobs (*c*), poly-hemerobs (*p*), and meta-hemerobs (*t*), are not marked (figure 4). Hemeroby index for the studied communities varied from 0 to 0.19. Average share of anthropo-tolerant species was 5.58%, anthropo-phobic - 94.42%. High share of the latter shows low ability of *C. cibarius* to tolerate human intervention in the sub zone of coniferous-deciduous forests.

4. Conclusion

Collected materials on plant communities with *C. cibarius* in southern taiga and sub taiga zones of Kirov region revealed that the species is mostly found in pure pine forests or mixed with spruce and birch in the tree stand of green-moos, lichen and cowberry types, with low to medium crown density. Species richness of lower forest synfolium varied from 5 to 29.

Ecological preferences of *C. cibarius*, estimated with Ellenberg's scales suggest that the species is of temperate climate, shade-resistant, rarely found in conditions of full illumination; mesophyte according to the soil humidity scale, prefers acidic nitrogen-poor soils, but as an exception marked on neutral nitrogen-rich soils. Differences in ecological preferences of the species between southern taiga and sub taiga forests are insignificant.

Hemeroby index for southern taiga communities varied from 0.05 to 0.33. Average share of anthropo-tolerant species - 13.23%, anthropo-phobic reached 86.77%. The same parameters calculated for sub taiga communities are slightly lower. Hemeroby index varied from 0 to 0.19. Average share of anthropo-tolerant species - 5.58%, anthropo-phobic spaces - 94.42%.

These data show that golden chanterelle is resilient to moderate human impact in southern taiga sub zone, but is less resilient in the sub zone of coniferous-deciduous forests.

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