Is a newly reported presence of *Stictis radiata* in Svalbard a result of global climate change, or is it due to the availability of a suitable substrate?

Liudmila A. Konoreva[1,2], Sergey V. Chesnokov[2*]

[1]*Polar-Alpine Botanical Garden-Institute of the Kola Science Centre of Russian Academy of Science, Botanical Garden Str. 1, Kirovsk 184256, Murmansk Region, Russia*
[2]*Komarov Botanical Institute of the Russian Academy of Sciences, Professor Popov Str. 2, St. Petersburg 197376, Russia*

Abstract

The identification of materials collected in Svalbard led to the discovery of the species *Stictis radiata* (L.) Pers. This species is a facultatively lichenized fungus and an epiphyte whose main range lies outside the Arctic. We collected two specimens of this species in the Colesdalen, Svalbard. This place is one of 'Arctic hotspot complexes', as Arve Elvebakk called them, where the only place in the archipelago with growing *Betula nana* is located. Colesdalen also had suitable conditions of moisture and "sheltered" from the winds for the formation of sufficiently large woody remains of vegetation, which became a suitable substrate for *Stictis radiata*, whose main range is confined to the forest zone. The closest known locations of the species are in the Pechenga region of the Murmansk Region (Russia) and Scandinavia. This article discusses the ecological preferences and distributional features of the species.

Key words: Arctic, lichenized fungi, ecology of lichens, distribution, new records

DOI: 10.5817/CPR2024-2-18

Introduction

Stictis s.l., as circumscribed by Wedin et al. (2006), includes several taxa from at least three ostropalean genera (*Carestiella* Bres., *Schizoxylon* Pers., and *Stictis* Pers. s. str. pro parte). Within *Stictis* s.l., some taxa have shown facultative lichenization, where the fungus may either persist as a saprotroph or become lichenized, apparently depending on its substrate, *i.e.*, bark or wood (Wedin et al. 2004).

Stictis s. str. is characterized (Sherwood 1977) by having a more or less orbicular ascoma that opens by a pore, a margin lined by periphysoids that extend the whole

Received September 10, 2024, *accepted* November 15, 2024.
*Corresponding author: S. V. Chesnokov <lukinbrat@mail.ru>
Acknowledgements: The study was carried out in the frame of the Avrorin Polar-Alpine Botanical Garden-Institute of the Russian Academy of Sciences research project "Study of flora, vegetation, productivity and soil formation processes in the Arctic ecosystems of the Svalbard archipelago" (FMER-2022–0003), No. 122091900008–4 (work by L. Konoreva); Komarov Botanical Institute of the Russian Academy of Sciences research projects "Flora and taxonomy of algae, lichens and bryophytes of Russia and phytogeographically important regions of the world" No. 121021600184–6 (work by S. Chesnokov).

length of the margin, a hymenium that splits away from the margin when dry, and filiform, thin-walled, multiseptate ascospores that do not disarticulate into part-spores. According to phylogenetic reconstructions (Wedin et al. 2004, 2006), *Stictis* is most likely a paraphyletic group whose distribution, due to substrate specificity to *Populus*, *Salix*, *Picea* and *Pinus*, is apparently limited to the boreal zone (Wedin et al. 2006, Popov et al. 2020) and one report is known from Canadian Arctic (Semenova et al. 2015).

Stictis radiata (L.) Pers., a facultatively lichenized fungus, was found when identifying specimens collected by the first author on the Svalbard archipelago in 2009 and 2015 in the West Spitsbergen (Isfjorden, Colesdalen and Grumantdalen area). Previously, no species of the genus *Stictis* s.l. were known from the Svalbard archipelago. Moreover, the closest occurrences of species from this genus, particularly *S. radiata*, in cold regions are known from the northwestern part of Russia and northern Scandinavia (Wedin et al. 2006, Konoreva et al. 2016).

Material and Methods

Research on lichen biodiversity has been a part of a comprehensive field study carried out in Svalbard by the Avrorin Polar-Alpine Botanical Garden-Institute of the Kola Science Centre of the Russian Academy of Sciences (KSC RAS, Russia). Since 2004, the research of PABGI KSC RAS on the archipelago covers about 25 localities in the Nordaustlandet, West Spitsbergen (including Isfjord area, Bockfjorden, St. Jonsfjorden, Hornsund, Stormbukta and other), on the Barentsoya and Prins Karls Forland. Information about the natural conditions on the Svalbard archipelago in the investigated areas, as well as our research on lichens in Svalbard, have been presented in several papers (*e.g.*, Konoreva 2014, Konoreva and Chesnokov 2018, 2022, 2023; Konoreva *et al.* 2024). The lichens were collected by Liudmila Konoreva in the Coles Bay area (West Spitsbergen) in July 2009 and 2015 (*see* Fig. 1). Morphological and anatomical features of the lichens were analyzed using Olympus SZ 6, MBS-10, MSP-2 stereomicroscopes and Olympus BX 51 and Carl Zeiss Primo Star microscopes and chemical tests (Smith et al. 2009). Voucher lichen specimens are deposited in the herbarium of the Avrorin Polar-Alpine Botanical Garden-Institute of KSC RAS (KPABG) and the Komarov Botanical Institute RAS (LE). The geographical names and topographic bases for Fig. 1 are based on the topographical Svalbard map service of the Norwegian Polar Institute[1]. Nomenclature follows Westberg et al. (2021). Photographs of the species were taken using a stereoscopic microscope Motic SMZ-171-LED with an attached MotiCam S6 camera. The distribution map of *S. radiata* was prepared using GIS Acsioma 5.1 software. Geographical coordinates are given in the spatial reference system WGS 1984.

Results

***Stictis radiata* Pers.**, Obs. Mycol. 2: 73 (1799), *see* Fig. 2.

Type: Germany: in cortice Pini abietis (L-Persoon 910.63 – 968, lectotype).
A detailed description of the species and differences from closely related taxa was provided by Wedin et al. (2006).

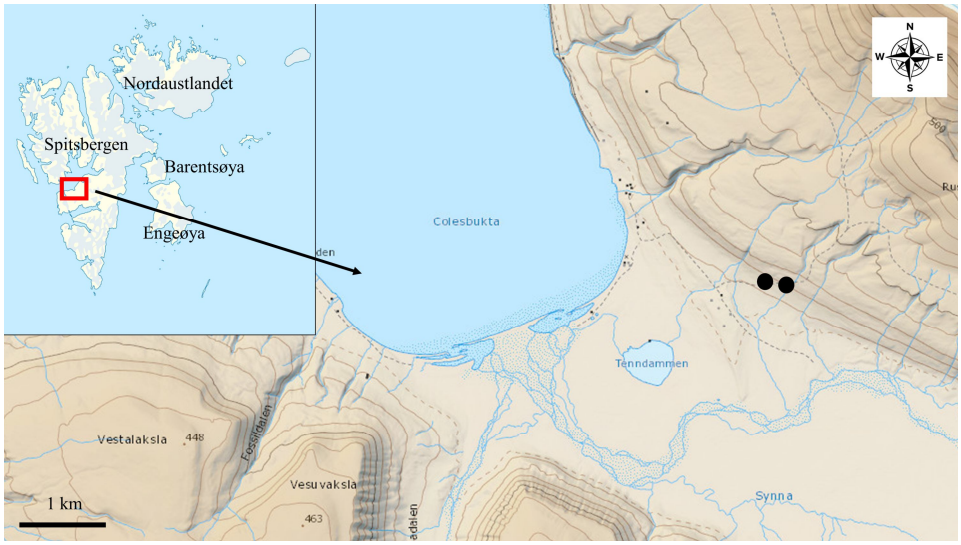

Fig. 1. Known locations of *Stictis radiata* in Colesdalen, Svalbard. *Source*: 'TopoSvalbard'[1].

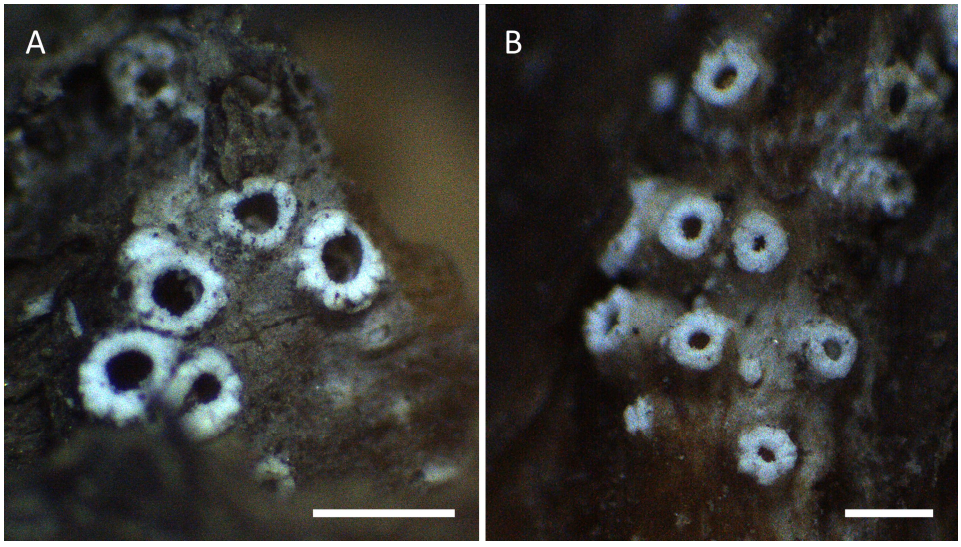

Fig. 2. *Stictis radiata* (A) on rotten branches of *Betula nana* (KPABG 21332) and (B) *Salix* sp. (LE L-26788). Scale bar: A and B = 0.5 mm.

Ecology: The species has a wide ecological niche (Wedin et al. 2006). By and large, it is distributed in different types of forests, mainly near water sources (along rivers, creeks, and lakes), on the bark or wood of *Picea*, *Pinus*, *Populus*, *Ulmus*, *Salix*, and *Sorbus* spp. Single finds are known on shrubs of *Salix* spp. in the forest-tundra zone.

Distribution: This cosmopolitan species is widely distributed in Eurasia, Africa, North and South America, Australia, and New Zealand (Rodway 1924, Sherwood 1977, Johnston 1983, Gamundí et al. 2004, Semenova et al. 2015). *S. radiata* is rather common species in Russia. It has been reported from the Murmansk Region (Karsten 1866, Konoreva et al. 2016), Leningrad Region (Kuznetsova et al. 2012, Himelbrant et al. 2017), St. Petersburg (Weinmann 1828), Moscow (Martius 1817), Ulyanovsk Region (Churakov et al. 2015, Huseyin *et al.* 2016), Kaluga Region (Popov and Volobuev 2014), Chelyabinsk Region (Urbanavichene 2011), Sverdlovsk Region (Sirko 1976), Krasnodar Territory (Vasil'eva 1939, Urbanavichene and Urbanavichus 2014), Republic of Adygea (Vaasma et al. 1986), Krasnoyarsk Territory, Trans-Baikal Territory, Yakutia (Konoreva et al. 2016), Karachayevo-Circassian Republic, and Sakhalin Region (Popov et al. 2020).

Specimens examined: Svalbard, West Spitsbergen, Colesdalen, 78°06′26.3″ N, 15°06′00.7″ E, alt. 89 m, slope with scarce *Betula nana*, on branches of *Betula nana*, 1 August 2009, L.A. Konoreva 149, KPABG 21332; *ibid.*, Coleselva river valley, 78°06′27.6″ N, 15°05′22.8″ E, alt. 130 m, stone field with *Salix* sp., on branches of *Salix* sp., 7 August 2015, L.A. Konoreva 163, LE L-26788.

Fig. 3. The community structure with *Salix* sp. on slope in the Coleselva River valley.

Discussion

The Svalbard locality is currently the northernmost known location of *Stictis radiata*, despite the species wide distribution throughout the world. Such northern occurrences of the species had not been previously discovered, despite large-scale studies (Øvstedal et al. 2009, Kristinsson et al. 2010). The northernmost locality reported before our research was Alaska. The species was found near the Toolik Lake Research Station, on the northern foothills of the Brooks Range (68°38′ N, 149°34′ W) (Semenova et al. 2015). However, this location is situated 10 degrees south of the point we marked in the area of Colesdalen (Svalbard) referred to by the authors as the "green tundra". The discovery of a species that prefers wood or, less often, tree bark as a substrate in high-latitude Arctic Svalbard seems worthy of attention.

Thus, it is worth noting that Øvstedal et al. (2009), in describing the modern bioclimatic zoning of Svalbard, referenced geobotanical papers. For example, Summerhayes and Elton (1928) were the first who presented a map of the bioclimatic zones of Svalbard. Three zones presented in the map were distinguished according to the occurrence of *Cassiope tetragona* (L.) D. Don, *Dryas octopetala* L., and a number of thermophilic species. The fourth zone, 'Barren Zone,' however, was characterized by the absence of all these indicator species. Elvebakk (1985) proposed a slightly different subdivision of vegetation zones and suggested a nomenclature related to both Fennoscandian and Russian traditions. He also used higher phytosociological units as criteria and later made a more detailed subdivision, now incorporating all species defined as relatively thermophilic (*i.e.*, requiring mean July temperatures above 3°C) (Elvebakk 1989). In this adopted system, the High Arctic is subdivided into the Arctic polar desert zone, the northern Arctic tundra zone, and the middle Arctic tundra zone. The southern arctic tundra zone, representing areas within the temperature range of 7–9°C, is not found with certainty on Svalbard due to the temperature characteristics but may be indicated by small areas with a high representation of thermophilic species (*e.g.*, the *Betula nana*/*Campanula gieseckiana* locality in Colesdalen, the west-facing Ossian Sarsfjellet near Ny-Ålesund, and the *Calamagrostis purpurascens* R. Br. locality at Wijdefjorden) (Elvebakk 1989). Elvebakk (2005) proposed a number of 'Arctic hotspot complexes' on Svalbard. These local areas of 'Arctic hotspot complexes' with thermophilic plant species might have been developed due to the combined influence of a warm current on one hand and an internal position in the fjords (shielded from harsh winds) on the other. Such small areas developed historically and create suitable areas of vegetation, the remains of which serve as substrates for such wood-preferring species as *Stictis radiata*. These areas are rare on Svalbard and are of great interest to researchers, since plant and fungal species that are not typical for high latitudes can be found there. Colesdalen is one of these 'Arctic hotspot complexes', as presented above, where the only place in the archipelago with growing *Betula nana* L. is located. One of the collected specimens of *Stictis radiata* was found on plant debris (twigs) from *Betula nana*. The second specimen was collected in the valley of the Coleselva River, on plant debris from *Salix* sp. (Fig. 3). This locality also had suitable conditions of moisture and shelter from the winds for the formation of sufficiently large woody remains of vegetation. Thus, small areas with more comfortable conditions for plants can be found far in the north, where suitable substrates are formed. This provides habitats for species that are uncharacteristic for such latitudes. However, our numerous studies in the archipelago that have been

conducted since 2008 (*e.g.*, Konoreva 2011, 2014; Belkina et al. 2015, Konoreva and Chesnokov 2018, 2021, 2022, 2023; Konoreva et al. 2019, 2024) have shown that such localities are rare. Therefore, southern species are expectedly absent in large areas of the archipelago. Only one more find of the species *Sarcosagium campestre* (Fr.) Poetsch et Schied., whose main range is outside the Arctic, was discovered in the vicinity of the former Russian settlement Pyramiden (Konoreva 2014, Belkina et al. 2015). The area where the species was found was the former cattle yard, where again there was a suitable, nutrient-rich substrate for the this species (soil from a former manure heap). Thus, the record of these two species support our assumption that the changes are local in nature and are primarily associated with microclimatic conditions in individual localities, and sometimes with human influence.

Conclusion

In the course of our research, new northern localities for the species *Stictis radiata* and other thermophilic species were discovered, highlighting the significance of polar ecosystems, such as Svalbard, as unique "Arctic hotspots". Despite the rarity of these localities, specific small-area spots in the archipelago, like *e.g.* Colesdalen, exhibit conditions favorable for the growth of species that are not typical for high latitudes. However, as our numerous studies demonstrate, such findings are not widespread and are rather indicative of localized changes in microclimate, possibly influenced by human activities. This underscores the need for further research to understand the impact of global climate change on the biological diversity of Arctic regions.

References

BELKINA, O. A., KONSTANTINOVA, N. A., KOROLEVA, N. E., KONOREVA, L. A., DAVYDOV, D. A., SAVCHENKO, A. N. and LIKHACHEV, A. YU. (2015): Bryophytes, lichens and Cyanoprokaryotes in surroundings of Pyramyden (Svalbard): A concese guide-book. DITON, St.-Petersburg, 253 p.

CHURAKOV, B. P., HUSEYIN, E. S., SELCUK, F., KORNILIN, K. E. and ROMANOVA, T. A. (2015): Preliminary synopsis of biota of micromycetes of forests of the Ulyanovsk region. *In*: A. V. Mukhin (ed.): Biodiversity and ecology of fungi and fungus-like organisms northern Eurasia. Publishing house of the Ural University, Yekaterinburg, pp. 273–276 (in Russian).

ELVEBAKK, A. (1985): Higher phytosociological syntaxa on Svalbard and their use in subdivision of the Arctic. *Nordic Journal of Botany*, 5: 273-284.

ELVEBAKK, A. (1989): Biogeographical zones of Svalbard and adjacent areas based on botanical criteria. Dr. scient. Diss. thesis. University of Tromsø, Norway. 129 p.

ELVEBAKK, A. (2005): A vegetation map of Svalbard on the scale 1: 3.5 mill. *Phytocoenologia*, 35: 951-967.

GAMUNDÍ, I. J., MINTER, D. W., ROMERO, A. I., BARRERA, V. A., GIAIOTTI, A. L., MESSUTI, M. I. and STECCONI, M. (2004): Checklist of the Discomycetes (Fungi) of Patagonia, Tierra del Fuego and adjacent Antarctic areas. *Darwiniana*, 42(1–4): 63-164.

HIMELBRANT, D. E., STEPANCHIKOVA, I. S., MOTIEJŪNAITĖ, J., GERASIMOVA, J. V., KUZNETSOVA, E. S., DYOMINA, A. V. and TSURYKAU, A. G. (2017): New records of lichens and allied fungi from the Leningrad Region, Russia. VIII. *Folia Cryptogamica Estonica*, 54: 63-70.

HUSEYIN, E. S., SELCUK, F., CHURAKOV, B. P., KORNILIN, K. E. and ROMANOVA, T. A. (2016): Microfungi on forest trees and shrubs of Duzce Province (Turkey) and Ulyanovsk Region (Russia). *Mikologiya i Fitopatologiya*, 50(1): 35-42. (In Russian with English summary).

JOHNSTON, P. R. (1983): *Stictis* and its anamorphs in New Zealand. *New Zealand Journal of Botany*, 21: 249-279.

KARSTEN, P. A. (1866): Enumeratio fungorum et myxomycetum in Lapponia orientali aestate 1861 lectorum. *Notiser ur Sällskapets pro Fauna et Flora Fennica förhandlingar*, 8: 193-224.

KONOREVA, L. (2011): Five lichen species new to Svalbard. *Graphis Scripta*, 23: 24-26.

KONOREVA, L. (2014): *Sarcosagium campestre* (Fr.) Poetsch & Schied. – the new lichen species with ephemeroid fruit bodies from Svalbard. *In*: Abstracts and Contact list of Polar Ecology Conference, České Budějovice, Czech Republic, Sept. 2014. České Budějovice, pp. 75–76.

KONOREVA, L. A., CHESNOKOV, S. V. (2018): Lichens of vicinity of the former township Kolsbey (West Spitsbergen). *Bulletin of the Kola Science Center RAS*, 3: 31-42. (In Russian with English summary).

KONOREVA, L., CHESNOKOV, S. (2021): Lichens of the Innvika Bay, Prins Oscars Land (Nordaustlandet, Svalbard). *Czech Polar Reports*, 11(2): 253-269.

KONOREVA, L., CHESNOKOV, S. (2022): Lichens of Frankenhalvøya Peninsula (Northern part of Barentsøya, Svalbard archipelago). *Polish Polar Research*, 43(1): 37-68.

KONOREVA, L. A., CHESNOKOV, S. V. (2023): Addition to the lichen biota of Prins Karls Forland (Svalbard archipelago). *Novosti Sistematiki Nizshikh Rastenii*, 57(2): L7–L14.

KONOREVA, L. A., CHESNOKOV, S. V. and BOLSHAKOV, S. YU. (2024): Inventory of lichenised and lichenicolous fungi of Nordaustlandet, Svalbard. *Polar Biology*, 47: 639-649.

KONOREVA, L. A., CHESNOKOV, S. V. and DAVYDOV, E. A. (2016): *Stictis* and *Schizoxylon* (Stictidaceae, Ostropales) in Russia. *Herzogia*, 29(2): 706-711.

KONOREVA, L., KOZHIN, M., CHESNOKOV, S. and HONG, S. G. (2019): Lichens and vascular plants in Duvefjorden area on Nordaustlandet, Svalbard. *Czech Polar Reports*, 9(2): 182-199.

KRISTINSSON, H., ZHURBENKO, M. and HANSEN, E. S. (2010): Panarctic checklist of lichens and lichenicolous fungi. *CAFF Technical Report*, 20: 1-120.

KUZNETSOVA, E. S., MOTIEJŪNAITĖ, J., STEPANCHIKOVA, I. S., HIMELBRANT, D. E. and CZARNOTA, P. (2012): New records of lichens and allied fungi from the Leningrad Region, Russia III. *Folia Cryptogamica Estonica*, 49: 31-37.

MARTIUS, H. (1817): Prodromus florae Mosquensis. Editio altera, Lipsiae: Commercio industriae, 288 p.

ØVSTEDAL, D. O., TØNSBERG, T. and ELVEBAKK, A. (2009): The lichen flora of Svalbard. *Sommerfeltia*, 33: 1-393.

POPOV, E. S., VOLOBUEV, S. V. (2014): New data on woodinhabiting macromycetes in key protected areas of the south-western part of the non-chernozem zone. *Mikologiya i Fitopatologiya*, 48(4): 229-237. (In Russian with English summary).

POPOV, E. S., CHESNOKOV, S. V., KONOREVA, L. A., EZHKIN, A. K., STEPANCHIKOVA, I. S., KUZNETSOVA, E. S., HIMELBRANT, D. E., GALANINA, I. A. and TCHABANENKO, S. I. (2020): *Stictis* s.l. (Ostropales, Ascomycota) in the Russian Far East. *Botanica Pacifica*, 9(2): 95-102.

RODWAY, L. (1924): Tasmanian Discomycetes. *Proceedings of the Royal Society of Tasmania*, 119: 90-122.

SEMENOVA, T. A., MORGADO, L. N., WELKER, J. M., WALKER, M. D., SMETS, E. and GEML, J. (2015): Long-term experimental warming alters community composition of ascomycetes in Alaskan moist and dry arctic tundra. *Molecular Ecology*, 24(2): 424-437.

SHERWOOD, M. A. (1977): The ostropalean fungi. *Mycotaxon*, 5: 1-277.

SIRKO, A. V. (1976): New and interesting species of ascomycetes in the flora of Urals. Discomycetes. *Novosti Sistematiki Nizshikh Rastenii*, 13: 120-126. (In Russian).

SMITH, C. W., APTROOT, A., COPPINS, B. J., FLETCHER, A., GILBERT, O. L., JAMES, P. W. and WOLSELEY, P. A. (2009): The lichen flora of Great Britain and Ireland. British Lichen Society, London, 1046 p.

SUMMERHAYES, V. S., ELTON, C. S. (1928): Further contributions to the ecology of Spitsbergen. *Journal of Ecology*, 16: 193-268.

URBANAVICHENE, I. N. (2011): First data on lichens of Zyuratkul national park (Chelyabinsk Region). *Novosti Sistematiki Nizshikh Rastenii*, 45: 223-236. (In Russian with English summary).

URBANAVICHENE, I. N., URBANAVICHUS, G. P. (2014): Contribution to the lichen flora of the Achipse River valley(SW Caucasus, Krasnodarsky Kray). *Novosti Sistematiki Nizshikh Rastenii*, 48: 315-326. (In Russian with English summary).

VAASMA, M., KALAMEES, K. A. and RAITVIYR, A. (1986): Macromycetes of the caucasian state reserve. Valgus, Tallin. (In Russian).

VASIL'EVA, L. N. (1939): Fungi of the Caucasian reserve. *Uchyonye Zapiski Kazanskogo Gosudarstvennogo Universiteta Imeni V.I. Ul'yanova-Lenina*, 99(1): 1-66. (In Russian).

WEDIN, M., DÖRING, H. and GILENSTAM, G. (2004): Saprotrophy and lichenization as options for the same fungal species on different substrata: environmental plasticity and fungal lifestyles in the *Stictis-Conotrema* complex. *The New Phytologist*, 164: 459-465.

WEDIN, M., DÖRING, H. and GILENSTAM, G. (2006): *Stictis* s. lat. (Ostropales, Ascomycota) in northern Scandinavia, with a key and notes on morphological variation in relation to lifestyle. *Mycological Research*, 110: 773-789.

WEINMANN, J. A. (1828): Enumeratio Fungorum in agro Pawlowskiensi praecipue crescentium. *Sylloge plantarum Novarum itemque minus cognitarum*, 2: 82-118.

WESTBERG, M., MOBERG, R., MYRDAL, M., NORDIN, A. and EKMAN, S. (2021): Santesson′s checklist of Fennoscandian lichen-forming and lichenicolous fungi. Uppsala, 933 p.

Web sources / Other sources

[1] 'TopoSvalbard' (https://toposvalbard.npolar.no/)