Marcin Pietras

The field of natural sciences

The discipline of ***Biological sciences***

Occurrence of alien non-pathogenic fungi classified in the Boletales and Phallales orders

SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS

Department of Biogeography and Systematics
Institute of Dendrology Polish Academy of Sciences
in Kórnik

1. NAME: Marcin Pietras

2. DIPLOMAS, DEGREES CONFERRED IN SPECIFIC AREAS OF SCIENCE OR ARTS, INCLUDING THE NAME OF THE INSTITUTION WHICH CONFERRED THE DEGREE, YEAR OF DEGREE CONFERMENT, TITLE OF THE PHD DISSERTATION.

2013, Kórnik	PhD in Biological Sciences in the field of Biology obtained at the Institute of Dendrology Polish Academy of Sciences in Kórnik. My doctoral dissertation is entitled: „Ectomycorrhizal community composition of oaks on Krotoszyńskie Forests area"; supervisor: prof. dr hab. Maria Rudawska, Institute of Dendrology Polish Academy of Sciences in Kórnik.
2008, Poznań	MSc in Forestry; Faculty of Forestry, Poznań University of Life Sciences. My thesis is entitled „Morphological and molecular structure of ectomycorrhizal fungi on oak seedling from bare-root forest nurseries"; supervisor: prof. Maria Rudawska, Institute of Dendrology Polish Academy of Sciences in Kórnik.
2003, Tuchola	Forest Technical Secondary School in Tuchola. Diploma of obtaining the title: forestry technician

3. INFORMATION ON EMPLOYMENT IN RESEARCH INSTITUTES OR FACULTIES/DEPARTMENTS OR SCHOOL OF ARTS:

from 1. Jan 2021	Head of Department of Biogeography and Systematics, Institute of Dendrology Polish Academy of Sciences in Kórnik
from 1. Nov 2018	Laboratory of Symbiotic Associations, Institute of Dendrology Polish Academy of Sciences in Kórnik, Assistant professor
1. Oct 2015- 30. Sep 2018	Department of Systematics and Nature Conservation, Faculty of Biology, University of Gdansk; Assistant professor
18.Aug 2012-31.Oct 2018	Laboratory of Symbiotic Associations, Institute of Dendrology Polish Academy of Sciences in Kórnik, Biologist (between 1 Oct 2015 and 30 Sep 2018 on unpaid leave related to obtained postdoctoral fellowship at the Department of Plant Taxonomy and Nature Conservation at the University of Gdansk)

4. DESCRIPTION OF THE ACHIEVEMENTS, SET OUT IN ART. 219 PARA 1 POINT 2 OF THE ACT:

A. The title of the scientific achievement:

Occurrence of alien non-pathogenic fungi classified in the Boletales and Phallales orders

B. The publications included in the scientific achievement:

LP	Publication	**MNiSW** points	**IF$_{2\ years}$**
H1	**Pietras M.,** Rudawska M., Iszkuło G., Kujawa A., Leski T. 2016. Distribution and molecular characterization of an alien fungus, *Clathrus archeri*, in Poland. Polish Journal of Environmental Studies 25: 1197-1204. https://doi.org/10.15244/pjoes/61230	20*	0,793
	My author's contribution included: development of the research concept, collection of materials for field research and searching for information on the occurrence of *C. archeri* based on the query of herbarium specimens deposited in Polish herbariums, conducting molecular analyzes with reporting the obtained ITS and LSU sequences to the NCBI database, preparation of the final version of the text, the practice of figures and tables, preparing most of the responses to reviews.		
H2	**Pietras M**., Litkowiec M., Gołębiewska J. 2018. Current and potential distribution of the ectomycorrhizal fungus *Suillus lakei* ((Murrill) A.H. Sm. & Thiers) in its invasion range. Mycorrhiza 28: 467–475. https://doi.org/10.1007/s00572-018-0836-x	35*	3,114
	My contribution included: development of the research concept, collection of materials for field research and searching for information on the occurrence of *S. lakei* based on the query of herbarium specimens deposited in herbaria around the world, preparation of a database presenting the occurrence of the *Suillus lakei* fungus in the world based on open databases (GBIF, MycoPortal), conducting molecular analyzes of the collected fruiting bodies and mycorrhizae along with submitting the obtained ITS sequences to the NCBI database, modeling the range of the climatic niche of *S. lakei* and Douglas fir, preparation of the final version of the text, preparation of the figures and tables, preparing responses to reviews.		
H3	**Pietras M**., Kolanowska M. 2019. Predicted potential occurrence of the North American false truffle *Rhizopogon salebrosus* in Europe. Fungal Ecology 9: 225-230. https://doi.org/10.1016/j.funeco.2018.12.002	100**	2,656
	My contribution included: development of the research concept, collection of materials for field research and research on the occurrence of *R. salebrosus* based on the query of herbarium specimens deposited in herbariums around the world, preparation of a database presenting the occurrence of *R. salebrosus* in the world based on o open databases (GBIF, MycoPortal) and databases of tree records with which this fungus can enter into mycotic symbiosis, conducting molecular analyzes together with submitting the ITS sequence obtained to the NCBI database, modeling the extent of the climatic niche of the fungus, preparing the final version of the text, preparing of figures, preparation of responses to reviews.		
H4	**Pietras. M**. 2019. First record of North American fungus *Rhizopogon pseudoroseolus* in Australia and prediction of its occurrence based on climatic niche and symbiotic partner preferences. Mycorrhiza 29: 397–401. https://doi.org/10.1007/s00572-019-00899-x	100**	3,069

H5	**Pietras M**., Kolanowska M., Selosse M.-A. 2021. *Quo vadis*? Historical distribution and impact of climate change on the worldwide distribution of the Australasian fungus *Clathrus archeri* (Phallales, Basidiomycota). Mycological Progress 20:299–311. https://doi.org/10.1007/s11557-021-01669-w	70**	2,149
	My contribution included: development of the research concept, collection of materials for field research and searching for information on the presence of *C. archeri* based on a query of herbarium specimens deposited in herbariums around the world, preparation of a database presenting the occurrence of the fungus in the world based on an open database (GBIF, MycoPortal), modeling the extent of the climate niche of *C. archeri* in the past, present and future, preparing the final version of the text, preparing some graphic illustrations and tables, preparing responses to reviews.		

* Scoring on the basis of the list of the Minister of Science and Higher Education of January 25,2017
** Scoring on the basis of the list of the Minister of Science and Higher Education of February 9, 2021

Summarized 2 year Impact Factor of the scientific achievement (H1-H5): **11,781**

Summarized points of scientific achievement based on the lists of Ministry of Higher Education:

55 points (based on the list of the Minister of Science and Higher Education of January 25,2017)

and

270 points (based on the list of the Minister of Science and Higher Education of February 9, 2021)

C. Overview of the scientific achievement (H1-H5)

The presence of alien and invasive organisms is one of the main problems in nature conservation (Vitousek et al. 1996). Most biogeography studies focus on the introduction of various species of plants and animals, mainly economically important and pathogenic organisms (Desprez-Loustau et al. 2007). However, little is known about the spread of alien fungi, especially nonpathogenic taxa, beyond their natural range.

Due to their cryptic nature, fungi can exist for a long time in the form of a mycelium that overgrows the soil substrate without the regular appearance of ephemeral fruiting bodies. Therefore, one of the most significant gaps limiting research on the occurrence of alien species of nonpathogenic fungi is the low level of knowledge about species distributions on regional and continental scales (**Pietras** 2019, **Pietras** and Kolanowska 2019). This phenomenon is especially true for taxa that were accidentally or intentionally moved to new areas.

There are three possible scenarios for the introduction of fungi to new areas (**Pietras** 2017). In the first, the fungus is not associated with another organism, which means that the spread of the taxon does not require coexistence with, for example, symbiotic organisms. Among the studies on the introduction of nonpathogenic fungi, only a few examples describe this phenomenon comprehensively. These include studies describing the introduction of the saprotrophic fungus *Flavolashia colacera* to Europe (Vizzini et al. 2009) or the spread of an Australian fungus - *Clathrus archeri* - in Europe (Parent et al. 2000, **Pietras** et al. 2016, **Pietras** et al. 2021). Another scenario of fungal taxa introduction is observed in the case of symbiotic fungi that form an ectomycorrhizal symbiosis with a tree species. This phenomenon is called cointroduction (coinvasion; Dickie et al. 2010) and involves the simultaneous transfer of a plant partner - in this case, a tree that forms ectomycorrhizal symbiosis - along with a fungal symbiont. It is assumed that the cointroduction of trees and related symbiotic fungi is the most frequently observed scenario for the introduction of alien nonpathogenic fungi (Dickie et al. 2010). On the European scale, this process was observed in a symbiotic fungus belonging to the genus *Laccaria* (*L. fraterna;* Diez et al. 2005). Recent studies have shown that in the cointroduction of the tropical plant *Coccoloba uvifera* and the symbiotic fungus *Scleroderma bermudense*, no demographic events, such as bottleneck or genetic drift, were observed in the populations of the fungus introduced to new areas (Sane et al. 2018). A review paper published by Vellinga et al. (2009) revealed almost 200 species of ectomycorrhizal fungi beyond their natural range. Based on the cited article, Poland was a blank spot in the global introduction of alien species of symbiotic fungi. The Polish List of Alien Organisms at that time included 86 species of exotic fungi, of which only eight were nonpathogenic taxa (Solarz 2006). Compared to other European countries, with particular emphasis on neighboring countries, the number of records of alien species seems to be highly underestimated. The Polish list included only one species of ectomycorrhizal fungus, *Suillus placidus*. For comparison, in neighboring Germany, nine other North American taxa belonging to the genera *Suillus* and *Rhizopogon* were found (Vellinga et al. 2009). A third scenario for the introduction of alien symbiotic fungi is the spontaneous transfer of a taxon, which forms an ectomycorrhizal symbiosis with new tree species, usually closely related to those with which it occurs within its natural range. An example is *Aureoboletus projectellus*, which forms symbiotic relationships with several North American pines in its natural range. In Europe, it also occurs with pine species native to this continent: *Pinus sylvestris* and *P. mugo* (Banasiak, **Pietras**, et al. 2019a, 2019b). It is assumed that a small number of foreign fungi records are closely related to a small number (and often the lack) of publications from a given country (Vellinga et al. 2009). In Poland, apart from a review article published by Wojewoda and Karasiński (2010), no publications have detailed the appearance and spread of alien species of fungi. Therefore, at that time, Poland was a "blank page" on the world map showing the introduction of nonpathogenic fungi, which motivated me to study the occurrence of foreign species of fungi. Initially, my assumption was to focus on species that could potentially occur in Poland. However, the research went far beyond the borders of our country because these studies used materials from three continents and New Zealand.

I have used various methodological approaches in my research, from the classical taxonomy of fungi, and molecular biology methods, to tools for modelling the bioclimatic niche (ENM). In this report, the results describing these scientific achievements will be presented to reflect upon the methodological approaches adopted in the research.

The use of open databases and herbarium specimen records of fungi in studies of the biogeography of nonpathogenic alien fungi

- Pietras M., Litkowiec M., Gołębiewska J. 2018. Current and potential distribution of the ectomycorrhizal fungus *Suillus lakei* ((Murrill) A.H. Sm. & Thiers) in its invasion range. Mycorrhiza 28: 467–475.
- Pietras M., Kolanowska M. 2019. Predicted potential occurrence of the North American false truffle *Rhizopogon salebrosus* in Europe. Fungal Ecology 9: 225-230.
- Pietras. M. 2019. First record of North American fungus *Rhizopogon pseudoroseolus* in Australia and prediction of its occurrence based on climatic niche and symbiotic partner preferences. Mycorrhiza 29: 397–401.
- Pietras M., Kolanowska M., Selosse M.-A. 2021. Quo vadis? Historical distribution and impact of climate change on the worldwide distribution of the Australasian fungus Clathrus archeri (Phallales, Basidiomycota). Mycological Progress 20: 299–311.

In the time of the "global village", the constant development of new technologies and the concentration of life in social media, open databases provide an excellent opportunity for comprehensive mycological research (Heilmann - Clausen et al. 2016) and allow us to obtain information from many places on Earth (Andrew et al. 2018). This is of great importance when working with organisms that occur thousands of kilometers from the research site or are located over many continents. The research on fungi species that constitutes the scientific achievement presented in this paper comes from North America, Australia, and New Zealand. Using open databases such as the UNITE sequence database, MycoPortal, and the Global Biodiversity Information Facility was crucial for achieving the goals detailed in the articles presented above. In total, information on 312 records of studied fungi was gathered, including 146 locations of *Clathrus archeri* (**Pietras** et al. 2021), 166 records of suilloid fungi (**Pietras** and Kolanowska 2019, **Pietras** 2019), and 1,846 locations indicating the distribution of North American trees associated with analysed fungal taxa (**Pietras** et al. 2018, **Pietras** and Kolanowska 2019, **Pietras** 2019) . The information obtained in this way was verified, filtered, and analysed in terms of suitability for research.

An additional source of knowledge about the distribution of fungal analysed species was information associated with the herbarium specimens deposited in herbaria. In 2015-2018, as part of the FUGA project, I contacted 17 herbaria from North America, Europe, Australia, and New Zealand, which allowed me to collect 295 fungal vouchers donated or borrowed for the research. The information contained in the descriptions of most of the collections has been verified in terms of reliability, accuracy, and suitability for the conducted research.

Standardized biogeographic data obtained from open databases and thanks to the possibility of querying herbarium specimens from herbaria were used in studies on the occurrence of *Suillus lakei* (**Pietras** et al. 2018), *Clathrus archeri* (**Pietras** et al. 2021), and *Aureoboletus projectellus* (Banasiak, **Pietras** et al. 2019a, 2019b). On the one hand, they allowed for determination of the current range based on "presence only" data. On the other hand, they could determine the potential distribution of the analysed taxa in the present (**Pietras** et al. 2018, **Pietras** 2019, **Pietras** and Kolanowska 2019 , Banasiak, **Pietras** 2019a, 2019b), and for the past and the future (**Pietras** et al. 2021). An additional advantage of using data related to herbarium specimens is the possibility of later use of the collected vouchers in research based on advanced molecular methods, e.g., population genetics. Such research is undertaken for potentially invasive fungi in the OPUS project that I am currently leading.

Molecular biology tools for research on the occurrence of foreign nonpathogenic fungi

- **Pietras M.**, Rudawska M., Iszkuło G., Kujawa A., Leski T. 2016. Distribution and molecular characterization of an alien fungus, *Clathrus archeri*, in Poland. Polish Journal of Environmental Studies 25: 1197-1204.
- **Pietras M.**, Litkowiec M., Gołębiewska J. 2018. Current and potential distribution of the ectomycorrhizal fungus *Suillus lakei* ((Murrill) A.H. Sm. & Thiers) in its invasion range. Mycorrhiza 28: 467–475.
- **Pietras M.**, Kolanowska M. 2019. Predicted potential occurrence of the North American false truffle *Rhizopogon salebrosus* in Europe. Fungal Ecology 9: 225-230.
- **Pietras. M.** 2019. First record of North American fungus *Rhizopogon pseudoroseolus* in Australia and prediction of its occurrence based on climatic niche and symbiotic partner preferences. Mycorrhiza 29: 397–401.

The development of molecular techniques over the past 20 years has undoubtedly contributed to the development of biological sciences. In mycology, we can follow a rapid boom related to the improvement of molecular tools in taxonomic, ecological, and population studies. Thanks to the adaptation of PCR-based techniques for mycological research, the availability of tools for analysing nucleotide sequences has increased (**Pietras** 2012). The recognition of the ITS fragment as a "barcode" used for molecular identification of fungi is also of great importance (Schoch et al. 2012). It has allowed the identification of mycorrhizae formed by different fungal taxa on the roots of various tree species under different environmental conditions (e.g., **Pietras** et al. 2013).

Molecular methods can be widely used in mycological research. In the publication describing the distribution of the alien saprotrophic *Clathrus archeri* in Europe (**Pietras** et al. 2016), I analysed the variability of 2 adjacent rDNA regions - the ITS (barcode recognized in mycological research) and the conservative marker LSU. One of the research goals was to determine the suitability of the regions mentioned above as markers carrying information about the origin of the species, i.e., a biogeographic marker. Earlier studies have shown the possibility of using the ITS region in studies of the biogeography of *Flavolachia colacera* (Vizzini et al. 2009) and an indication of the likely location from where this species was transferred to Europe. In the research conducted on *Clathrus archeri* (**Pietras** et al. 2016), 17 herbarium specimens collected in 1983-2014 in various parts of Poland were used. The analysis of phylogenetic similarity showed that both the ITS fragment and LSU showed a very low degree of divergence (averages of 0.2% and 0.1% for ITS and LSU, respectively). This was reflected in single nucleotide substitutions in ITS sequences and few changes in the LSU fragment (a maximum of 7 on the 855 bp fragment). The conducted research indicated the need to look for other genetic markers that could be used to study fungal biogeography. This conclusion was confirmed by later studies on the distribution of *Clathrus archeri* in Australia and New Zealand (**Pietras** et al. 2021), which also indicated a very low level of variation in ITS and LSU region sporocarps collected in their natural range (unpublished data).

In the next two publications that are part of the scientific achievement (**Pietras** et al. 2018, **Pietras** and Kolanowska 2019), I used the molecular identification of ectomycorrhizae to investigate fungi assembled with two North American conifers: Douglas fir (*Pseudotsuga menziesii*) and Eastern white pine (*Pinus strobus*). These studies were carried out as part of the PRELUDIUM project to assess the scale of occurrence of alien species of symbiotic fungi that could have been co-introduced with their tree partners. The three-year observations were carried out on 12 study plots covered with Douglas fir of different ages and three plots covered with Eastern white pine. The presence of ectomycorrhizae *Suillus lakei* on the roots of Douglas fir was recorded in four study plots, all located in home gardens. At the same time, mycorrhizae of this fungus were not found in old forests, tree stands, or Douglas fir seed plantations (**Pietras** et al. 2018). The abundance of mycorrhizae formed by *S. lakei* was, on average, 20% of all root tips. However, the number of mycorrhizae was different when analysing individual study plots. Observations of fruiting bodies confirmed the presence of the fungus in each of the 4 locations in home gardens. The sporocarps appeared in large numbers, regardless of the degree of root colonization by the fungus. The presence of *S. lakei* in gardens may only be related to their history. All gardens where the presence of the fungus was noted were established in a similar period (approx. 20-25 years ago). In the observation plot in Pruszcz, where *S. lakei* was found for the first time in Poland (Ujsewicz 2012), several-year-old Douglas fir seedlings came from Germany. In the 1990s, when the Polish nursery industry was in its infancy, planting material was imported mainly from abroad, mainly from Germany. This study indicated the potential pathway of *S. lakei* introduction to Poland and described the initial stage of the spread of the fungus.

Similar research was conducted in Eastern white pine plantations. This tree forms an ectomycorrhizal symbiosis with several species belonging to the *Rhizopogon* genus. In this study, the presence of one of these (*R. salebrosus*) was confirmed. Single ectomycorrhizas of this fungus were identified on the study plot located near the Ostrzycki Las Reserve in Pomerania. This finding is the first record of the fungus in Poland (**Pietras** and Kolanowska 2019). The identification of both North American fungi – *S. lakei* and *R. salebrosus* - in Poland proves that molecular methods are a helpful tool in detecting alien symbiotic fungi even though the fungus does not form visible sporocarps.

In the next publication, I used molecular methods to confirm the identification of sporocarps of the North American fungus *Rhizopogon pseudoroseolus*, recorded for the first time in Australia (**Pietras** 2019). This species was described in 1966, but based on numerous revisions within the *Roseoli* section, the taxon was synonymized with *R. roseolus* (Martin 1996). Molecular studies based on comparing the sequence of the ITS rDNA clearly showed the distinctiveness of *R. pseudoroseolus* from other isolated species in the Roseoli section (Martin and Garcia 2009). The sporocarps of *R. pseudoroseolus* found near Melbourne were characterized by a very intense reaction to $FeSO_4$ and large (compared to other taxa in the section) spores, the length of which exceeds 10 µm. Phylogenetic analysis (**Pietras** 2019, Supplement No. 2) showed the genetic differences between collected *R. pseudoroseolus* sporocarps and sequences of *R. roseolus* deposited in GenBank (ITS variability ranging from 3-5%). Sequences of sporocarps found for the first time in Australia were 100% similar with herbarium specimens of this taxon deposited at the Herbarium of the University of Michigan (species paratypes collected and deposited in the 1960s, sequences submitted to the UNITE database with numbers AJ810040 and AJ810042). The conducted survey of herbarium data and available public databases (GBIF, iNATURALIST, Atlas of Living Australia) indicated that *R. pseudoroseolus* had not been previously recorded in Australia. At the same time, Nuske et al. (2019) confirmed the presence of *R. pseudoroseolus* in eastern Australia based on studies of the presence of fungal spores in rodent faeces.

The use of bioclimatic niche modelling (ENM) tools in the study of the biogeography of nonpathogenic foreign fungi

- **Pietras M.**, Litkowiec M., Gołębiewska J. 2018. Current and potential distribution of the ectomycorrhizal fungus *Suillus lakei* ((Murrill) A.H. Sm. & Thiers) in its invasion range. Mycorrhiza 28: 467–475.
- **Pietras M.**, Kolanowska M. 2019. Predicted potential occurrence of the North American false truffle *Rhizopogon salebrosus* in Europe. Fungal Ecology 9: 225-230.
- **Pietras. M.** 2019. First record of North American fungus *Rhizopogon pseudoroseolus* in Australia and prediction of its occurrence based on climatic niche and symbiotic partner preferences. Mycorrhiza 29: 397–401.

In my research, I also used ecological niche modelling tools, which, based on data describing the presence-only data, allow us to estimate the potential range of a taxon based on the analyzed climatic or environmental variables.

The research carried out in my publication presents the potential occurrence of the North American species of the fungus *Suillus lakei* (Douglas fir) on a regional and global scale (**Pietras** et al 2019). The records of *S. lakei* was used, both from the natural range of the fungus occurrence (49 records located between 19 ° and 50 ° north latitude) and from outside this area, from Europe and New Zealand (44 records in total). Two independent approaches were used to prepare models of the potential distribution of fungus. In the first one, 12 uncorrelated climatic variables were used, and altitudinal data were taking into account . In the second, in addition to climatic variables, the presence of the fungal tree partner - Douglas fir was also analyzed. This tree is the only known mycorrhizal symbiont of *S. lakei*. The prepared databases correspond with the known distribution of the fungus (93 records) and trees (1147 records) worldwide. The performed models showed that the distribution of the bioclimatic niche potentially useful for *S. lakei*, is on the one hand compared to the range of the tree's potential occurrence, and on the other hand, much wider than the currently known range of this fungus. This is underlined in areas outside the natural range. In Europe, where this taxon is relatively rare and occurs mainly in Central and Southern Europe, the range of the bioclimatic niche is much wider. It stretches across a wide belt from the northern fringes of the Iberian Peninsula through France, Germany, Benelux countries to Poland. In addition, favourable conditions for the fungus were found in Great Britain, the lower parts of the Apennines, the Balkan Peninsula, and the southern seashores of the Black Sea. The conducted research clearly shows that *S. lakei* can potentially spread across significant parts of Europe, meeting climatic conditions optimal to the fungus. To fulfil such a scenario, two conditions are necessary: 1) the presence of Douglas fir, with which this fungus is closely related, and 2) a vector that will contribute to the spread of the fungus, e.g., along with seedlings of ornamental trees (**Pietras** et al. 2018).

In a study dealing with the distribution of the bioclimatic niche of another North American fungus, *Rhizopogon salebrosus*, we used the species distribution model to assess distribution of the fungus in Europe (**Pietras** and Kolanowska 2019). This fungus was found thanks to the detection of its ectomycorrhizae, identified on the roots of the Eastern white pine growing near the Ostrzycki Las Reserve during the research related to the PRELUDIUM project. It was the first record of this taxon in Poland. The locations of its previous records in Europe (from Switzerland and the Czech Republic) and records presenting the distribution of the species in North America were also used in the model. The model was created based on 12 uncorrelated climate variables. The conducted analysis shows that the currently known distribution of the fungus covers a potential natural range. In Europe, the highest predictions of fungal occurrence were detected in the regions where the fungus has been found in the Alps and the Sudetes and other mountain regions, such as the Cordilleras, Carpathian Mountains, Dinaric Mountains, Pontic Mountains, Taurus Mountains, Caucasus, and Middle Iranian Mountains. Thus, the distribution of highly suitable areas for *R. salebrosus* occurrence can potentially extend to mountain areas. However, the first record of the fungus in Pomerania may reflect that this species does not realize its climatic niche in Europe. Taxa classified to *Rhizopogon* genera form circular fruiting bodies that may grow partially or entirely in the soil. Thais is why they are called false truffles, a fact that is essential in biogeographical studies of *Rhizopogon* taxa because the presence of fruiting bodies may not be noticeable. The results of the obtained models indicate an underestimation of the assumed range of the fungus in Europe.

Introductions of symbiotic fungi are most often observed in regions where their plant partners have been introduced on a large scale. The highest number of alien tree species was introduced into the temperate climate regions of the Southern Hemisphere. One of the centres of occurrence of foreign woody plants is Oceania. In both New Zealand and Australia, the list of foreign trees appears to be very rich. Along with alien species of trees, symbiotic fungi were also introduced.

An excellent example of this is the North American species *Rhizopogon pseudoroseolus*. Its presence in 2017 was recorded during a field trip to Australia within the FUGA project, and the finding near Melbourne was the first record of the fungus in Australia (**Pietras** 2019). Here, I use the species distribution model to assess the potential range of *R. pseudoroseolus* in Australia and New Zealand. In addition to climatic factors, I also use Radiata pine (*Pinus radiata*) distribution data gathered from natural ranges in North America and from Australia and Oceania. A novelty in the conducted research was the use of geographic data describing both sporocarps and places where only mycorrhizas were found. As in previous publications, the prediction of the occurrence of the bioclimatic niche was prepared for 12 uncorrelated bioclimatic layers, and the distribution of the plant partner with which this fungus forms symbiotic relationships was used. The modelling carried out proved that the potential presence of *R. pseudoroseolus* in New Zealand is much wider than currently known based on the records of fruiting bodies and the observation of the presence of mycorrhizae of this fungus. In Australia, where the presence of this species was recorded for the first time, the bioclimatic niches favourable for the occurrence of *R. pseudoroseolus* overlapped with the potential range of the plant partner (*P. radiata*) and stretched along the southeast coast of Australia (from Brisbane to Melbourne). Favourable conditions for fungal occurrence were also found throughout Tasmania. The extensive range of *R. pseudoroseolus* occurrence in Australia proves that due to its small, imperceptible fruiting bodies, this species may be overlooked in mycological surveys or confused with other closely related species. The main conclusion from the conducted research is that the range of *R. pseudoroseolus* in Australia and New Zealand is underestimated. The fungus may be present there much more often than indicated by earlier records of sporocarp observations. This statement is confirmed by the description of the second location of *R. pseudoroseolus* in Australia (Nuske et al. 2019). This time, the conducted research used next-generation sequencing to prove the presence of *R. pseudoroseolus* spores in rodent faeces in eastern Australia. This location is located in an area that, based on my research, was characterized by high suitability for the fungus.

The use of the bioclimatic niche modelling (ENM) technique in research in historical biogeography and the impact of climate change on the distribution of nonpathogenic alien fungi

- **Pietras M.**, Kolanowska M., Selosse M.-A. 2021. *Quo vadis*? Historical distribution and impact of climate change on the worldwide distribution of the Australasian fungus *Clathrus archeri* (Phallales, Basidiomycota). Mycological Progress 20:299–311

Modelling tools can be used to predict potential occurrence in real time, as presented above, and in research on historical biogeography or the impact of climate change on the distribution of organisms. This approach was implemented in the study describing the distribution of *Clathrus archeri*, which was used as a model organism in historical, current, and future range research conducted during the FUGA project (**Pietras** et al. 2021). The most significant gap in mycological research is related to the biogeography of individual species of fungi. The inspiration for this research, based on the occurrence of the *C. archeri*, was the need to answer whether this species can be considered native to both Australia and New Zealand or whether it was introduced to New Zealand by Europeans after their discovery. Therefore, the study aimed to determine the distribution of *C. archeri* refugia in Australia and New Zealand during the Last Glacial Maximum (LGM, approx. 26500-19000 years ago). The fungus was considered endemic to Australia, where it is relatively common in the southeastern part of the continent. Based on the current localization of the *C. archeri* population in Oceania, using 12 climatic variables developed by the Paleoclimate Modelling Intercomparison Project Phase II (Braconnot et al. 2007), we created models of the distribution of climatic niches optimal for the occurrence of the fungus. A map presenting potential refugia of *C. archeri* in Australia and New Zealand during the last glacial maximum was created. The prepared models for the LGM indicate the presence of areas where this species could occur in its climatic optimum both in Australia and New Zealand but also on the islands located between them, which, as a result of the increase in ocean levels in the last 20,000 years, are underwater. The presence of refugia in these areas confirms that this species could exist and realize its climatic optimum in Australia and New Zealand. It also indirectly indicates that the Australian and New Zealand populations of *C. archeri* diverged much earlier, before the LGM period. Published research proves the need for further analyses based, for example, on molecular biology tools used in population genetics. This was reflected in the currently implemented OPUS project, which planned the development of microsatellite markers for population studies of *C. archeri* in both natural and invasive ranges. It is also worth noting that the described studies were the first published studies in the historical biogeography of fungi.

Models of bioclimatic niches also make it possible to compare the potential distribution of organisms between past and present times. In the case of such a comparison made for Australia and New Zealand, it turned out that *C. archeri* could occupy an area larger by 18.7%

in the past than today. Only populations within its natural range in Australia and New Zealand could be used to study the potential distribution of *C. archeri* in the past. In models created for the present time, European locations of fungi from native ranges and records representing places of introduction since the beginning of the 20th century were also included. This approach allowed a model of the distribution of a climate niche outside Australia and New Zealand. It has been shown that favourable climatic conditions conducive to the occurrence of the fungus occur on the west coast of North America, the Andes, and the east coast of South America, as well as in Madagascar, where it cannot be clearly stated whether the populations of the fungus occurring there can be classified as *C. archeri* whether they are another closely related taxon. In total, beyond the natural range, the conditions favourable for the occurrence of *C. archeri* cover an area of more than 3 million square kilometres. The largest area where the fungus could find favourable conditions for its occurrence is in Europe. The *C. archeri* climatic niche on this continent extends from the northern tip of Spain, through the countries of western and central Europe, to the eastern borders of Poland. In addition, the model shows the presence of sites suitable for occurrence of the fungus in southern Scandinavia, the British Isles, and the mountain regions of the Iberian Peninsula and the Balkans, the Carpathians, and the Dinaric Mountains.

Another issue analysed in the publication was the impact of climate change on the distribution of *C. archeri* in the future. In the model presenting the potential distribution of the fungus in 2080 (Ramirez & Jarvis 2008), all available localization data were used. Changes in the potential range of *C. archeri* occurrence were assessed for three available climate change scenarios: A1b, A2a, and B2a (detailed information about climate change scenarios has been published in our recent paper; Wiartowska et al. 2020) . The conducted analyses show that the climate niche distribution differs slightly for all three analysed climate change scenarios. *Clathrus archeri's* response to changing climatic conditions varies from region to region of the world. All three analysed climate change scenarios indicate a reduction in the range of fungal climatic niche occurrence in Australia. For the most pessimistic scenario (A1b), a reduction in the potential occurrence area of up to 8% was observed in comparison with the present time. Such a reduction was not observed in Tasmania and New Zealand, where it is anticipated that the known localities of *C. archeri* will be maintained, or even the extent of the climatic niche will be extended to areas where this fungus is currently not recorded. However, in Europe, all prepared models indicate possible migration of the species towards the northeast until 2080. This result confirms conclusions obtained in my previous research, indicating the same direction of species migration in the last 40 years, observed only in a limited area of Poland (**Pietras** et al. 2016). Each of the analysed climate change scenarios also indicated a reduction in the climate niche area corresponding to the requirements of *C. archeri* in the southern part of the range predicted in Europe. This reduction will cover the Iberian Peninsula, the Apennine Peninsula, Turkey's territory, and the central part of Europe and the Balkans. The most significant reduction in the extent of the respective climatic niche is observed in the A2a scenario. By analysing the relation of the potential range currently observed concerning future predictions, a reduction in the spread of the fungus in Europe can be observed in the case of the A2a scenario and its extension within the A1b and B2a scenarios.

The presented results (**Pietras** et al. 2021) allow us to answer three questions posed in the article. First, *C. archeri* can be considered native in both Australia and New Zealand. Second, it shows that the current worldwide distribution of the species covers the fungal ecological requirements. The conclusions obtained in the research also answer the question "quo vadis?" included in the title, referring to the future of *C. archeri* in the era of observed climate changes. In this regard, the studies carried out indicate that in the next decades, this fungus may become an endangered species in places where it occurs naturally, particularly in Australia. The range of the potential occurrence of *C. archeri* has decreased since the LGM. At the same time, the currently observed climate changes may significantly accelerate the loss of suitable habitats in the natural range of the fungus. On the other hand, beyond its natural range, the species can extend its range, making it a potentially invasive species. According to the IUCN definition, an invasive organism can be considered a species with proven unfavourable influence on components of native nature (Blackburn et al. 2011). In the case of nonpathogenic fungi, it is challenging to investigate such influence. However, this issue was addressed in the OPUS project, the aim of which is to assess the impact of nonpathogenic alien fungi on the native mycobiota, soil biochemical processes, and assemblages of other organisms, such as soil mites, which are commonly used as bioindicators signalling changes in the soil environment.

The use of the bioclimatic niche (ENM) tools in studies covering the ecoclimatic conditions of the distribution of foreign nonpathogenic fungi

- **Pietras M**., Rudawska M., Iszkuło G., Kujawa A., Leski T. 2016. Distribution and molecular characterization of an alien fungus, *Clathrus archeri*, in Poland. Polish Journal of Environmental Studies 25: 1197-1204.
- **Pietras M.**, Litkowiec M., Gołębiewska J. 2018. Current and potential distribution of the ectomycorrhizal fungus *Suillus lakei* ((Murrill) A.H. Sm. & Thiers) in its invasion range. Mycorrhiza 28: 467–475.
- **Pietras M.**, Kolanowska M. 2019. Predicted potential occurrence of the North American false truffle *Rhizopogon salebrosus* in Europe. Fungal Ecology 9: 225-230.
- **Pietras. M.** 2019. First record of North American fungus *Rhizopogon pseudoroseolus* in Australia and prediction of its occurrence based on climatic niche and symbiotic partner preferences. Mycorrhiza 29: 397–401.
- **Pietras M.,** Kolanowska M., Selosse M.-A. 2021. Quo vadis? Historical distribution and impact of climate change on the worldwide distribution of the Australasian fungus *Clathrus archeri* (Phallales, Basidiomycota). Mycological Progress 20:299–311

Sporocarp formation is closely related to weather conditions. Climatic factors determine the occurrence and distribution of fungi on a larger scale. Therefore, climate can be considered the most important factor influencing species distribution on a continental scale (Pearson and Dawson 2003). The modelling methods, apart from indicating the potential distribution of organisms, also demonstrate the climatic factors that most significantly affect their occurrence.

In my two papers (**Pietras** et al. 2016, 2021), the influence of 12 climatic variables on the occurrence of *Clathus archeri* was examined. The local weather conditions favouring the formation of fruiting bodies of this fungus were presented. Over 80% of *C. archeri* records were observed in upland and mountain areas, where the total annual rainfall exceeded 600 mm. (**Pietras** et al. 2016). The conducted research indicates the significant importance of precipitation in the formation process of *C. archeri* sporocarps. This is supported by the results of modelling a climatic niche, showing that the most critical factor responsible for the occurrence and distribution of the fungus in Poland is precipitation of the driest month (**Pietras** et al. 2016). The results obtained in second study showing the conditions for the distribution of the fungus at the global scale indicate the same factor as the critical ones for the occurrence of *C. archeri* (**Pietras** et al. 2021). This is despite a different methodological approach. In the first study, only the records from Poland were analysed. In the latest work, the locations of the *C. archeri* population collected from three continents (Australia, Africa, Europe) and New Zealand were analysed.

Next, three works analysed the influence of climatic variables on the occurrence and distribution of suilloid fungi native to North America and transferred to Europe and Oceania. In the case of *Suillus lakei* (**Pietras** et al. 2018), the most important factor was precipitation of the coldest quarter, followed by isothermality and average annual temperature. Similar relationships were found in the case of fungi belonging to the genus *Rhizopogon* (**Pietras** 2019, **Pietras** Kolanowska 2019). Both taxa - *R. salebrosus* and *R. pseudoroseolus* - were the most influenced by precipitation in the coldest quarter. However, for the investigated suilloid fungi, models have shown that tree partner distribution is the most decisive factor crucial for fungal occurrence. Occurrence of *S. lakei* was determined in 86.7% by Douglas fir presence. In the case of R. pseudoroseolus and Radiata pine, the fungus dependence reached over 30%.

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5. Presentation of significant scientific or artistic activity carried out at more than one university, scientific or cultural institution, especially at foreign institutions. .

Important scientific activity before doctorate (before 2013)

I started my studies in 2003 at the Faculty of Forestry of the University of Life Sciences in Poznań. During the third year of my studies, I started research work on the team of Prof. Maria Rudawska in the Laboratory of Symbiotic Associations of the Institute of Dendrology of the Polish Academy of Sciences in Kórnik. During this period, I was included in research describing the communities of symbiotic fungi in forest nurseries. The results obtained as part of my master's thesis describing the conditions for the formation of mycorrhizae by seedlings of pedunculate and sessile oak in the conditions of a forest nursery were published in Mycorrhiza (Leski et al. 2010). After graduating in November 2008, I started one year of professional work in the Piaski Forest District. At the same time, I was admitted to the Ph.D. Studies at the Faculty of Biology at Adam Mickiewicz in Poznań. I carried out my doctoral dissertation in the Laboratory of Symbiotic Associations of the Institute of Dendrology of the Polish Academy of Sciences in Kórnik.
My dissertation was a continuation of the research conducted during my PhD thesis and concerned the chronosequence of the mycorrhizal oak fungus communities growing in forest nurseries (**Pietras** et al. 2015), as well as forest ecosystems (Pietras et al. 2016). During my doctorate, I also conducted research on the communities of mycorrhizal fungi associated with other forest species, such as European beech (**Pietras** et al. 2013).

In the period preceding the obtainment of my doctoral degree (in the years 2008-2013), the following scientific articles in which I was involved were published:

- Leski T., Rudawska M., Aučina A., Skridaila A., Riepšas E., **Pietras M.** 2009. Influence of pine and oak litter on growth and mycorrhizal community structure of Scots pine seedlings in bare-root nursery condition (in Polish). Sylwan 153 (10): 675-683.

- Leski T., Aučina A., Skridaila A., **Pietras M**., Riepšas E., Rudawska M. 2010. Ectomycorrhizal community structure of different genotypes of Scots pine under forest nursery conditions. Mycorrhiza 20:473-481
- Leski T., **Pietras M.**, Rudawska M. 2010. Ectomycorrhizal fungal communities of pedunculate and sessile oak seedlings from bare-root forest nurseries. Mycorrhiza 20: 179-190.
- Aučina A., Rudawska M., Leski T., Ryliškis D., **Pietras M.,** Riepšas E. 2011. Ectomycorrhizal fungal communities on seedlings and conspecific trees of Pinus mugo grown on the coastal dunes of the Curonian Spit in Lithuania. Mycorrhiza 21: 237-245
- **Pietras M.**, Rudawska M., Leski T., Karliński L. 2013. Diversity of ectomycorrhizal fungus assemblages on nursery grown European beech seedlings. Annals of Forests Sciences 70: 115-121.

Additionally, at that time, I published one chapter in a monograph

- **Pietras M**. 2012. The molecular methods in research on the biodiversity of mycorrhizal fungi. In: New trends in natural research 2 (Kuczera ed.), Volume 1 (in Polish) [Wykorzystanie metod molekularnych w badaniach nad różnorodnością biologiczną grzybów mikoryzowych. W: Nowe trendy w badaniach przyrodniczych 2 (Kuczera ed.), Tom 1] Creativetime, Kraków, 113-121,

and two popular science articles:

- **Pietras M.** 2010. Stinkhorn octopus - Oversea fungus found in the Piaski Forest District in Greater Poland (in Polish) [Osobliwy okratek - Zamorski grzyb odnaleziony na terenie Nadleśnictwa Piaski w Wielkopolsce]. Las Polski. 11: 16.
- **Pietras M.** 2012. Alien non-pathogenic fungi in Polish forests (in Polish) [Obce grzyby niepatogeniczne w polskich lasach]. Las Polski 15-16: 26-27.
-

During the doctorate, in 2011, I also did my first internship abroad (Belowground Carbon Turnover in Forests) at the University of Tartu (Estonia). Its purpose was to learn methods investigating the role of fungi in the carbon cycle in forest ecosystems. The trip to Estonia was possible thanks to my participation in the COST Action program FP0803 (entitled "Belowground carbon turnover in European forests"), financially supported by the European Union. Thanks to the invitation to the abovementioned COST program, I was also able to participate in a series of meetings that took place at conferences. In 2012, I obtained a travel grant, thanks to which I was able to complete a monthly internship (a short-term scientific mission) in the group of Dr. Leho Tedersoo (University of Tartu). My visit aimed to learn modern molecular techniques based on next-generation sequencing. In 2012, I also participated in the one-week course "Identification of Corticioid Basidiomycetes," organized by the same university, which took place in Otepa.

During my doctorate, I also participated in the following training, courses, and workshops:

- "Molecular Phylogenetics" - MBS Warsaw, October 26-28, 2008,
- "Summer School of Taxonomy" - Faculty of Biology, University of Gdańsk 18-20 September 2013,
- "Fungal Conservation - Red Listing, Communicating, Taking Action" Polish Mycological Society Lodz 24-28 September 2014.

Apart from the conferences under the COST program (2012 Antalya and 2013 Bordeaux), I also participated in 8 other conferences (6 national and 2 international)

During my doctorate, I prepared a proposal for research funding approved by the National Science Center in a call for scientists without a doctorate (PRELUDIUM). This project was entitled "Mycorrhizal communities of Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) and Eastern white pine (*Pinus strobus* L.) in Poland - in quest of foreign species of symbiotic fungi". The project's main aim was to evaluate the number of introduction of foreign mycorrhizal fungi cointroduced with Douglas fir and Eastern white pine in Poland. The research was based on the molecular method of mycorrhizal identification using Sanger sequencing. The research was conducted in the stands of the first plantations of these species in Poland. The results obtained in the project allowed us to describe the mycorrhizal fungal communities of two North American tree species. The most important conclusion from the research is that both Douglas fir and Eastern white pine growing in Poland commonly establish mycorrhizal symbiosis with cosmopolitan fungi, i.e., those that occur in many regions of the globe. A relatively frequent phenomenon is entering into mutualistic relationships of the studied trees with fungi occurring only in the areas of introduction, which results in the establishment of completely new tree-fungus connections, which, if the trees were not introduced into new areas, could never exist ("novel mutualisms"). On the other hand, the phenomenon of cointroduction of trees and their mycorrhizal partners originating from the natural range of occurrence ("coinvasion") has by far the least importance. Out of over a hundred identified mycorrhizal fungi, only two taxa originate from North America. *Suillus lakei* is one of the most common species of fungi found in the natural range of Douglas fir. In contrast, one of the *Rhizopogon* species – *R. salebrosus* – often establishes a mycorrhizal symbiosis with several five-needle North American pines (research on the abovementioned species is part of the scientific achievement). Therefore, based on the research carried out, it can be concluded that North American species of fungi may be considered more "stowaways" than partners in the process of colonizing new areas together with invasive trees.

Important scientific activity after doctorate (since 2013)

The PRELUDIUM project started during my doctorate, and it ended after defending my doctorate. Obtained results allowed to publish two articles constitute scientific achievements and the chapter of a monograph, the editor of which I was:

- **Pietras M.** 2017. Occurrence of alien non-pathogenic fungi as a threat to the environment. In: Pietras M., Romanik W. (eds.) Selected threats to the environment - the view of young scientists. (in Polish) [Występowanie obcych gatunków grzybów niepatogenicznych jako zagrożenie dla środowiska przyrodniczego. W: **Pietras M**., Romanik W. (red.) Wybrane zagrożenia dla środowiska - spojrzenie młodych naukowców] CREATIVETIME, Kraków. pp. 65-72.

After obtaining the results from scientific research as part of a doctoral dissertation following articles has been also published:

- **Pietras M.**, Leski T., Rudawska M. 2015. Temporal dynamics of ectomycorrhizal community of pedunculate oak seedlings during the first year of growth in bare‒root forest nursery. (in Polish) Sylwan 159(10): 831-838.
- **Pietras M.**, Kujawa A., Leski T., Rudawska M. 2016. Macrofungi. In: Danielewicz W. (red). Dąbrowy Krotoszyńskie - the monography (in Polish). Oficyna Wydawnicza G&P, Poznań. pp. 89-131.

During the PRELUDIUM project, another application was submitted to the competition for scientists with a doctoral degree for a three-year postdoctoral fellowship (FUGA) organized by the National Science Center. Launching the project involved the transfer of my scientific activity to the Faculty of Biology of the University of Gdańsk, where I started working in October 2015. The project was entitled "*Clathrus archeri* (Berg.) Dring. *Suillus lakei* (Murrill.) AHSM & This and *Boletus projectellus* (Murrill.) Singer as a model organisms in studies describing spread of alien non-pathogenic fungi". The project started in the Department of Taxonomy and Nature Conservation and aims to assess the scale of occurrence of *C. archeri*, *S. lakei* and *A. projectellus* in Europe. Thanks to the conducted analyses, it was possible to prove that in the near future, these species can be used in the future as model organisms, and the expansion of *A. projectellus* is unstoppable across Europe (Banasiak, **Pietras**, et al. 2019 a, 2019b).

The project also developed tools useful in biogeographical studies of alien fungi. Each organism has unique fragments (DNA sequences) in its DNA, specific only for the species. Thanks to the collection of 300 fungal vouchers of the studied species, it was possible to find unique ITS rDNA fragments characteristic of each fungus. Therefore, it is possible to determine the presence of the examined taxa without observing ephemeral fruit bodies. This approach also allows us to include the amount of mycelium analysed in the soil and describe the quantitative and qualitative relationships of these fungi and our native mycobiota. To determine the impact of fungal species on native ecosystems over time, the program is included as part of my research (ongoing OPUS project).

In the FUGA project, I planned a trip to New Zealand and Australia. It took place in 2017. The purpose of the stay was to collect material for research and to visit herbaria in Australia, where there are collections of *C. archeri*. A positive effect of my stay in New Zealand (20/04-10/05) was the deposition of over 20 collections of fungal specimen vouchers in the New Zealand Herbarium collection (PDD). Due to phytosanitary regulations, it was not possible to transport the collected materials to the European Union, and all records of rare and foreign taxa identified by me during the stay in Australia (May 10-30.06) were reported to the open database "Atlas of Living Australia" (https:biocache.ala.org.au/occurrences/993986cd-6f25-45bc-9a72-51c7caf73014). One of the most interesting findings was the identification of a North American fungi, *Rhizopogon pseudoroseolus*, which was first found in Australia and I described in a separate publication (**Pietras** 2019). During the stay in Australia, I also contacted with the Australian National Herbarium in Canberra (CANBR), thanks to which the herbarium specimens representing the *C. archeri* vouchers collected in southeastern Australia has been gifted to the University of Gdańsk Herbarium.

During the FUGA project, the following scientific articles were published, including **two papers** constitute the part of scientific achievement:

- **Pietras M.** 2019. First record of North American fungus Rhizopogon pseudoroseolus in Australia and prediction of its occurrence based on climatic niche and symbiotic partner preferences. Mycorrhiza 29: 397–401.
- Banasiak Ł., **Pietras M.**, Wrzosek M., Okrasińska A., Gorczak M., Kolanowska M., Pawłowska J. 2019a. Aureoboletus projectellus (Fungi, Boletales) – an American bolete rapidly spreading in Europe as a new model species for studying expansion of macrofungi. Fungal Ecology 39: 94-99.
- Banasiak Ł**., Pietras M**., Wrzosek M., Okrasińska A., Gorczak M., Kolanowska M., Pawłowska J. 2019b. Aureoboletus Projectellus (Fungi, Boletales) e Occurrence Data, Environmental Layers and Habitat Suitability Models for North America and Europe. Data in Brief 23:103779.
- **Pietras M.**, Kolanowska M., Selosse M.-A. Quo vadis? Historical distribution and impact of climate change on the worldwide distribution of the Australasian fungus Clathrus archeri (Phallales, Basidiomycota). Mycological Progress 20: 299–311.

After completing my postdoctoral fellowship at the Faculty of Biology of the University of Gdańsk in 2018, I returned to the Institute of Dendrology of the Polish Academy of

Sciences, where I started working on the application financing the next project. The OPUS project entitled "The genetic structure of the population and the impact of potentially invasive species of nonpathogenic fungi on native ecosystems" was awarded to me by the National Science Center in 2019 and started at the beginning of July 2020. This project is a continuation and extension of research undertaken earlier in the PRELUDIUM and FUGA projects. It also uses materials collected during my postdoctoral fellowship between 2015 and 2018. The project's main goal is to assess the impact of alien fungi on native ecosystems, with particular emphasis on mycobiota, vegetation, and the presence of indicator organisms such as mite communities. It was assumed that the influence of alien species might be significant, and their presence will negatively affect our native fungi, soil, and entire ecosystems. The project uses modern molecular biology tools (next-generation sequencing, population genetics tools), which allows estimation of the quantitative and qualitative occurrence of alien fungal species at the sporocarp level, the amount of mycelium in the soil, and the occurrence of symbiotic fungi on tree roots. The obtained data will allow assessment of the scale of the threat resulting from the presence of alien species, as well as implementing plans to prevent their further spread. A novelty is the combination of the above-described molecular methods with methods allowing us to estimate the impact of alien species on the soil ecosystem by examining the decomposition rate of the litter or the enzymatic activity of the soil and mycorrhizae. Additionally, the impact of the occurrence of alien species of fungi on mite communities, which are considered to be bioindicators of changes taking place in the environment, is investigated. All planned research is in line with the latest research trends on the functional ecology of fungi. It also combines the issues of molecular and environmental biology as well as nature protection. The project is expected to be completed in mid-2024.

Other scientific activity

Studies on the diversity and species richness of fungi in various environmental conditions:

- Kujawa A., Wrzosek M., Domian G., Kędra K., Szkodzik J., Rudawska M., Leski T., Karliński L., **Pietras M.**, Gierczyk B., Dynowska M., Ślusarczyk D., Kałucka I., Ławrynowicz M. 2012. Preliminary studies of fungi in forests and inland dunes of the Biebrza National Park. Part II. Macromycetes. - Acta Mycologica vol. 47 (2) 215-240.
- Kujawa A., Gierczyk B., Domian G., Wrzosek M., Stasińska M., Szkodzik J., Leski T., Karliński L., **Pietras M.**, Dynowska M., Henel A., Ślusarczyk D., Kubiak D. 2015. Preliminary studies of fungi in the Biebrza National Park. Part IV. Macromycetes – New data and the synthesis. Acta Mycologica 50(2):1070, 1-28.
- Rudawska M., **Pietras M**., Smutek I., Strzeliński P., Leski T. 2016. Ectomycorrhizal fungal assemblages of Abies alba Mill. outside its native range in Poland. Mycorrhiza 26: 57-65.

The publications of Kujawa et al. (2012, 2015) were created as part of the activities of the Polish Mycological Society. In 2012 and 2013, society's field sessions were held in Biebrza National Park. The conducted research allowed the identification of 346 species of macrofungi in Park, among which eight taxa were species new to Poland, seven species were protected, and another 95 species were listed on the red lists of endangered species of fungi. In addition to noting the presence of 22 taxa identified during the research, my contribution was the molecular identification of 12 found fruiting bodies and depositing the ITS rDNA sequences obtained in this way in the NCBI open database.

In another work, together with the coauthors, we described the communities of symbiotic fungi of silver fir (*Abies alba* Mill.) beyond its natural range, in Pomerania (north

Poland). These studies were based on the molecular method of mycorrhizal identification. It was possible to describe the communities of ectomycorrhizal fungi of silver fir, forming forest ecosystems in Pomerania. The conducted research allowed the identification of a total of 35 taxa of mycorrhizal fungi in 5 analysed silver fir stands. Among the identified taxa, there were no specific species known from the natural range of silver fir. The recognized suite of fungi creating symbiotic relationships with fir fully allowed adaptation to the conditions in Pomerania.

The use of molecular methods for identifying edible mushrooms in ethnomycological studies

Thanks to a fruitful cooperation with Professor Łukasz Łuczaj from the University of Rzeszów, a series of publications was created in which the methods for the molecular identification of fungi in ethnomycological research were described:

- Łuczaj Ł., Stawarczyk K., Kosiek T., **Pietras M.**, Kujawa A. 2015. Wild food plants and fungi used by Ukrainians in the western part of the Maramureş region in Romania. Acta Soc Bot Pol 84(3):339–346.
- Kang J., Kang Y., Ji X., Guo Q., **Pietras M.**, Jacques G., Luczaj N., Li D., Luczaj L. 2016. Wild food plants and fungi used in the mycophilous Tibetan community of Zhagana (Tewo county, Gansu, China). Journal of Ethnobiology and Ethnomedicin 12: 21.
- Kasper-Pakosz R., **Pietras M.**, Łuczaj Ł. 2016. Wild and native plants and mushrooms sold in the open-air markets of south-eastern Poland. Journal of Ethnobiology and Ethnomedicine12:45.
- Kotowski M.A., **Pietras M.**, Łuczaj Ł. 2019. Extreme levels of mycophilia documented in Mazovia, a region of Poland. Journal of Ethnobiology and Ethnomedicine 15:12.
- Łukasz Ł., Tongchan K., Xayphakatsa K., Phimmakong K., Radavanh S., Kanyasone V., **Pietras M.**, Karbarz M. 2021. Wild food plants and fungi sold in the markets of Luangprabang, Lao PDR. Journal of Ethnobiology and Ethnomedicine 17:6.

Ethnobotanical and ethnomycological research are performed in many parts of the world. The purpose of conducting such research is to document plants and fungi by various cultures, to indicate changes in the attitude of society to food sources and to indicate the connection of ethnobotany and ethnomycology with biological sciences (Kotowski et al. 2021).

In the publications in the list presented above, one novelty was the use of molecular methods based on the identification of the ITS rDNA barcode allowing for the identification of fungal taxa. In the publication of Łuczaj et al. (2015), we used this approach for the first time, which also made it possible to recognize 24 species used by Ukrainians living in the Maramureş region in Romania. Research carried out proved that the society of this region can be considered one of the most mycophilic communities in Europe.

Another publication (Kang et al. 2016) presented the traditional use of plants and fungi by the Tibetan community living in Zhagana Province in China. The conducted research clearly indicated that wild plants and mushrooms are an important source of food of the surveyed community. Moreover, mushroom picking, morels for example, was often treated as a source of income, and some other species, such as *Cordyceps sinensis*, are considered medicinal species,

In the studies by Kasper-Pakosz et al. (2016), we examined the availability of wild plants and mushrooms offered for sale at the open air market in southeastern Poland. In the conducted research, a list of 32 species of mushrooms sold at the marketplace was presented. *Neoboletus luridiformis* (previously known as *Boletus luridiformis*) was the most frequently offered fungus for sale. However, the most interesting result obtained in this research was the discovery of two species new to Poland. These taxa were *Leccinum schistophilum*, confused with *L. scabrum*, and an edible milk cup, *Lactarius quieticolour*. The conducted studies highlight the importance of applying molecular methods in ethnomycological research.

A subsequent study (Kotowski et al. 2019) was performed in Mazovia, where nearly 100 species of fungi were used for various purposes. Edible mushrooms constituted over 75% of all identified taxa. Twenty-one taxa were recognized based only on molecular methods implementing ITS analysis. Two identified fungi (*Hydnum ellipsosporum* and *Paxillus curpinus*) were considered new taxa for Poland. The published results are the longest published list of mushrooms used by various communities worldwide.

In a recently published work (Łuczaj et al. 2021), we conducted ethnobotanical research at the Luang Prabang market in Laos. Southeast Asian communities are among the most mycophilic communities in the world. Our research revealed lists of more than 50 species of mushrooms sold in the Luang Prabang marketplace. On the other hand, this region is also one of the most undiscovered in terms of mycobiota. Among the long lists of identified fungi, some taxa with an unclear taxonomic position were identified, such as several *Russula* species. Some of them have not been identified even when using molecular methods. The published results showed the need for future mycological exploration in this area.

Research on ecological and climatic conditions for the distribution of trees and fungi

In the field of scientific activity, there are 6 publications:

- Walas Ł., Dering M., Ganatsas P., **Pietras M.**, Pers-Kamczyc E., Iszkuło G. 2018. The present status and potential distribution of relict populations of *Aesculus hippocastanum* L. in Greece and the diverse infestation by *Cameraria ohridella* Deschka & Dimić. Plant Biosystems 152: 1048-1058.
- Banasiak Ł., Pietras M., Wrzosek M., Okrasińska A., Gorczak M., Kolanowska M., Pawłowska J. 2019a. *Aureoboletus projectellus* (Fungi, Boletales) – an American bolete rapidly spreading in Europe as a new model species for studying expansion of macrofungi. Fungal Ecology 39: 94-99.
- Banasiak Ł., Pietras M., Wrzosek M., Okrasińska A., Gorczak M., Kolanowska M., Pawłowska J. 2019b. *Aureoboletus Projectellus* (Fungi, Boletales) e Occurrence Data, Environmental Layers and Habitat Suitability Models for North America and Europe. Data in Brief 23: #103779.
- Wiatrowska B., **Pietras M**., Kolanowska M., Danielewicz W. 2020. Current occurrence and potential future climatic niche distribution of the invasive shrub *Spiraea tomentosa* in its native and non-native ranges. Global Ecology and Conservation 24: #e01226.
- Dyderski M.K., Chmura D., Dylewski Ł., Horodecki P., Jagodziński A.M., **Pietras M**., Robakowski P., Woziwoda B. 2020. Biological Flora of the British Isles: *Quercus rubra*. Journal of Ecology 108: 1199-1225.
- Kujawska M.B., Rudawska M., Stasińska M., **Pietras M**., Leski T. 2021. Distribution and ecological traits of a rare and threatened fungus *Hericium flagellum* in Poland with the prediction of its potential occurrence in Europe. Fungal Ecology 50: #101035

Aureoboletus projectellus is a North American fungus introduced to Europe at the beginning of the 21st century. Recently, fungi have begun to expand into new areas of Poland, as well in Europe as a whole. In our research, this species was used as a model organism (Banasiak et al. 2019a, 2019b). This allowed us to prove the suitability of the implemented method in studies describing the dynamics of alien fungus spread. To show the potential occurrence of the fungus in Europe, we used climatic variables and the occurrence of ectomycorhizal partners in Scots pine trees in Europe. The obtained model proved that further expansion of Aureoboletus projectellus was unstoppable, and the crucial factor for this was the presence of the fungal symbiont Scots pine.

In the next work (Wiatrowska et al. 2020), we analysed the distribution of climatic niches that affected the distribution of the North American shrub *Spiraea tomentosa* in the native range and in Europe. This species was introduced to Europe and is considered an invasive organism. In the described research, we used models presenting a climate niche distribution at present and in 2080, analysing the impact of climate change on the distribution of *S. tomentosa* in Europe. The prepared models indicated the possibility of shrub spread in Europe far beyond the range currently known. The research concludes that *S. tomentosa* does not fully realize its climate niche in Europe. Shrubs can find favourable conditions in several regions in Europe, such as the Scandinavian Peninsula and northeastern edges of the continent. Therefore, we confirmed the invasive status of *S. tomentosa* in Europe.

In a review article published in the renowned series "Flora of British Isles" published in the Journal of Ecology, we presented the various aspects of the occurrence of North American red oak in the UK (Duderski et al. 2020). In this article, my participation was the preparation of a comprehensive review of the literature related to oak fungi, including symbiotic, saprotrophic, and pathogenic fungi. Altogether, interactions with nearly 80 species of fungi in Great Britain have been confirmed. Among them, most of the taxa were symbiotic or saprotrophic fungi from Europe. On the other hand, information on the presence of the North American oomycete *Phytophthora ramorum* was presented. This pathogen caused sudden oak death in North America and Europe. Another interesting oomycete occurring in the UK is *Phytophthora cinnamomi*, a fungus-like organism of unknown origin. The presence of this pathogen with red oak in Europe is a rare example of the introduction of two alien organisms introduced from different parts of the world (the so-called "Co-xenic Novel Association". This review article is currently the most extensive and complete compendium of knowledge about oak outside the natural range, which may be of great importance for the invasiveness of red oak in the UK and throughout Europe.

In an article published in the journal Fungal Ecology, we presented ecological traits such as habitat, substrate preferences, phenology, and climate-related ecology, which are crucial for the occurrence of *Hericium flagellum* in Europe (Kujawska et al. 2021). This fungus is listed on the Red List of Polish fungi and is considered an umbrella species characteristic of old silver fir forests. In this study, we used bioclimatic niche modelling to determine the potential range of the fungus based on climatic data and the occurrence of the host tree silver fir. More than half of the silver fir records were located in protected areas. However, the key factors for the occurrence of the fungus are the distribution of silver fir, the precipitation of the driest month, and the average annual temperature. We conclude that the factors threatening the fungus are the disjunctive range of silver fir, which is connected with the lack of old dead wood of the tree and the limited possibility of spreading the fungal spores.

I am also a coauthor of a study describing a new species of fungus, *Coprinopsis rugosomagnispora* (Gierczyk et al. 2018). In this study, I was responsible for the preparation of the ITS sequence of the newly described taxa, submission of the holotype sequence in the NCBI database and the preparation of a set of sequences for phylogenetic analyses of the genus *Coprinopsis*, showing the genetic distinctiveness of *C. rugosomagnispora*.

Memberships in Editorial Boards:

Since the beginning of 2021, I have been the Coeditor-in-chief of the journal Dendrobiology (JCR, $IF_{2019} = 1.375$). At the same time, I was appointed to the Editorial Board (as Topic Editor) of the Plants journal (JCR, $IF_{2019} = 2.762$). From 2020, I am also a member of the Scientific Council of the Institute of Dendrology of the Polish Academy of Sciences in Kórnik.

SUMMARY
My most important scientific achievements are:

- Updating or preparing maps of the current distribution of *Clathrus archeri*, *Suillus lakei*, and 2 North American Rhizopogon taxa (*Rhizopogon salebrosus* and *R. pseudoroseolus*) on regional and continental scales, in native ranges and in regions where the species has also been introduced;
- A collection of more than fifty-five herbarium specimens of Australian *Clathrus archeri*, which have been used in the present studies, as well as a collection of 288 DNA isolates of fungal specimen vouchers from Europe, Australia, New Zealand, and North America, which will be used in the ongoing OPUS project;
- Development of models showing the potential distribution of the alien fungi Europe, Australia and New Zealand;
- The first historical biogeography study of fungi, presenting the distribution of *C. archeri* during Last Glacial Maximum, and one of the few studies showing the effect of global climate changes on the distribution of fungi in the future.
- Reported for the first time the presence of *Rhizopogon salebrosus* in Poland and *R. pseudoroseolus* in Australia, demonstrating their potential invasiveness in place of introduction.

During my earlier work, I carried out my scientific activity at two academic organizations: the Institute of Dendrology of the Polish Academy of Sciences in Kórnik (in 2009-2015 and 2018 to date) and a postdoctoral fellowship at the Faculty of Biology of the University of Gdańsk (2015-2018). At that time, I was (and I am) leading three projects (2012-2015 PRELUDIUM, 2015-2018 FUGA, 2020-2024 OPUS) financed by the National Science Center. The total value of the funds received from the National Science Center is nearly PLN 3 million. Thanks to the obtained funding and in the course of researching other studies, I published 22 articles indexed on the JCR (Clarivete Analytics) list, 17 of which were created after my doctoral dissertation. Five of them constitute the presented scientific achievement. I am also the author of five chapters in monographs and popular science articles that appeared before my graduation and after completing my doctoral studies. Additionally, I am the editor of one monograph.

During my 10-year research work, I submitted 482 ITS and LSU nucleotide sequences of several fungal taxa to the NCBI and UNITE databases, including sequences of a newly discovered *Coprinopsis rugosomagnispora*, as well as sequences representing the first records of *Rhizopogon* taxa in Poland and Australia.

	Article type	**No. of articles**		
		Before PhD (1)	**After PhD (2)**	**Sum (1)+(2)**
1.	Original papers publish in journal listed in JCR	5	19	24
2	Original papers publish in journal other than listed in JCR	1	2	3
3	Editing a monograph	0	1	1
4	Chapters in a monographs	1	4	5
5	Popular science articles	2	8	10
	Altogether	**9**	**34**	**43**

A. Summed Impact Factor of articles based on Journal Citation Reports (JCR) list, in the year of publication: **53,479**;
B. Sum of points based on the list of articles published by Ministry of Higher Education:

385 points (based on the list published January 25. 2017) and

990 points (based on the list published Febryary 9. 2021)

C. Number of citations besed on Web of Science (WoS): 237;
without self-citations: 204 (28. May 2021)

D. index Hirsch Index based on Web of Science (WoS): **9** (28. May 2021)

E. Principal investigator in three project, in next tree coinvestigator;

F. International and others awards:
- National Conference "Polish traditions of mushroom use and their protection as a contribution to European cultural heritage", 3-5 November 2011 Łódź - 1st place in the competition for the best poster
- International Conference on Mycorrhiza - ICOM 7, 6-11.I 2013 New Delhi, India Larry Peterson Award for the best poster,
- 2nd-degree award in the PTB competition "Young Researchers Award" awarded by the Board of the Polish Botanical Society in 2013
- Obtaining the award of the Scientific Council of the Institute of Dendrology of the Polish Academy of Sciences "The structure of mycorrhizal fungi communities of the English and sessile oak in the area of the Krotoszyńska Plate", Kórnik, June 14, 2013,
- International Conference of Young Scientists "Nature-Forest-Technology" 6-8.IX 2013, Poznań - 2nd place in the competition for the best poster,
- Workshops of the Polish Mycological Society "Mushrooms - key organisms for life on Earth", Polish Mycological Society, September 24-28, 2014 Łódź, distinction in the competition for the best paper,
- Award of the Director of the Institute of Dendrology of the Polish Academy of Sciences for a significant contribution to the publishing achievements of the Institute in 2015-2018, Kórnik, 19 December 2019,
- Nomination for the “Scientist of the Future Award 2021” in the category: Science for a better life in the future. 3. March 2021, Tychy, Intelligent Development Center

G. Participation in 9 international and 25 national conferences, with four lectures at international conferences and nineteen at national conferences (including two invited lectures).

6. PRESENTATION OF TEACHING AND ORGANIZATIONAL ACHIEVEMENTS AS WELL AS ACHIEVEMENTS IN POPULARIZATION OF SCIENCE OR ART

Teaching achievements and contributions regarding dissemination of science

During my previous work (at the Institute of Dendrology of the Polish Academy of Sciences and the Faculty of Biology at the University of Gdańsk) I had limited possibility to teaching. Institute of Dendrology is an academic organization without regular studies and teaching. During my stay at postdoctoral fellowship I could not provide regular lessons and lectures because of formal circumstances connected with position of Assistant Professor (FUGA project conditions precluding regular teaching). However my achievements in this issues are presented as follows:

Classes and lectures:

- conducting “green lessons” and guided tours as part of the didactic activity of the Arboretum of the Institute of Dendrology of the Polish Academy of Sciences in 2009-2013,

- lectures within educational program of the University of Gdańsk "Invite a Scientist to School" in 2015-2017, a total of 30 hours.

- lectures on the subject "Selected aspects of plant protection" at postgraduate studies "Valorization and protection of natural areas" at the Faculty of Biology of the University of Gdańsk in the academic year 2017-2018 - 6 hours.

- lectures on the subject "The Hidden Life of Mushrooms" at postgraduate studies in "Silviculture" at the Faculty of Forestry of the University of Life Sciences in Poznań in 2019, 2020, 2020 - 8 hours.

Scientific supervision of students:

As a formal supervisor of Bachelor Thesis dissertations:

- Robin Wilgan „Ectomycorrhizal community composition of *Carya lacinosa* (F. Michx._ G.Don) and *C. cordiformis* (Wangenf.) K.Koch) – in quest of alien symbiotic fungi”, Faculty of Biology, Adam Mickiewicz University in Poznań 2014;
- Aneta Ladach „Ectomycorrhizal community composition of silver fir in Kłodzka Volley”, Faculty of Forestry, University of Life Sciences in Poznań 2015;

As a formal supervisor of Master Thesis dissertations:

- Aneta Ladach “Ectomycorrhizal community composition of silver fir (*Abies alba* Mill.) in its native range”, Faculty of Forestry, University of Life Sciences in Poznań, 2017;
- Michał Leski, temat „Impact of acorns preparation on ectomycorrhizal community of oak seedlings in early stage of growth”, Faculty of Forestry, University of Life Sciences in Poznań, 2020;

As a co-advisor of PhD students:

- M.Sc. Robin Wilgan, „Interaction between exotic deciduous trees and native mycorrhizal fungi”, Institute of Dendrology PAS. Dissertation opened in 2019;
- M.Sc. Joanna Korybut-Orłowska „The influence of forest management on the ectomycorrhizal fungi communities of acid beech forests”, Faculty of Biology, University in Gdańsk, 2014. Dissertation opened in 2019.

Presentation organizational achievements:

Participation in conferences Organizing Committee:

- 23.X 2016 Kraków. Conference of Young Scientists "Environmental threats. The view of young scientists ",
- 26.X 2016 Kraków. Conference of Young Scientists "Biological and Chemical Sciences. The view of young scientists ",

- 10.IX 2017 Gdańsk. Conference of Young Scientists "New challenges for Polish Science. 2nd edition",

Participation in conferences Scientific Committee:

- 23.X 2016 Kraków. Conference of Young Scientists "Environmental threats. The view of young scientists",
- 2016-2017 Conference of Young Scientists "The influence of Young Scientists on the Achievements of Polish Science. 10th edition" (Warszawa, Wrocław, Kraków, Poznań),
- 2017 Conference of Young Scientists "Scientific achievements of PhD students. 5th edition" (Warszawa, Kraków),
- 10.IX 2017 Gdańsk. Conference of Young Scientists "New challenges for Polish Science. 2nd edition",
- 9.XII 2017 Kraków. Conference of Young Scientists "Biology, Chemistry and Environment. View of Young Scientists. 1st edition",
- 2017-2018 Conference of Young Scientists " New challenges for Polish Science. 2nd edition"- (winter session)
- 2018 Conference of Young Scientists "Scientific achievements of PhD students. 6th edition" (Warszawa, Poznań, Kraków),
- 2018 Conference of Young Scientists " New challenges for Polish Science. 4th edition",
- 8.IX 2018 Gdańsk. Conference of Young Scientists " New challenges for Polish Science. 3nd edition",
- 2019 Kraków. Conference of Young Scientists "Topis' and results analysis of research of the Young Scientist. 1st edition",
- 2019 Conference of Young Scientists "Scientific achievements of PhD students. 7th edition".

Presentation in popularization of science or art

Popular science articles:

- **Pietras M.** 2010. Osobliwy okratek - Zamorski grzyb odnaleziony na terenie Nadleśnictwa Piaski w Wielkopolsce [Stinkhorn octopus - Oversea fungus found in the Piaski Forest District in Greater Poland]. Las Polski. 11: 16.
- **Pietras M.** 2012. Obce grzyby niepatogeniczne w polskich lasach [Alien non-pathogenic fungi in Polish forests]. Las Polski 15-16: 26-27.
- **Pietras M.** 2017. Wśród gór, pastwisk i...plantacji [Between the mountains, grasslands and ... plantations]. Głos lasu 7-8 (560): 42-45.
- **Pietras M.** 2017. Czego oczy nie widzą [What the eyes cannot see]. Głos lasu 1(554): 40-41.
- **Pietras M.** 2019. Obcy są wśród nas [Aliens among us]. ACADEMIA – Magazyn Polskiej Akademii Nauk 3-4: 38-43.
- **Pietras M.** 2019. Gatunki obcego pochodzenia – wiemy, co dalej! [Alien species - we know what to do!] Las Polski 12: #28.
- Leski T., Wilgan R., **Pietras M**., Karliński L., Rudawska M. 2019. Podziemny świat grzybów ektomykoryzowych [The belowground world of ectomycorrhizal fungi]. Las Polski 24: 20-21.
- **Pietras M.** 2020. Czas na klimat. Wędrówki grzybów [Time for a climate. Fungal trips]. Głos Lasu 7-8: 26-28.
- **Pietras M.**, Szwed-Pietras K. 2020. Obce gatunki grzybów w Ogrodach Kórnickich [Alien fungi in the Kórnik Arboretum.]. Kórniczanin 3: #12.
- Kijowska-Oberc J., **Pietras M**., Ratajczak E. 2020. Dopóki susza ich nie rozłączy [Till drought do them part]. ACADEMIA - The magazine of the Polish Academy of Sciences 2: 26-29.

Others achievements in popularization of science:

Contribution in „Night of Biologists" organized by Faculty of Biology University of Gdańsk in 2016, 2017, 2018 (lectures and preparation of workshops).

Since the beginning of 2020I'm a section editor (forestry and agriculture) of the Magazine of Polish Academy of Sciences „ACADEMIA".

In addition to the above-mentioned activity, I gave an interview for the website Science in Poland [NaukawPolsce] (PAP link) and talk about occurrence and distribution of alien non-pathogenic fungi. This material was widely shared on many websites.

In 2019, together with Dr. hab. Tomasz Leski, I wrote the scenario and commentary as well shared photos for the film "The Life of the Forest. Fungi" produced by the Development and Implementation Center of the State Forests Holding in Bedoń. The license for the film was purchased by polish television (TVP), the premiere of the film is planned for the third quarter of 2021.

Marcin Pietras
……………………………………………
(applicant's signature)