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ORIGINAL PAPER

New occurrences of the rare fungus *Boreostereum radiatum* in Poland

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ABSTRACT

Boreostereum radiatum (Gloeophyllales, Basidiomycota) is a saprobic fungus that causes decay of coarse fallen wood in forests and has remarkable effused-reflexed basidiocarps with a folded, ochraceous brown hymenial surface. It was identified and published for the first time in Poland in 1971 and was known only to grow in the primeval forests of the Białowieża National Park (BNP). In this paper the previously known Polish locations of *B. radiatum* are inventoried and new locations are described. During route-based field studies in the northeast part of Poland from 2006--2022, 29 locations of *B. radiatum* were found with 23 of them concentrated in an area of about 25 km^2 in the BNP, 5 discovered in the Hajnówka Forest District of the Białowieża Forest, and one found in the Antoniuk Nature Reserve near the city of Białystok. The habitats outside of the BNP were classified as old-growth and not primeval forests. In Poland this fungus is mostly associated with *Tilio-Carpinetum* and large, decorticated logs of *Picea abies* on the ground. The appearance of the new locations may be associated with the mass die-off of old *P. abies* trees as a consequence of climate change and bark beetle outbreaks. The presence of *B. radiatum* basidiomata in contact or proximity to eight other aphyllophoroid fungi, in particular *Rhodofomes roseus* and *Trichaptum abietinum*, was recorded. Global distribution and host/substratum data for *B. radiatum* are described. In the North American part of its range it occurs on various coniferous but rarely angiosperm trees, whereas in the Asian part of its range it often colonizes angiosperm wood. Further, a number of recordings of this species in North America have been made on processed (structural) and charred wood. Prior Western European locations of this fungus are in Germany and Czechia, but the recently confirmed ones are only in northeast Poland. A single location is known in the Belarusian part of the Białowieża Forest. This fungus deserves attention as an object of conservation due to its disjunct, circumboreal natural range and strict ecological preferences.

KEY WORDS

aphyllophoroid fungi, Białowieża National Park, biogeography, *Picea abies*, wood decay

Introduction

Boreostereum radiatum (Peck) Parmasto is a wood-inhabiting fungus with conspicuous, coriaceous basidiomata about 1 mm thick that can reach 10 cm or more in length. It has a characteristic matted,

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undulating or folded hymenial surface with a yellowish-brown, cinnamon with orange or ochraceous tint. Its role in forest ecosystems is to decompose large tree logs along with other organisms related to succession on coarse woody debris.

Earlier *B. radiatum* was classified in an artificial group of stereoid fungi, but today it belongs to the natural lineage of gloeophylloid fungi in the phylum Basidiomycota (Gloeophyllaceae, Gloeophyllales; Larsson, 2007). It is one of four species accepted in the genus *Boreostereum* Parmasto (Index Fungorum, 2023).

Boreostereum radiatum is a rare species in Europe and has been published for the territory of Poland in a number of sources from 1971 to 2020 (Jahn, 1971; Gorczak *et al*., 2020). Due to its peculiar geography and ecology, it was included in a red list of Polish endangered (E) fungi classified as belonging to species threatened with extinction and whose survival is unlikely if the factors causing its potential extinction continue to be present (Wojewoda and Ławrynowicz, 2006). All observations of this fungus in Poland have originated from a comparatively small area in the Białowieża National Park (BNP) which is a part of the Białowieża Primeval Forest (BPF). The latter is one of the best-preserved natural lowland forests in Europe, a UNESCO cross-border Biosphere Reserve, a UNESCO World Heritage Site, and has been included in the European Natura 2000 network program. The BPF is known for its species richness and is considered a remarkable European biodiversity hotspot which makes it a desirable place to study factors affecting biological diversity (Okołów *et al*., 2009; Kujawa *et al*., 2017, 2018). The BPF is one of the most mycologically valuable areas in Europe as well as one of the most studied European woodlands with respect to fungi. Within its area there is the greatest diversity of fungi in Poland with over 3650 non-lichenized species (Ruszkiewicz-Michalska *et al*., 2021). Over 40% of the Polish macromycobiota species are found here. Among the recorded species of macrofungi over 50% are the taxa of special attention including over 200 species with locations known in Poland only within the Białowieża Forest (Kujawa and Szczepkowski, 2022).

In this paper we describe the new locations of *B. radiatum* in Poland, put on map the previously known locations within the BNP, and analyze the global distribution of this species.

Materials and methods

The locations of the fungus were found during conventional route-based searches for wood-inhabiting macrofungi in northeastern Poland in field seasons from 2006-2022 (M. Wołkowycki) and 2009-2018 (A. Szczepkowski). Forest communities were identified and named according to Matuszkiewicz *et al*. (2012). The composition of the tree stands was described by taking into account the share [%] of each tree species in the total volume of the living trunks. The codes for forest compartments (abbreviated as 'comp.') and plots within them follow those of the Polish Forest Databank (Bank Danych o Lasach, Mapa podstawowa; https://www.lasy.gov.pl/pl/nasze-lasy/mapa-lasow). The nomenclature of fungi follows that of the Index Fungorum (2023). Reference specimens were deposited in the BLS (Białystok University of Technology) herbarium (this acronym and those mentioned in the 'Discussion' follow Thiers, 2023) and the fungarium of the Department of Forest Protection of the Warsaw University of Life Sciences – SGGW (WAML). Micromorphology was studied from both freshly collected and dried specimens. For identification, thin cuts from basidiomata (especially from the hymenium layer) were made manually with a razor blade, prepared as microscopic slides in 3% aqueous KOH, and examined at magnifications ×400 and ×1000 under a light microscope.

For analysis of the global distribution of *B. radiatum*, besides the usual publications, online resources Global Biodiversity Information Facility (GBIF; https://www.gbif.org) and Mycology Collections Portal (MyCoPortal; https://www.mycoportal.org/portal/collections/index.php) were used.

Results and Discussion

The basidiocarps of *Boreostereum radiatum* that were found fit the morphological characteristics of this species (Chamuris, 1988; Bernicchia and Gorjón, 2010; Larsson and Ryvarden, 2021). During younger stages basidiomata had more pronounced (Fig. 1) or less pronounced (Fig. 2) radially plicate relief of the hymenial surface. The basidiomata shape varied from resupinate with slightly free margins (Fig. 1, 2) to effused-reflexed and narrowly semipileate, semi-flabelliform, or almost imbricate with the pileus up to 15 mm wide (Fig. 3). These shapes depended on basidiomata age and substratum position. Younger basidiocarps often produced yellow-brown droplets of exudates on the hymenial surface and had traces of confluence between the primarily orbicular basidiomata (Fig. 1, 2). Black or dark brown portions of subiculum and abhymenial surfaces were exposed at margins of old or partly destroyed basidiomata (Fig. 3). Some basidiocarps after several periods of growth reached a thickness of 5 mm. In vertical microscopic sections, the basidiomata demonstrated a clearly stratified structure with the hyphae covered by brown incrustation with the latter turning greenish and bluish in 3% aqueous KOH (Fig. 4). The hymenial layer in this fungus consists mostly of acute or subacute sterile elements (cystidioles or hyphidia) and often lacks basidia, *i.e.* the basidiocarps are temporarily sterile. Pigmented incrustation of the hymenial elements provide the peculiar ochraceous brown colour of the hymenial surface. Spores were mid-sized, 5.5-10.5 µm long in our specimens.

Boreostereum radiatum has previously been observed several times in Poland in the area of the BNP which is a special strictly preserved core part of the primeval Białowieża Forest. Consequently, the first recording in Poland identifying *B. radiatum* was done in this forest by S. Domański in 1959 (Domański, 1991). The occurrence of *B. radiatum* in the Białowieża Forest was also reported by Jahn (1971), Wojewoda (2003), Okołów *et al.* (2009). According to Karasiński (2014), all Polish locations of *B. radiatum* were found in BNP.

The locations of this fungus were listed in an unpublished manuscript 'Plan ochrony Białowieskiego Parku Narodowego. Operat ochrony gatunków grzybów' created by D. Karasiński, A. Kujawa, A. Szczepkowski, and M. Wołkowycki in 2010. A total of 23 locations were counted in the BNP which are restricted to its central, southern, and south-eastern parts (Fig. 9 III). These locations are situated on forest compartments 285Aj, 287Aa, 316Bf, 316Da, 318Cl, 318Dd, 319Ca, 319Ch, 319D, 345B, 346Aa, 346Dj, 370Cf, 373Ch, 374Cf, 374Cg, 374Dh, 375Ag, 375Bi, and 399Bg. Some of these locations were confirmed in reports from the XIV, XVI, XXIII, and XXIV exhibitions of fungi in Białowieża (Szczepkowski *et al.*, 2008, 2010; Gierczyk *et al.*, 2018, 2019). The following locations were recorded in GBIF: comp. 398Ca (J. Kinnunen, 2018), comp. No. 342A (D. Schigel, 2019), and a confirmed location in comp. 318Dd (J. Kinnunen, 2019). Two other GBIF records from the Polish part of the Białowieża Forest (http://id.luomus.fi/MY.3646733, collected by T. Niemelä, D. Schigel, 2009; http://id.luomus.fi/MY.3638207, collected by J. Kinnunen, T. Niemelä, D. Schigel, 2010) are not accompanied by detailed geographic data. The bioblitz of the 18th Congress of European Mycologists (Gorczak *et al.*, 2020) confirmed locations on plot No. 319Ca and in comp. 342A. In addition to the previously known locations, seven new ones were found as described below.

Location 1. Podlaskie voivodeship, Białystok Eminence, on the northern outskirts of the city of Białystok, Dojlidy Forest District, Antoniuk Nature Reserve, comp. 118a (Fig. 5, 6, 9 I); *Calamagrostio arundinaceae-Piceetum*, stand of *Pinus sylvestris* L. (50%; *ca* 130 years old), *Picea abies* (L.). Karst. (30%; *ca* 130 years), admixture of deciduous trees, and shrub layer dominated by *Corylus avellana* L.; on a log of *P. abies ca* 40 cm in diameter and 5 m long. The tree was most likely cut down for safety reasons because of a nearby forest road. The confluent basidiomata are about 80 cm long

and up to 20 cm wide growing on the lateral surface of the log together with basidiomata of *Fomitopsis pinicola* (Sw.) P. Karst. The forest island with this location is a historical fragment of the Knyszyńska Primeval Forest situated 3 km south of the edge of the main Knyszyńska Forest and separated from it by the valley of the Supraśl river. Reference specimen: BLS M-3982, collected by M. Wołkowycki, 6.10.2022.

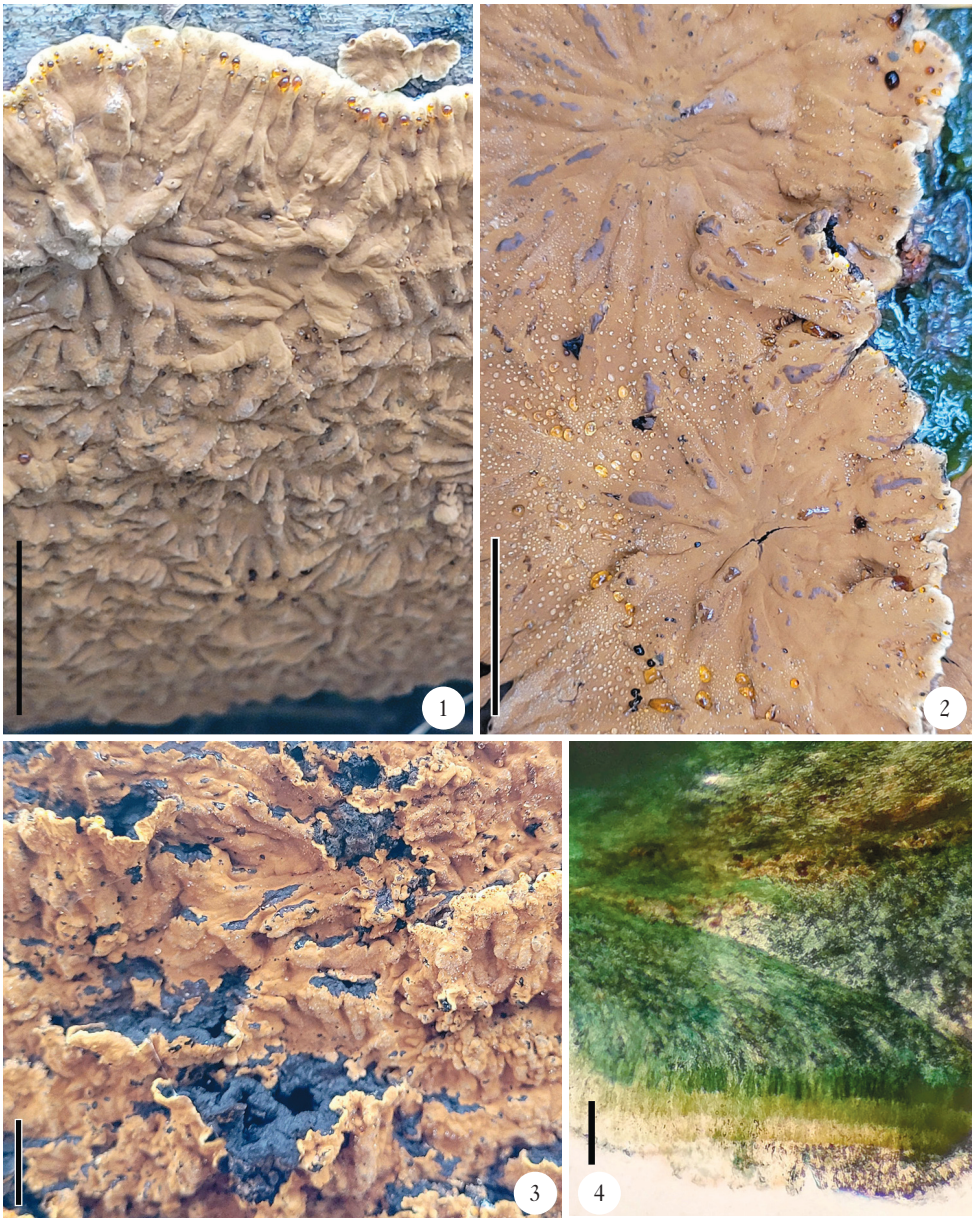

Fig. 1-4.

Morphology of *Boreostereum radiatum* basidiomata

1, 2. In location 1 (Antoniuk Nature Reserve). 3. In location 6 (BPF, Hajnówka Forest District, plot No. 466Ad; photos: M. Wołkowycki, 2022). 4. Vertical section of the basidioma prepared in 3% aqueous KOH, hymenium is below (BLS M-4781; photo: E. Yurchenko). Scale bars: 1 cm for 1-3; 100 µm for 4

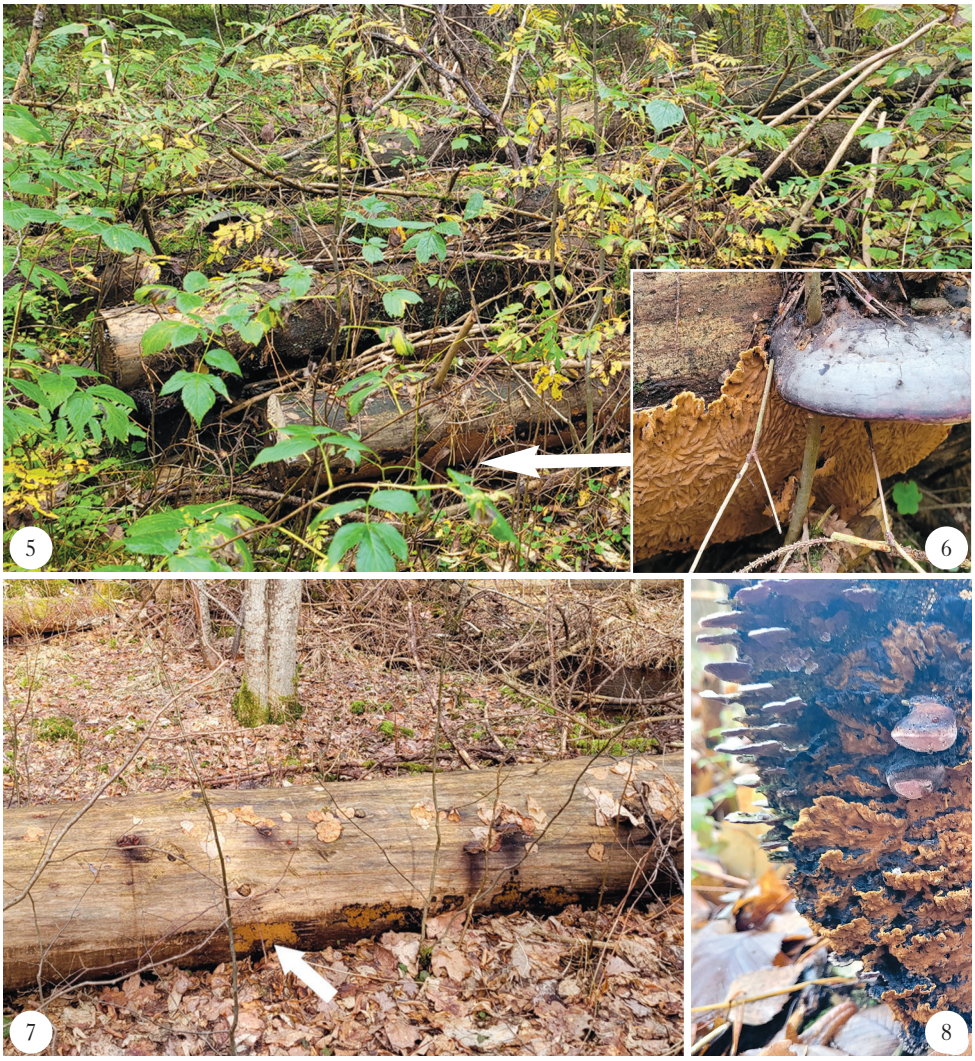

Fig. 5-8.

Boreostereum radiatum in situ

5. General view of the habitat in location 1, Antoniuk Nature Reserve. 6. Part of a spruce log with *B. radiatum* and *Fomitopsis pinicola* basidioma in Antoniuk. 7. General view of the habitat in location 5, BPF, Hajnówka Forest District, plot No. 465Cc. 8. Fructifications of *B. radiatum*, *Rhodofomes roseus* and *Trichaptum abietinum* on a spruce log in location 6, Białowieża Forest, Hajnówka Forest District, plot No. 466Ad. The basidiomata of *B. radiatum* are marked with arrows. Photos: 5, 6, 8 – M. Wołkowycki, 2022; 7 – M. Wołkowycki, 2023

Locations 2-6 are mapped on Fig. 9 (II).

Location 2. Podlaskie voivodeship, Bielsk Plain, BPF, Hajnówka Forest District, comp. 333C, *Tilio-Carpinetum*, on *P. abies* wood. Reference specimen: BLS M-4315, collected by M. Wołkowycki, 23.09.2020.

Location 3. BPF, Hajnówka Forest District, comp. 440B, *Tilio-Carpinetum*, on *P. abies* wood. Reference specimen: BLS M-2991, collected by M. Wołkowycki, 5.03.2020.

Location 4. BPF, Hajnówka Forest District, comp. 440Da; *Tilio-Carpinetum stachyetosum*, stand of *Quercus robur* L. (20%, *ca* 220 years old), *Carpinus betulus* L. (30%, *ca* 150 years; 20%, *ca* 60 years), and *Acer platanoides* L. (20%, *ca* 150 years); on log of *P. abies ca* 100 cm in diameter and

ca 30 m long, resupinate basidioma 10×10 cm is on the top of the log and several semi-pileate basidiocarps on the upper surface of the log together with *Gloeophyllum abietinum* (Bull.) P. Karst. and *Neoantrodia serialis* (Fr.) Audet fructifications. In the past, the stand had a high proportion of spruce (30%, *ca* 150 years), but at present all the spruce is dead as a result of bark beetle damage. The host spruce was cut down for safety reasons because of a nearby forest road. Reference specimen: BLS M-4780, collected by M. Wołkowycki, 11.11.2022.

Location 5. BPF, Hajnówka Forest District, comp. 465Cc (Fig. 8); *Tilio-Carpinetum circaetosum alpinae*, stand of *Alnus glutinosa* (L.) Gaertn. (20%, *ca* 100 years old) and *C. betulus* (20%, *ca* 80 years); on log of *P. abies ca* 50 cm in diameter and *ca* 10 m long; confluent basidiomata 60×20 cm, growing on the lateral surface of the log together with basidiocarps of *Rhodofomes roseus* (Alb. & Schwein.) Kotl. & Pouzar and *Hermanssonia centrifuga* (P. Karst.) Zmitr. Prior the forest stand was dominated by *P. abies* (30%, 100 years) and *Fraxinus excelsior* L. (20%, 100 years). At present, all the spruce is dead as a result of bark beetle damage, and the ash is dead as supposedly a result of infection by the fungus *Hymenoscyphus fraxineus* (T. Kowalski) Baral, Queloz & Hosoya. Reference specimens: BLS M-4280, coll. M. Wołkowycki, 15.09.2022; BLS M-4781, collected by M. Wołkowycki, 11.11.2022.

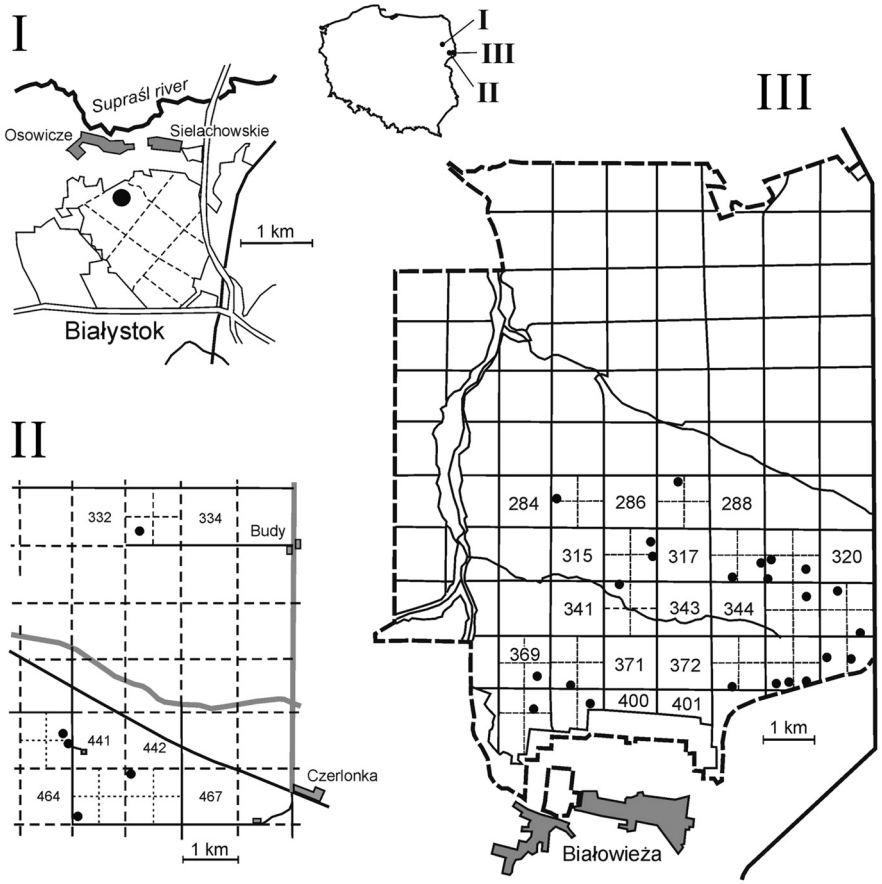

Fig. 9.

Distribution of *Boreostereum radiatum* in Poland

I – near Białystok; II – in the central-western part of the Białowieża Forest, III – in the Białowieża National Park. Locations are marked with black circles

Location 6. BPF, Hajnówka Forest District, comp. 466Ad; *Tilio-Carpinetum typicum*, stand of *Q. robur* (30%, *ca* 120 years old) and *C. betulus* (30%, *ca* 130 years; 20%, *ca* 80 years), the whole spruce died as a result of bark beetle damage; on log of *P. abies ca* 40 cm in diameter and *ca* 20 m long, basidioma on 20 cm diameter head of the log together with *Rhodofomes roseus* and *Trichaptum abietinum* (Pers. ex J.F. Gmel.) Ryvarden. The host tree was cut down for safety reasons because of a nearby forest road. Reference specimen: BLS M-5555, collected by M. Wołkowycki, 12.04.2023.

Location 7. BNP, comp. 369G (Fig. 9 III); *Tilio-Carpinetum*, on log of *P. abies*, together with *Rhodofomes roseus* and *Osteina undosa* (Peck) Zmitr. Reference specimen: WAML 1163, collected by A. Szczepkowski, 12.09.2018.

Other locations that were recorded in 2006-2009 were within the BNP (Fig. 9 III). Reference specimens: BLS M-0123, comp. 285Aj, *Tilio-Carpinetum*, on *P. abies* wood, collected by M. Wołkowycki, 20.07.2009; BLS M-3588, comp. 374C, *Tilio-Carpinetum*, on *P. abies* wood, collected by M. Wołkowycki, 25.10.2006; WAML 1159, comp. 375B, *Tilio-Carpinetum*, on log of *P. abies* together with *Rhodofomes roseus*, collected by A. Szczepkowski, 27.07.2009; WAML 1160, comp. 375A, *Tilio-Carpinetum*, on log of *P. abies*, collected by A. Szczepkowski, 15.09.2009; WAML 1161, comp. 319D, *Tilio-Carpinetum*, on log of *P. abies* together with *Trichaptum abietinum* and *Rh. roseus*, collected by A. Szczepkowski, 16.09.2009; WAML 1162, comp. 345B, on log of *P. abies* together with *Amylocystis lapponica* (Romell) Bondartsev & Singer and *Rh. roseus*, collected by A. Szczepkowski, 16.09.2009.

All specimens from recorded observations in Poland grew on *Picea abies* logs with fructifications appearing both on the lateral surface of the logs and on the surface of their transverse cuts. Thus, the logs originate from natural windfall and cutting. Domański (1991) also observed this species on *Pinus sylvestris* logs. From the data above it has been observed that *B. radiatum* in Poland is confined to *Tilio-Carpinetum* with one exception found in *Calamagrostio arundinaceae-Piceetum*. Fructifications of *B. radiatum* were observed in contact or in close proximity with basidiomata of the following eight wood-decay fungi: *Amylocystis lapponica*, *Fomitopsis pinicola*, *Gloeophyllum abietinum*, *Hermanssonia centrifuga*, *Neoantrodia serialis*, *Osteina undosa*, *Rhodofomes roseus*, and *Trichaptum abietinum*.

The basidiomata of this species are described as annual (Bernicchia and Gorjón, 2010). However, observation were made by us on portions of new growth in spring on the basidiocarps developed from the previous year which would suggest they are often hibernating. Despite the fungus being confined to old and shady forests, hymenium with abundant hyphidia is considered to be an adaptation to drought (Larsson and Ryvarden, 2021). Due to a lack of clamp connections, *B. radiatum* is a presumed homothallic organism (Boidin and Lanquetin, 1984), *i.e.* its basidiomata originate from a single sexual spore.

According to our observations *B. radiatum* provokes white rot on spruce. In earlier studies the type of rot caused by *B. radiatum* was suggested as white (Martin and Gilbertson, 1980; Ginns, 1986; Domański, 1988, 1991) or brown (Larsson, 2007). Chamuris (1988) noted that white rot and distinct brown cubic rot were observed under basidiomata in different locations.

Boreostereum radiatum has been reported in Poland only in primeval forests (Wojewoda, 2003). According to the definition a primeval forest is 'a large-scale forest ecosystem for which no direct human interventions are known and the composition of the natural biotic communities and the forest-typical processes have never been significantly altered' (Luick *et al.*, 2021). The ecosystems of the BNP correspond to this definition (*e.g.* Keczyński, 2017). However, location 1 near Białystok is not in a primeval forest, but a forest that was routinely under management

until the establishment of the Antoniuk Nature Reserve in 1995. Locations 3, 5, 6 are situated in the parts of the Białowieża Forest classified as productive or managed forests. Concurrently, locations 2 and 4 belong to local reserves classified as 'natural forests' (Sokołowski, 2004). We assume that the population of *B. radiatum* in the Białowieża Forest outside the BNP progressed due to the mass death and windfall events of *P. abies* which produced more substratum with colonization of the latter being only possible in adequately shady habitats such as *Tilio-Carpinetum*.

In order to determine the position of the Polish locations within the whole natural range of *B. radiatum*, available data was considered of all its locations on a global scale. The species is known in Canada, mainland USA, Germany, Czechia, Latvia, Belarus, Georgia, Russia, China, and Japan. There are questionable records from Mexico (Mexico City; specimen BPI 1100605; MyCoPortal data) and from southern Brazil (specimen in PACA, collected by J. Rick, 1930 – GBIF data; specimen BPI 274973, collected by J. Rick, 1931 – MyCoPortal data).

In North America the species occurs in temperate Canada from British Columbia to Quebec. In the USA most of locations that known are in the northeast such as the Appalachian Mountains and around the Great Lakes. The fungus rarely occurs in the Rocky Mountains and the westernmost locations are in Arizona and Washington (Lentz, 1955; Chamuris, 1988; Ginns and Lefebvre, 1993).

In Western Europe there was a single very old record from Saxony in Germany in the Ore Mountains near the Czech border (specimen in ISC, No. F-0132576, collected by W. Krieger, 1884). According to Larrson and Ryvarden (2021), the fungus occurs in the northern Carpathian Mountains. However, it is not known from Polish part of Carpathians, and as far back as 2006 it was assumed that *B. radiatum* was extinct in Czechia (Holec and Beran, 2006). A single location has been documented in Belarus in the Belavezhskaya Pushcha Forest about 1.5 km to the east of Lyatskiya khutor (collected by H. Kotiranta, 2016, identified by V. Spirin; GBIF data, occurrence id.luomus.fi/MY.5942220).

The locations in the Caucasus region are found in Georgia as well as the Russian side (Ghobad-Nejhad, 2011). According to GBIF data, there are 35 locations of *B. radiatum* in Russia with sufficient information to indicate the natural region of occurrence. There are 12 locations in the Eastern European Plain, four in the Western Siberian Plain, one in Altai, one in Middle Siberia, six in the Lower Amur region, nine in the Sikhote-Alin Mountains and other areas of Primorye, and two in Kamchatka. The species has also been reported in northeastern Siberia (Davydkina, 1980). In northern Eurasia the species occurs in a latitudinal range from the zone of boreo-nemoral forests (sub-taiga) to the zone of northern taiga with the northernmost location at 64°N.

The records in east and southeastern Asia are in China (Dai, 2011) and Japan (Maekawa, 2021). The locations in China are in the Tibetan part of Yunnan Province (specimen in MB, collected by F. Popa, 2014; occurrence HILIFE_FUNGI_OCC_ICIMOD_0328; GBIF data). The records from Zhejiang Province in eastern China (specimens in BPI and CUP, coll. S.C. Teng, 1940; MyCoPortal data) indicating the presence of *B. radiatum* are questionable.

Thus, *B. radiatum* has been found to occur in temperate climates and has a circumboreal (panboreal) natural range, but parts of its range are significantly disconnected. According to Ghobad-Nejhad *et al.* (2012), the range type of this species is putatively disjunct. The genus *Boreostereum*, based on four species, has cosmopolitan distribution.

According to the data from all parts of the fungus' range, the species is obligatory saprobic. In North America it usually grows on decorticated coniferous wood of *Picea*, *Pinus*, *Tsuga*, *Larix*, *Thuja*, and more rarely on angiosperms such as *Malus* and *Populus* (Chamuris, 1988; Nakasone,

1990; Ginns and Lefebvre, 1993). Further, it has been known to occur on this continent on various processed wood types such as boards in greenhouses, cellar doors, planks, shed beams, other structural timbers originating from gymnosperms, and on charred wood (Lentz, 1955; Chamuris, 1988; Ginns and Lefebvre, 1993). In Asia it is known to occur on *Picea* and angiosperms such as *Populus*, *Fraxinus*, *Quercus*, and *Salix* (Davydkina, 1980; Li and Azbukina, 2011). One further host is *Alnus* in the Caucasus region (Ghobad-Nejhad, 2011).

Basidiomycetes are well known to be producers of biologically active metabolites with a high application potential. A species of the genus *Boreostereum*, *B. virbans* (Berk. & M.A. Curtis) Davydkina & Bondartseva, has been studied for the presence of such metabolites (Liu *et al.*, 2006). One of the discovered compounds, vibrolactone, was considered to be a drug candidate for the treatment of obesity (Zhao *et al.*, 2013). Consequently, *B. radiatum* deserves similar studies on its biochemical potential.

Conclusions

- The known distribution of *B. radiatum* in Poland is very uneven: 23 of the 29 known locations are restricted to an area of about 25 km^2 with one location outside the Białowieża Forest about 70 km further away.
- The appearance of new locations of *B. radiatum* in northeastern Poland in recent years may be associated with the weakening of the health and mass death of *Picea abies* under the pressure of unfavourable biotic and abiotic factors – climate changes and *Ips typographus* (L.) outbreaks – that produce a large amount of coarse dead spruce wood which is the main substratum in Poland for this rare, boreal-montane fungus.
- In Poland the fungus has strict substratum preferences that include growth on decorticated parts of large *P. abies* logs lying on the ground in the middle stages of decay and less frequently on *Pinus sylvestris*. At the same time in the western part of the natural range this fungus grows on various coniferous species but seldom on angiosperms as well as on charred and structural wood. In the Asian part of its range, it occurs on various angiosperm trees.
- The fungus deserves attention as an object of conservation due to its disjunct natural range (with the recently confirmed Western European locations only in Poland), strict ecological preferences, and the presumed potential as a source of bioactive secondary metabolites.

Authors' contributions

E.Y. – research concept, revision of collections, literature survey, geography study, first version and final formatting of the MS, preparation of colour plates and schematic maps; M.W. – research concept, field studies, identification of specimens, photographs, contribution to the text; A.S. – field studies, identification of specimens, contribution to the text, Polish abstract; E.Z. – contribution to the text.

Conflict of interests

The authors declare no conflicts of interest.

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STRESZCZENIE

Nowe wystąpienia rzadkiego grzyba *Boreostereum radiatum* w Polsce

Puszcza Białowieska (PB), a w szczególności Białowieski Park Narodowy (BPN), stanowi jeden z najcenniejszych obszarów mykologicznych nie tylko w Polsce, ale i w Europie. Na terenie PB występuje największa w Polsce różnorodność taksonów grzybów (ponad 3650, bez porostów) (Ruszkiewicz-Michalska i in. 2021). Jednym z gatunków, który dotychczas był notowany wyłącznie w PB, a dokładniej w granicach BPN, jest *Boreostereum radiatum* (Peck) Parmasto (ciemnoskórnik północny). Gatunek ten został wpisany na Czerwoną listę grzybów wielkoowocnikowych Polski w kategorii zagrożenia – wymierające (E), czyli zagrożony wymarciem, którego przeżycie jest mało prawdopodobne, jeśli nadal będą działać czynniki zagrożenia (Wojewoda i Ławrynowicz 2006). Ogólny zasięg tego gatunku charakteryzuje rozproszone występowanie na północnej półkuli. W Europie znany jest z nielicznych lokalizacji. Po raz pierwszy w BPN grzyb został stwierdzony w 1959 r. przez Stanisława Domańskiego, profesora nauk leśnych, wybitnego mykologa specjalizującego się w grupie grzybów afylloforoidalnych. W latach 2006-2022 stwierdzono występowanie tego gatunku w oddziale 369G, niepodawane dotychczas z BPN, oraz po raz pierwszy wykazano lokalizacje poza granicami BPN, w Nadleśnictwie Hajnówka: oddziały 333C, 440B, 440Da, 465Cc

(ryc. 4, 7), 466Ad (ryc. 3, 8), i jedno stanowisko poza obszarem PB, w pobliżu Białegostoku, w rezerwacie przyrody Antoniuk położonym na terenie Nadleśnictwa Dojlidy (ryc. 1, 2, 5, 6). Rezerwat Antoniuk uznawany jest za pozostałość historycznej Puszczy Knyszyńskiej. Na odnalezionych stanowiskach owocniki *B. radiatum* wyrastały na bocznej powierzchni pni leżących świerków, a także na czołach strzał. Stwierdzono współwystępowanie owocników *B. radiatum* z następującymi gatunkami grzybów makroskopowych: *Amylocystis lapponica*, *Fomitopsis pinicola* (ryc. 6), *Gloeophyllum abietinum*, *Hermanssonia centrifuga*, *Neoantrodia serialis*, *Osteina undosa*, *Rhodofomes roseus* (ryc. 8) i *Trichaptum abietinum* (ryc. 8). Większość polskich stanowisk tego grzyba zlokalizowano w grądach *Tilio-Carpinetum* z udziałem *Picea abies*. *Boreostereum radiatum*, jako obligatoryjny saprotrof, zasiedlał głównie grubowymiarowe drewno *P. abies* oraz, według Domańskiego (1991), sporadycznie *Pinus sylvestris*. W innych obszarach występowania (Ameryka Północna, Azja) obserwowany był na różnych gatunkach drzew, zarówno iglastych (*Larix*, *Picea*, *Pinus*, *Thuja*, *Tsuga*), jak i liściastych (*Alnus*, *Fraxinus*, *Malus*, *Populus*, *Salix*, *Quercus*) oraz na drewnie spalonym i konstrukcyjnym. Na podstawie danych z literatury i badań własnych ustalono, że gatunek ten ma w Polsce 29 stanowisk, w tym 23 w BPN (ryc. 9). Polskie stanowiska *B. radiatum* są jedynymi niedawno potwierdzonymi w zachodniej części europejskiego zasięgu występowania tego gatunku. Odkrycie w ostatnich latach nowych stanowisk *B. radiatum* w północno-wschodniej Polsce może być związane z osłabieniem stanu zdrowotnego świerka (zmiany klimatyczne, gradacja kornika drukarza) i wydzielaniem się dużej ilości grubowymiarowego drewna świerkowego, które stanowi główny substrat dla tego rzadkiego, borealno-górskiego gatunku grzyba.