Edible spring fungi in southern taiga communities

A V Kislitsina, A A Sorokina, E A Luginina, A V Yaroslavtsev and S I Obotnin
Russian Research Institute of Game Management and Fur Farming, Kirov, Russian Federation

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

Abstract. Morphological characteristics of fruit bodies of several species of edible spring fungi were studied in southern taiga plant communities of Kirov region, European part of Russia. Investigation revealed productivity of Gyromitra esculenta Pers. Ex Fr. (9.7 kg/ha), Gyromitra gigas (Krombh.) Cooke (8.0 kg/ha), Verpa bohemica (Krombh.) J. Schröt. (4.8 kg/ha), Morchella esculenta (L.) Pers. (0.7 kg/ha). Connections between morphological parameters of fruit bodies and weight were defined for each species.

1. Introduction
Kirov region is considered one of the most fungi-rich areas of European part of Russia [1,2]. Studies on productivity and stocks of fungi [3,4,5], peculiarities of their use [6,7] and species identification [8,9,10] are traditionally conducted in the region. However data on biology of edible spring fungi is limited [11].

First spring fungi in Kirov region belong to order Ascomycota, or sac fungi, class Pezizomycetes, most of which have macroscopic fruit bodies of various forms and colors [12].

False morel (Gyromitra esculenta Pers. Ex Fr.) is one of the first spring sac fungi in Kirov region, it starts fruiting right after the loss of snow cover and continues till the end of May [13]. During certain years it can last till June, 20. The species is found on sandy, bare or low-matted soils, on openings, fire sites, along the roads, in coniferous (predominantly pine) or mixed forests [14].

Fruit body (sporocarp) is brittle and delicate, with cerebriform cap on short stipe, filled with septums and convolutions. Chocolate-brown cap can reach up to 120 mm in diameter, stipe to 60 mm high [14,15,16].

Besides G. esculenta one more Gyromitra species is found in forests of Kirov region – snow false morel (Gyromitra gigas (Krombh.) Cooke). Visually these two species are alike, but snow false morel’s apothecium is light sienna-yellow, roundish or oviform, plicate, it intergrows with white short stipe. The fruit body can reach 300 mm in diameter [17]. It is usually found in groups on rich soils, rarely solitary; in deciduous and mixed forests, often in birch forests [18]. Fruit bodies appear from the middle of April till the end of May.

False morel and snow false morel (G. esculenta and G. gigas) are considered conditionally edible species; some researchers define them as poisonous due to the presence of gyromitrin toxin infruit bodies [19]. Concentration of the toxin is unstable and varies from almost harmless to deadly doses [20], it is significantly lower in G. gigas, compared to G. esculenta. According to numerous studies right preparation of raw material (30-minutes long boiling of fruit bodies or 1-month long drying) can reduce the level of toxin or totally neutralize it [21,22]. According to official data, cases of G. esculenta poisoning in Kirov region are mostly caused by improper preparation of fruit bodies or by consumption...
of old and overripe fungi [17]. In folk medicine tincture of G. gigas fruit bodies is used to treat joints and lumbus radiculitis [6]. In 1970-80’s dried false morels were the objects of organized collection. In Kirov region the species preserve its economic value.

Early morel (Verpa bohemica (Krombh.) J. Schröt.) is another rather popular spring fungi, has brown crinkly cap 20-30 mm in diameter on white-cream stipe 40-140 mm high and 15-20 mm in diameter [23]. It prefers humus-rich soils in coniferous deciduous forests of green-moss type. Usually found in sparse tree stands under aspen and linden [24]. Fruiting of V. bohemica is relatively short and starts in the second decade of May. But depending on weather conditions it can shift to the end of May, and end in the beginning of June [13]. The species is also conditionally edible, of 3rd category. It is used in folk medicine to treat eye disorders and digestive tract [6, 8].

Morel (Morchella esculenta) is collected throughout its range and is a subject of industrial collection in many areas [25, 26].

2. False morel

False morel (Gyromitra esculenta Pers. Ex Fr.) within the studied area typically inhabits spruce-pine and pine cowberry-green moss forests with birch. Fruit bodies occurred on sandy soils. Most fruit bodies of G. esculenta were found along forest roads and on damaged soil cover, where clusters of fruit bodies were the largest.

G. esculenta fruit body height varied from 18 to 120 mm, average 61.0±1.9 mm. Variation of the parameter was high (CV=37%). Cap height varied from 8 to 77 mm, stipe height –8 - 74 mm, average 36.0±1.5 and 32±1.3 mm correspondingly. Parameters were highly variable: cap height (CV=41%), stipe height (CV=42%). Cap diameter of found specimens of G. esculenta varied from 19 to 145 mm, average 56.0±1.9 mm (CV=36%). The highest variability was defined for stipe diameter (CV=50%), 5-66 mm, average 21.0±1.0 mm.

False morel average fruit body weight was 29.0±2.3 g, varying from 1 to 152 g. Variability level of the parameter was very high (CV=97%), significantly higher than for other parameters. Observations showed that fruit body weight was higher in pine green moss, spruce-pine bilberry-green moss forests and on the opening under spruce forest, compared to other studied plant communities (figure 1).

Figure 1. Average weight of Gyromitra esculenta fruit body in different plant communities in Kirov region (1 – pine green moss forest; 2 – spruce-pine cowberry-green moss forest; 3 – pine cowberry-green moss forest; 4 – mixed cowberry-green moss forest; 5 – spruce oxalis forest; 6 – spruce-pine bilberry-green moss forest; 7 – opening under spruce forest).
Connection between morphometric parameters of fruit bodies and its weight was defined: with fruit body height \( r=0.81 \), cap height \( r=0.73 \) stipe height \( r=0.67 \), cap diameter \( r=0.89 \) and stipe diameter \( r=0.79 \). Power regression equations approximated dependency of fruit body weight more to fruit body height \( (y = 0.0243x^{1.9162}; R^2 = 0.863) \) and cap diameter \( (y = 0.0012x^{2.4794}; R^2 = 0.7215) \). Figure 2 demonstrates the connection between the features.

Productivity of fruit bodies was 9.7 kg/ha.

3. Snow false morel
Snow false morel (Gyromitra gigas (Krombh.) Cooke) is marked in spruce-birch mixed-herbs (littery) and spruce green moss plant communities. Study of morphometry showed that the height of G. gigas fruit bodies varied from 28 to 113 mm, average 60.2±3.5 mm, variability of the parameter was high \((CV=37\%)\). Cap height varied from 16 to 81 mm, stipe height – from 7 to 50 mm, average values of the parameters are 40.8±2.7 and 20.9±1.6 mm correspondingly. Variability was high for both – \(CV=42\%\) and \(CV=50\%\) correspondingly. Apothecium diameter varied from 21 to 132 mm, average 69.6±4.0 mm, stipe diameter – from 13 to 97 mm (average 40.7±2.7 mm). The parameters were highly variable \((CV=37\%\) and \(CV=43\%\) correspondingly). Weight G. gigas fruit bodies was the most variable parameter \((CV=37\%)\). It ranged from 3 to 219 g, average 63.1±8.03 g. Connection between sporocarp weight and its morphological characteristics was defined (figure 3): fruit body height \( r=0.82 \), cap height \( r=0.81 \), cap diameter \( r=0.94 \), and stipe diameter \( r=0.79 \). Power regression equations reliably approximated dependency of fruit body weight more to fruit body height \( (y = 0.0064x^{2.1904}; R^2 = 0.7817) \) and cap diameter \( (y = 0.0026x^{2.3329}; R^2 = 0.924) \). Figure 3 demonstrates the connection between the features.

G.gigas productivity in studied communities was 8 kg/ha.

4. Early morel
Early morel (V. bohemica) is found in spruce-birch mixed herbs (littery) and willow herbaceous plant communities on loamy soils. The study of V. bohemica morphometry revealed that sporocarp height varied from 30 to 151 mm, average 70.7±2.6 mm. The feature was highly variable \((CV=40\%)\). Cap height varied from 5 to 56 mm, stipe height – from 8 to 107 mm. The parameters were also highly variable \((CV=39\%\) and \(CV=51\%\) correspondingly). Average cap height was 28.4±1.0 mm, stipe height – 43.8±2.1 mm. Cap diameter ranged from 14 to 66 mm (average 35.3±0.8 mm), stipe diameter – from 8 to 36 mm (average 20.6±0.5 mm), variability \(CV=25\%\) and \(CV=28\%\) correspondingly. Average fruit body weight was 18.6±0.9, varying from 4 to 52 g \((CV=52\%)\). Connection between sporocarp weight
and its morphological characteristics was defined (figure 4), the closest connection revealed with cap diameter \( r=0.861 \) and stipe diameter \( r=0.835 \). The connection was approximated by the following power regression equations: stipe diameter \( y = 0.1675x^{1.5346}; R^2 = 0.6695 \) and cap diameter \( y = 0.0479x^{1.6505}; R^2 = 0.6286 \). Figure 4 demonstrates the connection between the features.

![Figure 4](image_url)

**Figure 4.** Distribution of *Gyromitra gigas* fruit bodies by weight, height and cap diameter.

V. *bohemica* productivity in studied communities was 4.8 kg/ha. But published data on productivity of the species in Kirov regions show average values of 36.4 kg/ha for willow dominated plant communities [27].

![Figure 3](image_url)

**Figure 3.** Distribution of *Gyromitra gigas* fruit bodies by weight, height and cap diameter.

5. Morels
Morels were found in scanty groups mostly in spruce-birch herbaceous (littery), pine lingonberry-green moss and pine calamagrostis plant communities within the spots of disturbed soil cover.

M. *esculenta* fruit bodies height ranged from 34 to 81 mm, average 52.7±3.0 mm, highly variable (CV= 27%). Cap height – from 21 to 44 mm (average 30.3±1.5 mm), stipe height - 11 to 40 mm (average – 22.4±1.6 mm); CV= 25% and CV= 34% correspondingly. Cap diameter ranged from 11 to 42 mm, average 19.8±1.5 mm; stipe diameter – from 5 to 12, average 7.4±0.4 mm; CV= 36% and CV= 28%
correspondingly). The most variable parameter was sporocarp weight, which ranged from 0.9 to 18.1 g, average 4.2±0.8 g.

Connection between sporocarp weight and its morphological characteristics was defined (figure 5), the closest connection revealed with cap diameter (r=0.928), stipe diameter (r=0.773), and cap height (r=0.715). The connection was approximated by the following power regression equations: cap diameter (y = 0.0057x2.1579; R² = 0.914), stipe diameter (y = 0.028x2.3962; R² = 0.7571), cap height (y = 0.0003x2.7555; R² = 0.758). Figure 5 demonstrates the connection between the features.

M. esculenta productivity in studied habitats was 0.7 kg/ha. Some researchers note the productivity of morels in old herbaceous aspen forest being 3.9 kg/ha [27].

Figure 5. Distribution of Morchella esculenta fruit bodies by weight, height and cap diameter.

6. Conclusion
The study revealed average values of morphometric parameters of main economically important spring sac fungi. All studied features were highly variable, sporocarp weight being the least stable. Correlations between fruit body weight and morphometry were defined for each species. It was determined that power function is reliable for correlation approximation of sporocarp weight and its morphometric peculiarities. Productivity of spring fungi in southern taiga communities in Kirov region reached 9.7 kg/ha for Gyromitra esculenta, 8 kg/ha - for Gyromitra gigas, 4.8 kg/ha - for Verpa bohemica, and 0.7 kg/ha – for Morchella esculenta.

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