Fruiting fluctuation of fungus *Sarcosoma globosum* and correlation with environmental factors

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Introduction

The research into the effects of climate change on fungal biology and ecology began in the first decade of the 21st century. Studies show that climate variability affects fungal phenology, geographic distribution, substrate preference and other fungal properties.

Fungus *Sarcosoma globosum* (*Ascomycota*) form globose, dark brown, macroscopic fruit-bodies in early spring in forests dominated by spruce (Fig. 1).

Fig 1. Fruit-body of *Sarcosoma globosum*

This rare fungal species is distributed in boreal, hemiboreal and taiga areas of Europe, Asia and North America. This species was classified as *Near Threatened* in the Red List of Threatened Species which was compiled by *International Union for Conservation of Nature* (IUCN). *S. globosum* is a strictly protected species in Lithuania.

Aim of study

The aim of this study was twofold. First it was to investigate the interannual fruiting pattern of *Sarcosoma globosum.* Secondly, to evaluate the correlation of fungal fruiting with environmental factors, such as forest age and climatic factors.

Methods

Long-term observations were provided in all known modern localities of *S. globosum* in Lithuania during the period 2007–2017 (Fig. 2).

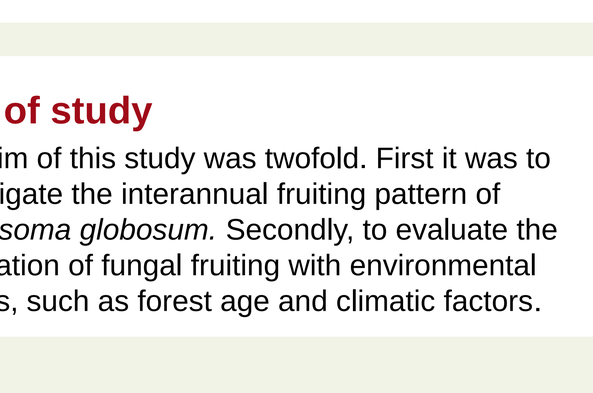

Fig 2. Study design

Each study site was visited at least one time per year. During the visit the number of fruit-bodies, and the size of fruiting area was recorded. Main count of fruit-bodies was performed during the moment of peak productivity (March–April months).

Climate data have been obtained from *Global Historical Climatology Network-Daily (GHCN-Daily)*, *Version 3* dataset. Climatic variables (air and soil temperatures, precipitation) were analyzed using Multiple linear regression with logarithmically transformed data.

Results

Fruiting fluctuations. Fruiting of *S. globosum* do not exhibit extreme qualitative fluctuations (Fig. 3). Fruit-bodies within locality could be completely absent for 1–3 successive years.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Az1	1	3	3	0	0	5	0	0	3	3	19
Vz		173	0	22	90	341	170	263	926	111	4
Zi		7	5	1	4	5	29	27	119	13	0
An1-4			6	0	0	0	218	14	82	60	11
Pa						63	69	63	51	5	0
La						5	6	153	276	132	620
Kr						56	8	0	29	2	0
Vyt								96	90	85	61
An5-6								15	59	12	0

Fig. 3. Number of fruit-bodies of *Sarcosoma globosum* in 9 localities with 4 and more successive years of observation

The results from multiple field surveys indicate that the fruiting of *S. globosum* exhibit distinct quantitative fluctuations. We found that the annual fruit-body count in a single locality varied from zero to 926. The annual mean number of fruit-bodies per locality (Fig. 4) during study period varied from 3.5 (in 2009) to 114.2 (in 2015). During the fruiting peak in the year 2015 the production of fruit-bodies in all studied localities exceeded more than two times interannual average (53.1 fruit-body per locality).

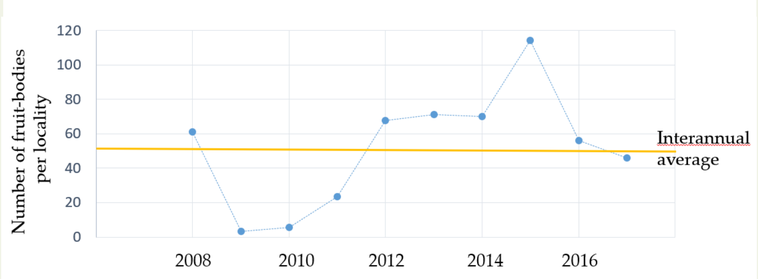

Fig. 4. Dynamics of *Sarcosoma globosum* fruiting in 2008–2017

The start of fruiting varied over the years. Most reports (75 %) on the first observation of fungus fruiting have been received in March and April. Very early starts of fruiting were observed in November and December since 2011. The earliest ever start of fruiting in Lithuania was registered on 2nd of November, 2015. Number of early formed fruit-bodies constituted 2-75 % (average = 23 %) of fruit-bodies formed next year in the spring.

The main climatic factor that stimulated the early beginning of fruiting of *S. globosum* in November and December could be the marked air temperature fluctuation (abrupt temperature decrease below zero and then increase) (Fig. 5).

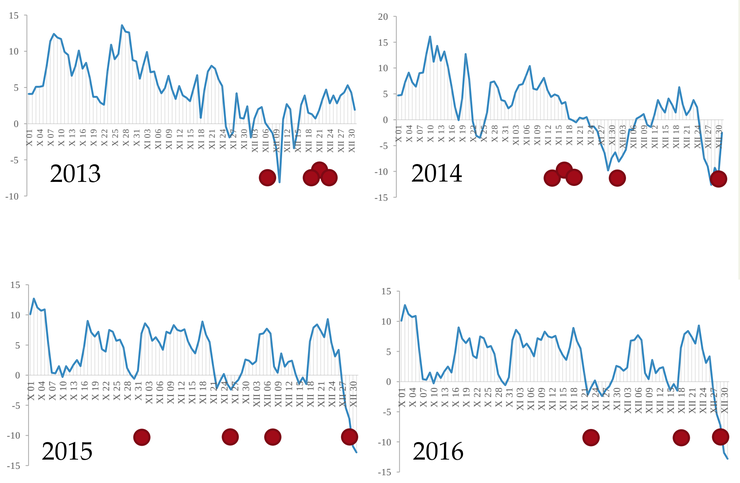

Fig. 5. Air temperature (°C) and early occurrence (●) of *Sarcosoma globosum* in 2013–2016

Forest age. We found that *S. globosum* in Lithuania prefer aged (more than 70 year old) forest stands (Fig. 6). However, the predominant part of most productive populations of *S. globosum* live in forest stands that are composed of different age classes.

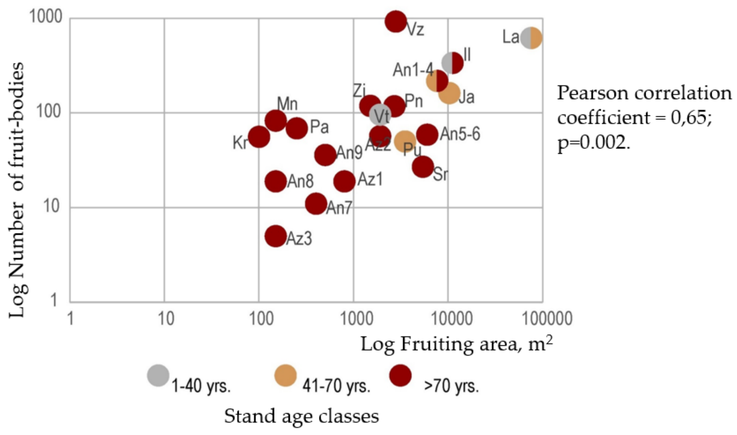

Fig. 6. Relationship between maximum number of produced fruit-bodies of *Sarcosoma globosum*, the size of fruiting area, and the stand age

Climatic factors. We analyzed several climatic variables (monthly averages of air and soil temperatures, precipitation) using Multiple linear regression with logarithmically transformed averaged fruiting yield data, however, the analysis don‘t explain the yearly variation in fungal fruiting using such independent factors as air and soil temperatures. Only linear models with average monthly precipitation in February–April statistically significantly ($F(3, 5) = 6.40$, $p<0.04$) explain yearly variation of *S. globosum* yield, with an $R^2 = 0.79$. But only two predictors were statistically significant: negative – precipitation in March (snow?) and positive – precipitation in April (Fig. 7).

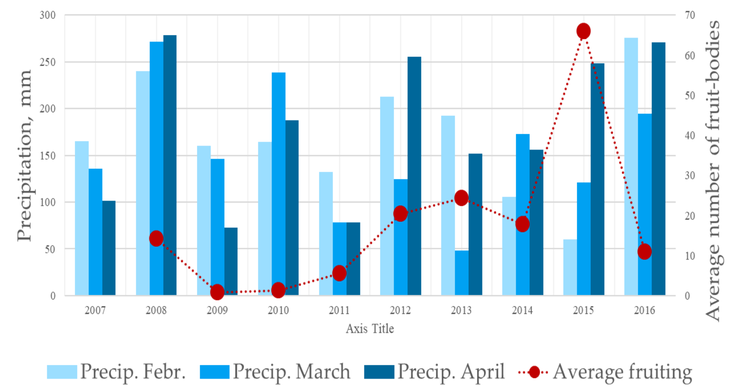

Fig. 7. Fruiting yield of *Sarcosoma globosum* in Lithuania and variation of average monthly rainfall and snow (Utena station, WMO No 26633) during 2007–2016

Conclusions

- The populations of strictly protected fungus *Sarcosoma globosum* in Lithuania regularly fruit and do not show extreme qualitative fluctuations.
- Only few populations of *S. globosum* are very productive and live in comparatively large areas within forest stands that are composed of different age classes.
- Climatic conditions triggers fungus to start fruiting much earlier than usually.
- The preliminary attempt to correlate the fungal fruiting and climatic data demonstrated positive correlation between fruit-body yield and precipitation in April.

Future research

- Long-term observation of *S. globosum* in all known localities in Lithuania will be continued.
- We intend to focus on the question – do climatic variations affect the fruiting and distribution of populations of this threatened fungus.