

DOI: 10.5586/am.1077

**Publication history**

Received: 2016-04-11

Accepted: 2016-06-23

Published: 2016-07-26

**Handling editor**

Tomasz Leski, Institute of Dendrology, Polish Academy of Sciences, Poland

**Authors' contributions**

AS and BG collected and identified the material; all authors contributed to the manuscript preparation

**Funding**

The study was financed from the Forest Fund. The title of the project: "Contemporary occurrence of the diversity of the fungi and slime moulds species in the area of the 'Bory Tucholskie' National Park".

**Competing interests**

No competing interests have been declared.

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## SHORT COMMUNICATION

# Preliminary investigations into the slime moulds (Myxogastria) in the "Bory Tucholskie" National Park

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Field investigations into slime moulds were conducted in the "Bory Tucholskie" National Park in 2014. These were preliminary inventory studies, as research into myxogastria had not been conducted previously in this area. A total of 34 taxa (32 species, 2 varieties) belonging to 16 genera were identified. Of them, *Stemonitopsis amoena* (Nann.-Bremek.) Nann.-Bremek. is a species new to the biota of Poland. The taxon *Symphytocarpus flaccidus* is on the red list of slime mould rare in Poland. Localities of two species – *Cribraria languescens* Rex and *C. pertenuis* Flatau & Schirmer, were recorded in Poland for the second time.

**Keywords**

Myxogastria; protected area; rare species; new species to the biota of Poland

**Introduction**

Myxogastria are complex organisms with unique biology. Their life cycle combines features of both animals and fungi. Although they have been classified in the kingdom Protozoa, slime moulds are often collected during mycological investigations because of the sites they colonize. Published data show that Polish biota currently consists of 268 taxa (261 species, 7 varieties) [1–12] which is ca. 25% of the total number of slime moulds described worldwide [13]. This number is certain to increase as under-explored areas are further investigated for myxogastria.

The "Bory Tucholskie" National Park (PNBT) was created in 1996 and covers the area of 4 613.0439 ha. It is located in the area of the Chojnice district, in the Pomeranian Voivodship. In the area of the National Park 21 lakes are located, including seven, which are linked together and create The Seven Lakes Stream. Coniferous forest communities dominate in the park, mainly *Cladonio-Pinetum*, which comprises 23% of the area. Non-forest communities such as peat bogs, reeds, or psammophilous grasslands also occur in the Park [14]. To date, investigations into slime moulds have not been conducted in the Park. The most of the species noted so far has been collected during the study of the macromycetes for the master's dissertations. They are: *Ceratiomyxa fruticulosa* (O.F. Müll.) T. Macbr., *Lycogala epidendrum* (L.) Fr., *Stemonitis* sp. Gled. [15,16]. Furthermore, the locality of a rare species in Poland, *Symphytocarpus trechisporus* (Berk. ex Torrend) Nann.-Bremek. was reported from the Park [17]. The current study presents a full list of myxogastria taxa identified together with the available information regarding the location, habitat and substrate of each specimen recorded.

**Material and methods**

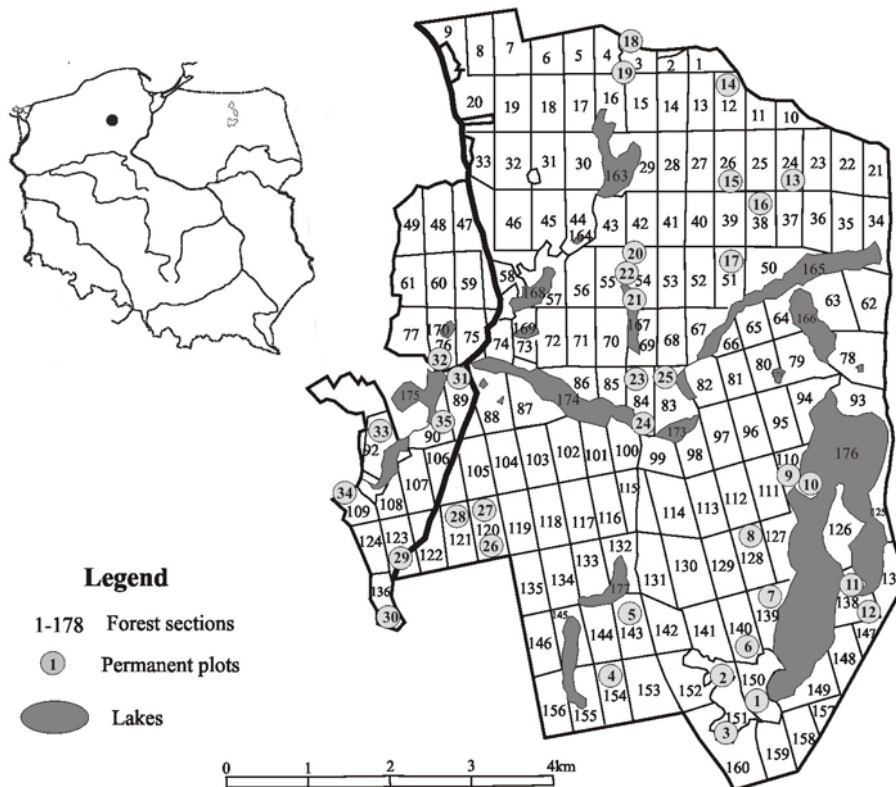
The material was collected in the vegetative season in 2014, mostly from permanent plots established to research macroscopic fungi (Fig. 1; 35 plots, measuring 1 ha in forest habitats and 10 are in non-forest habitats). The method of the investigations included only field studies. As research in the Park was pilot one, the majority of the collections were made in July 2014, when field investigations focused on slime moulds were intensified. At that time, the observations on three plots were made every day.

Herbarium material was identified using a Zeiss Axioskop 2 light microscope and Wetzlar Hund stereomicroscope. Permanent slides were made using Hoyer’s medium. Spores were measured with  $\times 100$  magnification using immersion oil. A Nikon D7000 equipped with a Nikon SMZ645 stereomicroscope was used for photographs given in the study. Spore ornamentation of *Stemonitopsis amoena* species was observed with a scanning electron light microscope JEOL JSM 5410. Scanning electron micrographs were taken in the Department of Cell Biology and Imaging at the Institute of Zoology, Jagiellonian University, Cracow.

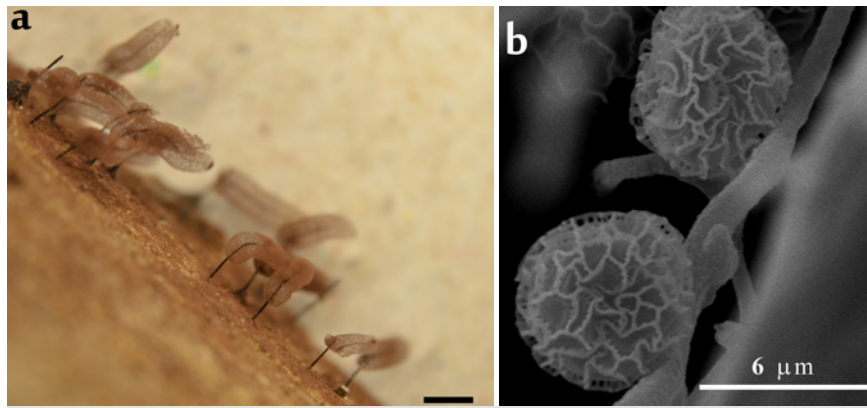
The nomenclature was accepted after Lado [13]. The collections were deposited in the herbarium of the Institute of Botany, Jagiellonian University (KRA), in the MYXO division.

**Results and discussion**

Based on the collected herbarium material (130 specimens) 32 species and two varieties covering 16 genera were identified. Among them, the greatest number of specimens were noted for three taxa: *Fuligo septica* var. *candida* (Pers.) R.E. Fr., *Lycogala epidendrum* (L.) Fr., *Physarum virescens* Ditmar. These are cosmopolitan species that are recorded in a variety of regions worldwide and are classified as taxa with a wide range of occurrence (that is they are recorded on different substrate types). They have



**Fig. 1** Localization of permanent plots in the Bory Tucholskie National Park.



**Fig. 2** *Stemonitopsis amoena*. **a** Sporocarps in groups. **b** Spores. Scale bar: **a** 1 mm.

been reported on different substrate types also in the Park. The locality of *Stemonitopsis amoena* (Nann.-Bremek.) Nann.-Bremek. is the first published locality in Poland (Fig. 2a,b). While there are other known sites of the species in the country, but the locality in the Bory Tucholskie National Park is the first one reported in the literature. The taxon *Symphytocarpus flaccidus* (Lister) Ing & Nann.-Bremek. is included on the red list of slime moulds rare in Poland [18]. The localities of *Cribraria languescens* Rex and *C. pertenuis* Flatau & Schirmer are the second sites published in Poland to date. As research literature shows, the latter two species are rarely noted in Europe [12].

Permanent research plots were established in a variety of forest and non-forest communities. In forest sites, the taxa were mostly recorded on different types of dead pine and birch wood. In non-forest sites (e.g., grasslands, meadows), slime moulds were practically not recorded.

Results from the Bory Tucholskie National Park show that even short-term field investigations in areas of special natural value contribute to the development of knowledge on the species diversity, ecology, and distribution of slime moulds in Poland.

The following abbreviations were used in the list of taxa recorded in the Bory Tucholskie National Park: P1-35 – research plot number; Sect. 1-178 – section number; L-P – *Leucobryo-Pinetum*; M-P – *Molinio-Pinetum*; Mc – *Molinion caeruleae*; Phr – *Phragmition*; B-Qr – *Betulo-Quercetum roboris*; Sp – *Scheuchzerietalia palustris*; Sm – *Sphagnion magellanici*; Vu-P – *Vaccinio uliginosi-Pinetum*; Vu-Bp – *Vaccinio uliginosi-Betuletum pubescentis*; P-C + C – *Pohlio-Callunion + Corynephorion*; F-Qp – *Fago-Quercetum petraeae*; S-C – *Stellario-Carpinetum*; F-A – *Fraxino-Alnetum*; Rn-A – *Ribeso nigri-Alnetum*; A. g. – *Alnus glutinosa*; B. sp. – *Betula* sp.; P. a. – *Picea abies*; P. s. – *Pinus sylvestris*. Initials of the names are given to denote collecting and/or identifying person, namely AS – Agnieszka Salamaga, BG – Barbara Grzesiak; ! – taxa new for Poland; \* – species rare in Poland.

Geographical coordinates of the research plots: P5 – N 53°47'27", E 17°33'39"; P6 – N 53°47'16", E 17°34'55"; P7 – N 53°47'33", E 17°35'20"; P8 – N 53°47'36", E 17°35'09"; P10 – N 53°48'17", E 17°35'32"; P12 – N 53°47'30", E 17°36'09"; P13 – N 53°50'26", E 17°35'02"; P16 – N 53°50'03", E 17°35'04"; P20 – N 53°49'41", E 17°33'47"; P21 – N 53°49'45", E 17°33'48"; P22 – N 53°49'46", E 17°33'50"; P24 – N 53°48'52", E 17°33'48"; P25 – N 53°48'54", E 17°34'07"; P27 – N 53°48'04", E 17°32'17"; P28 – N 53°47'55", E 17°31'45"; P29 – N 53°47'46", E 17°31'06"; P30 – N 53°47'31", E 17°30'53"; P31 – N 53°49'03", E 17°31'52"; P32 – N 53°49'12", E 17°31'47"; P35 – N 53°48'31", E 17°31'19".

#### A list of taxa recorded in the Bory Tucholskie National Park

*Arcyria cinerea* (Bull.) Pers. – on log of B. sp., P12, B-Qr, 25 July, leg. & det. AS; on log of deciduous trees, P32, Sm, 24 July, leg. & det. AS; on log of A. g.: P35, Rn-A, 24 July leg. & det. AS; P31, F-A, 24 July, leg. & det. AS; on trunk of B. sp., P12, B-Qr, 25 July, leg. & det. AS.

*Arcyria incarnata* (Pers. ex J.F. Gmel.) Pers. – on twig of P. s.: P6, L-P, 18 July, leg. & det. AS; P25, L-P, 22 July, leg. & det. AS; Sect. 2a, 26 July, leg. & det. AS.

*Ceratiomyxa fruticulosa* (O.F. Müll.) T. Macbr. – on log of coniferous trees, P8, Mc, 7 Aug. leg. BG det. AS; on log of P. s.: P28, L-P, 22 July, leg. & det. AS; P5, L-P, 17 July, leg. & det. AS; P5, L-P, 17 July, leg. & det. AS; P6, L-P, 18 July, leg. & det. AS; on twig of P. s., P22, Vu-P, 20 July, leg. & det. AS; on wood of P. s.: Sect. 7d, 21 July, leg. & det. AS; Sect. 12b, 21 July, leg. & det. AS; on soil, P21, Sm, 20 July, leg. & det. AS.

*Collaria arcyronema* (Rostaf.) Nann.-Bremek. ex Lado – on log of *Picea abies*, P32, Sm, 24 July, leg. & det. AS; on log of B. sp.: P12, B-Qr, 25 July, leg. & det. AS; P12, B-Qr, 25 July, leg. & det. AS; on log of A. g., P31, F-A, 24 July, leg. & det. AS; on log of P. s., P5, L-P, 17 July, leg. & det. AS.

*Cribraria argillacea* (Pers. ex J.F. Gmel.) Pers. – on log of A. g.: P35, Rn-A, 13 June, leg. BG det. AS; P35, Rn-A, 24 July, leg. & det. AS.

*Cribraria aurantiaca* Schrad. – on log of B. sp., P12, B-Qr, 25 July, leg. & det. AS; on log of P. s., P7, M-P, 18 July, leg. & det. AS; on stump of P. s., P21, Sm, 20 July, leg. & det. AS.

*Cribraria cancellata* var. *cancellata* (Batsch) Nann.-Bremek. – on log of *Picea abies*, P32, Sm, 24 July, leg. & det. AS; on stump of P. s., P8, Mc, 18 July, leg. & det. AS.

*Cribraria cancellata* var. *fusca* (Lister) Nann.-Bremek. – on log of P. s.: P5, L-P, 17 July, leg. & det. AS; P20, Sp, 20 July leg. & det. AS; on stump of P. s.: P32, Sm, 24 July, leg. & det. AS, Sect. 138, 16 June, leg. BG det. AS.

*Cribraria intricata* Schrad. – on log of P. s., P5, L-P, 17 July, leg. & det. AS.

\**Cribraria languescens* Rex – on log of P. s.: P7, M-P, 18 July, leg. & det. AS; P7, M-P, 18 July, leg. & det. AS.

**Notes.** Species known in Poland from a single locality [12]. Our specimen does not differ from the described specimen.

\**Cribraria pertenuis* Flatau & Schirmer – on stump of P. s., P21, Sm, 20 July, leg. & det. AS.

**Notes.** Species known in Poland from a single locality [12]. Our specimen does not differ from the described specimen.

*Cribraria rufa* (Roth) Rostaf. – on log of P. s., P5, L-P, 17 July, leg. & det. AS.

*Cribraria splendens* (Schrad.) Pers. – on log of A. g., P35, Rn-A, 24 July, leg. & det. AS; on log of B. sp., P12, B-Qr, 25 July, leg. & det. AS.

*Diderma deplanatum* Fr. – on mosses and plant debris, P32, Sm, 24 July, leg. & det. AS.

*Diderma testaceum* (Schrad.) Pers. – on mosses, P35, Rn-A, 13 Aug., leg. BG det. AS.

*Enerthenema papillatum* (Pers.) Rostaf. – on twig of P. s., Sect. 12b, 21 July, leg. & det. AS.

*Fuligo septica* var. *candida* (Pers.) R.E. Fr. – on log of P. s.: P12, B-Qr, 25 July, leg. & det. AS; Sect. 127, 25 July, leg. & det. AS; on log of B. sp., P12, B-Qr, 7 Aug, leg. & det. BG; on log of B. sp., on mosses, P12, B-Qr, 25 July, leg. & det. AS; on stump of P. s., Sect. 120, 19 Sept., leg. & det. BG; on bark of living P. s., P29, F-Qp, 23 July, leg. & det.

AS; on bark of P. s., P27, P-C + C, 22 July, leg. & det. AS; on fallen branches, needles of P. s. and on soil, P28, L-P, 22 July, leg. & det. AS; on *Vaccinium myrtillus* and fallen branches, P29, F-Qp, 23 July, leg. & det. AS; on fallen leaves: Sect. 13, 11 Aug, leg. & det. BG; Sect. 160, 6 Aug., leg. & det. BG; on fallen leaves and mosses: P13, 8 Aug., leg. & det. BG; Sect. 12, 11 Aug., leg. & det. BG; on mosses and needles of P. s., P13, L-P, 19 July, leg. & det. AS; on mosses: Sect. 42, 21 July, leg. & det. AS; P25, L-P, 22 July, leg. & det. AS; Sect. 7d, 21 July, leg. & det. AS.

*Fuligo septica* var. *septica* (L.) F.H. Wigg. – on log of B. p., Sect. 138, 7 Aug., leg. & det. BG; on stump of P. s., Sect. 138, 16 June, leg. BG det. AS; on needles of P. s., P16, 18 July, leg. & det. AS; on fallen leaves, Sect. 12, 11 Aug., leg. & det. BG; Sect. 7, 11 Aug., leg. & det. BG; Sect. 33, 11 Aug., leg. & det. BG; on *Pleurozium schreberi*, Sect. 142, 6 Aug., leg. & det. BG; on mosses: P13, L-P, 19 July, leg. & det. AS; Sect. 33, 22 June, leg. & det. BG; Sect. 8, 11 Aug., leg. & det. BG; Sect. 29, 21 June, leg. & det. BG; Sect. 12, 21 June, leg. & det. BG; Sect. 8, 11 Aug., leg. & det. BG.

*Licea minima* Fr. – on log of P. s., P28, L-P, 22 July, leg. & det. AS.

*Licea variabilis* Schrad. – on twig of P. s.: Sect. 12a, 26 July, leg. & det. AS; Sect. 12a, 26 July, leg. & det. AS.

*Lycogala epidendrum* (L.) Fr. – on log of A. g., P31, F-A, 24 July, leg. & det. AS; on log of B. sp., P24, Vu-Bp, 22 July, leg. & det. AS; on log of P. s.: P29, F-Qp, 23 July, leg. & det. AS; P5, L-P, 17 July, leg. & det. AS; P5, L-P, 17 July, leg. & det. AS; P5, L-P, 17 July, leg. & det. AS; Sect. 13a, 21 July, leg. & det. AS; on stump of P. s., Sect. 138, 16 June, leg. BG det. AS; on stump of B. sp., P12, B-Qr, 25 July, leg. & det. AS; on twig of P. s., P13, L-P, 18 June, leg. BG det. AS.

*Physarum leucopus* Link – on stump of P. s., Sect. 138, 16 June, leg. & det. BG.

*Physarum virescens* Ditmar – on stump of P. s., Sect. 138, 16 June, leg. BG det. AS; on mosses and on needles of P. s., Sect. 7d, 21 July, leg. & det. AS; on mosses: Sect. 163, 21 June, leg. BG det. AS; Sect. 14, 17 June, leg. BG det. AS; P13, L-P, 19 July, leg. & det. AS; P25, L-P, 22 July, leg. & det. AS; Sect. 42, 21 July, leg. & det. AS; Sect. 7d, 21 July, leg. & det. AS; on plant debris, P20, Sp, 20 July, leg. & det. AS.

*Physarum viride* var. *viride* (Bull.) Pers. – on twig of P. s.: P12, B-Qr, 25 July, leg. & det. AS; Sect. 2a, 26 July, leg. & det. AS.

*Reticularia lycoperdon* Bull. – on twig of P. s., Sect. 90, 7 Aug., leg. & det. BG.

*Stemonitis axifera* (Bull.) T. Macbr. – on log of A. g.: P35, Rn-A, 24 July, leg. & det. AS; P35, Rn-A, 24 July, leg. & det. AS; on log of P. s.: P5, L-P, 17 July, leg. & det. AS; P30, S-C, 23 July, leg. & det. AS; on log of B. sp.: Sect. 84, 22 July, leg. & det. AS; P12, B-Qr, 25 July, leg. & det. AS; on twig of P. s., P31, F-A, 24 July, leg. & det. AS; on muck soil, P7, M-P, 18 July, leg. & det. AS.

*Stemonitis fusca* Roth – on log of B. sp., Sect. 84, 22 July, leg. & det. AS.

*Stemonitis herbatica* Peck – on log of P. s., P12, B-Qr, 25 July, leg. & det. AS; on twig of P. s., Sect. 12b, 21 July, leg. & det. AS.

*Stemonitopsis amoena* (Nann.-Bremek.) Nann.-Bremek. – on twig of P. s., Sect. 7d, 21 July, leg. & det. AS; on twig of P. s., P25, 22 July, leg. & det. AS.

**Notes.** Species hitherto not reported in Polish literature, known also from the Niepołomice Forest and Las Łągiwnicki forest (Bochynek, Salamaga, unpublished data). Our specimen does not differ from the described specimen.

*Stemonitopsis hyperopta* (Meyl.) Nann.-Bremek. – on log of B. sp.: P12, B-Qr, 25 July, leg. & det. AS; P12, B-Qr, 25 July, leg. & det. AS; on log of P. s.: P10, Phr, 25 July, leg. & det. AS; P6, L-P, 18 July, leg. & det. AS; P32, Sm, leg. & det. AS; Sect. 7d, 21 July, leg. & det. AS.

*Stemonitopsis typhina* (F.H. Wigg.) Nann.-Bremek. – on log of B. sp., P24, Vu-Bp, 22 July, leg. & det. AS; on log of P. s.: P30, S-C, 23 July, leg. & det. AS. Sect. 127, 25 July, leg. & det. AS.

\**Symphytocarpus flaccidus* (Lister) Ing & Nann.-Bremek. – on log of P. s.: P28, L-P, 22 July, leg. & det. AS; Sect. 90m, 24 July, leg. & det. AS. on bark of living P. s., P21, Sm, 20 July, leg. & det. AS.

**Notes.** Species known in Poland from few localities [1,7,9,19].

*Trichia favoginea* (Batsch) Pers. – on log of B. sp.: P12, B-Qr, 25 July, leg. & det. AS; P12, B-Qr, 25 July, leg. & det. AS.

*Tubifera ferruginosa* (Batsch) J.F. Gmel. – on mosses, P12, B-Qr, 25 July, leg. & det. AS.

### Acknowledgments

The authors would like to thank Dr. Joanna Kazik for her help with English and anonymous reviewers for considerable remarks on the text.

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