Questionnaire
Summary of the main activities of a research institute of the Slovak Academy of Sciences

Period: January 1, 2016 - December 31, 2021

1. Basic information on the institute:

1.1. Legal name and address

Centrum biológie rastlín a biodiverzity SAV, v. v. i. (Plant Science and Biodiversity Centre SAS)
Dúbravská cesta 9, 845 23 Bratislava

1.2. URL of the institute web site

https://cbrb.sav.sk/

1.3. Executive body of the institute and its composition

Directoriat	Name	Year of birth	Years in the position, from - to
Director	Anna Bérešová	1972	8, 2014 ongoing
Deputy director	Alena Gajdošová	1957	3, 2019 ongoing
Scientific secretary	Andrea Hricová	1970	5, 2017 ongoing

1.4. Head of the Scientific Board

Radoslava Matúšová

1.4.1 Composition of the International Advisory Board

prof. RNDr. Jana Albrechtová, PhD.: Department of Experimental Plant Biology, Faculty of Science, Charles University, Praha
prof. Gerald M. Schneeweiss: Department of Botany and Biodiversity Research, Faculty of Life Sciences, University of Vienna
prof. RNDr. Milan Chytrý, PhD.: Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno
Sándor Bartha, PhD.: Institute of Ecology and Botany, Centre for Ecological Research, Hungarian Academy of Sciences, Vácrátót
Univ. Prof. Mag. rer. nat. Dr. rer. nat. Peter Hietz: University of Natural Resources and Life Sciences (BOKU), Vienna

1.5. Basic information on the research personnel

1.5.1. Fulltime equivalent work capacity of all employees (FTE all), FTE of employees with university degrees engaged in research projects (FTE researchers)

2016		2017		2018		2019		2020		2021		2016-2021	
FTE all	FTE researchers	FTE all	FTE researchers	FTE all	FTE researchers	FTE all	FTE researchers	FTE all	FTE researchers	FTE all	FTE researchers	average FTE all per year	average FTE researchers per year
108,55	63,43	107,28	67,87	105,20	65,74	105,00	63,57	110,20	69,66	109,20	69,65	**107,57**	**66,65**

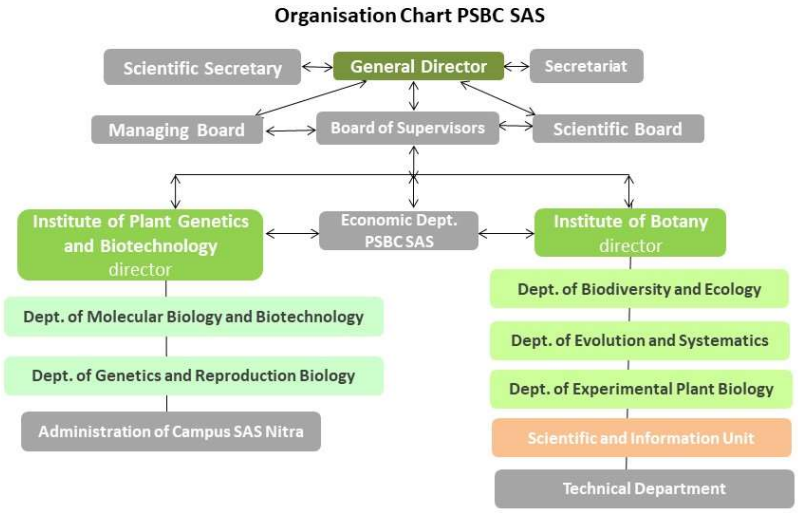
1.5.2. If applicable, add also a short information on the merger of the institute in the evaluation period. You can also add rows in the above table corresponding to the founding institutes

The Plant Science and Biodiversity Centre, Slovak Academy of Sciences (PSBC SAS) was established by merging the Institute of Plant Genetics and Biotechnology of the Slovak Academy of Sciences with the Institute of Botany of the Slovak Academy of Sciences. The Centre was established based on the decision of the Presidium of the Slovak Academy of Sciences no. 1069 on September 8, 2016 with effect from January 1, 2017. It was preceded by the mutual statements of the representatives of the Institute of Botany of the Slovak Academy of Sciences and the Institute of Plant Genetics and Biotechnology of the Slovak Academy of Sciences and the chairpersons of the scientific councils of both institutes, who approved the merger of the institutes and creation of a joint Centre. PSBC SAS is the institution with legal subjectivity. Institute of Botany and Institute of Plant Genetics and Biotechnology are organizational units of the Centre. The motive behind this decision was to enhance the productivity of both involved institutes and improve the quality of research by sharing the infrastructure and methodologies established in both institutes.

The creation of the PSBC SAS was preceded by **communication of the reasons and visions** of both institutes to merge. This was formulated in the internal documents setting common rules:

1) Basic theses of the merge which govern the process of creation and future operation of the Centre, signed by the two directors in October 2016,
2) statutes of the PSBC SAS stipulating basic characteristics of the centre, organisational structure, organs, statutory representative and deputy, academia, managing board, scientific board, financial competencies, etc and
3) the set of obligatory internal regulations in force since January 2017.

PSBC SAS is currently organized as follows:



1.6. Basic information on the funding of the institute

1.6.1. Institutional salary budget, other salary budget[1], non-salary budget[2]

Salary budget	2016	2017	2018	2019	2020	2021	average
Institutional salary budget *[millions of EUR]*	1,350	1,672	1,763	2,039	2,263	2,280	**1,895**
Other salary budget *[millions of EUR]*	0,315	0,088	0,107	0,098	0,094	0,088	**0,132**
Total salary budget *[millions of EUR]*	1,665	1,760	1,870	2,137	2,357	2,368	**2,026**
Non-salary budget *[millions of EUR]*	0,150	1,759	0,122	0,136	0,155	0,165	**0,415**

1.7. Mission Statement of the Institute as presented in the Foundation Charter indicating the years when it was adopted and revised

Foundation Charter of 15 November, 2021
Number: 06163/2021

Main purpose and scope of activities:

1) The scientific research of the PSBC SAS is focused on basic research in the following fields: biosystematics, evolution, taxonomy, biogeography, organismal diversity and ecology. The main objects of research are the naturally growing lower and higher plants and their communities, as well as invasive, non-native and cultivated plants together with selected groups of animals. Besides Slovakia, the Carpathians and the adjacent Pannonian Plain, the research area covers also the Alps, the Mediterranean, Scandinavia, North and South America and Asia. The key research topics include:

a. biosystematics and biogeography of critical groups of vascular plants, fungi and animals, especially endemic, endangered or those that have the edge of their distribution area in Slovakia. We have expanded our research in evolutionary mechanisms of the studied organisms in the context of climate change, their autecology, synecology and as well as in modelling of ecological niches;

b. variability of plant communities in space and time. Apart from syntaxonomy, focus is also given on the research in vegetation changes at different scales, in modelling and prediction of its development, as well as on studying non-native and invasive species. The subject of research is the relationship between vegetation and environmental factors, including human impact and climate change.

The research activities aim to understand the flora, mycobiota and selected components of fauna on the territory of Slovakia, as well as in adjacent areas of Europe and/or the world, thus that we can maintain their irreplaceable functions in ecosystems, as well as the services and benefits to society of a significant economic value. The territory of Slovakia is one of the richest in Europe in terms of diversity of native flora – about 32% of the total number of species reported from Europe grows here. It is a crossroads of biogeographical regions and migratory routes of organisms and one of the northernmost centres of endemism in Europe. Our task is to explore and highlight these unique natural values of our country.

2) Plant genetics, biotechnology and physiology. The key research topics are:

a. study of hybridological relationships, genetic variation and biodiversity of some woody plants;

b. exploration of the possibility of modifying the plant genome by transferring foreign genes to economically important crops in order to improve their performance and increased resistance to pathogens, examination of the expression of introduced genes and factors influencing the expression;

[1] Salary budget originating outside the regular budgetary resources of the organization, e.g. from the project funding.
[2] Includes Goods and Services and PhD fellowships

c. use of transgenosis for a more detailed characterization of the role of individual plant genes in the processes taking place in plants during development, growth and under conditions of biotic and abiotic stress;
d. testing genomes of selected plant species to identify genes responsible for the desired traits;
e. functional genomics of plants, especially during the development of embryos in the framework of zygotic, somatic and gametic embryogenesis
f. study of plant regeneration in *in vitro* culture at the structural, biochemical and molecular levels in order to extend the knowledge on the processes of plant development regulation, especially in the field of sexual and asexual embryogenesis of higher plants;
g. reproduction and mapping of genetic resources obtained by biotechnological approaches;
h. stress physiology: experimental study of the structure and functions of plant organisms at different levels of their organization and their responses to abiotic and biotic factors in order to know the causal relationships and mechanisms of ongoing processes and their regulation.

Scientific activities are focused on the field of plant propagation *in vitro* for the purpose of routine application for rapid and economically advantageous clonal propagation of planting material of economically important crops and for the mass multiplication of valuable genotypes for the needs of breeding and cultivation practice. The field of reproductive and developmental biology is focused on understanding the regulation of developmental processes at the cytological and molecular level in economically important crops in order to control the regulation of these processes in the desired direction.

Targeted gene transfer into plant genomes using the *Agrobacterium tumefaciens* system together with mutation techniques will significantly contribute to streamlining the breeding process and will improve the performance of economically important crops. The result will be the creation of new valuable genotypes, their efficient multiplication using *in vitro* cultures and their integration into agricultural production. At the same time, the acquired knowledge will enable a more detailed characterization of the processes taking place in plants during their development and growth or even under conditions of biotic/abiotic stress.

Research in the field of systems biology, genomics and proteomics is focused on the characterization of the genotypes with desirable traits and potential application in plant biotechnology as well as identification of unexplored plant genetic resources. It will allow to identify key components important for food and nutrition. Monitoring the response of plants to biotic and abiotic stressors, as well as the study of plant adaptation mechanisms to adverse conditions, will ultimately lead to more efficient breeding efforts and regulation of plant cultivation conditions so as to achieve maximal yield and quality production.

3) PSBC SAS creates a basic knowledge base for complex research of ecosystems on various geographical scales (local, regional, continental) and for scientifically justified protection, rational use and management of nature and landscape. In the field of research and application of biotechnological methods, the PSBC SAS contributes to the efficient production of attractive and economically valuable genotypes of agricultural crops and woody plants and to increasing the food security of the country.

4) PSBC SAS provides consulting and expert services related to the main activities of PSBC SAS.

5) PSBC SAS conducts PhD studies as an external institution for doctoral studies in accordance with legal regulations.

6) PSBC SAS supplies the publication of the results of scientific research activities through periodicals and non-periodicals in accordance with the resolution of the Presidium of SAS.

7) PSBC SAS houses scientifically important collections that are included in the international list Index Herbariorum under the acronym "SAS". The collections represent objects of significant scientific, cultural-historical and financial value. PSBC SAS has been building e-infrastructure

(botanical information resources) for a long time, including the Slovak Vegetation Database (SVD) in Slovakia; Non-native plant database (DASS); Slovakia Flora Database (DataFloS); Karyological database of ferns and seed plants of Slovakia; DNA barcoding of aquatic fauna of Slovakia (SKBAF); World Elmidae database. PSBC SAS manages an internal collection of microorganisms storing commercial bacterial strains for both cloning and expression as well as the agrobacterial strains for plant transformation that have been or are being used for experimental purposes.

8) PSBC SAS cooperates with the decision-making sphere, especially with the State Nature Conservancy of the Slovak Republic and the Ministry of the Environment of the Slovak Republic in the implementation of inventory research, creation and assessment of national and European lists of rare, endangered and legally protected species and habitats, in the zonation of national parks, preparation of management models for the maintenance, protection and restoration of habitats, in the development of care programs for protected areas, etc. The results of scientific research are the basis for fulfilling Slovakia's obligations as a signatory to the Convention on Biological Diversity (CBD), for fulfilling its obligations to European legislation, especially in relation to the NATURA 2000 system (e.g. Council Directive 92/43 / EEC on habitat protection, Council Directive 79/409 / EEC on the conservation of wild birds, the emerging Directive on the regulation of non-native species (Water Framework Directive 2000/60 / EC) transposed into national legislation, or the implementation of the Global Plant Protection Strategy 2011-2020.

9) PSBC SAS cooperates with the agricultural sector through the AgroBioTech Research Center at the IPGB PSBC SAS as a partner of the Slovak University of Agriculture in Nitra and the University of Constantine the Philosopher in Nitra. In addition to basic and applied research, the activities are also focused on monitoring the interest and needs of practice in the field of plant biotechnology and on the offer of services and knowledge for agricultural practice in the form of professional advice.

10) PSBC SAS organizes scientific events, conferences, workshops, seminars and trainings within the scope of the performed research.

The mission is revisited and revised during the preparation of strategy and action plan, so far for two periods: 2016–2020 and 2021–2025. Adopted mission statement for current period:

PSBC SAS is a public research institution whose scientific research is focused **mainly on basic research** with an outreach towards applications. It consists of two organizational units – the Institute of Botany (founded in 1963) and the Institute of Plant Genetics and Biotechnology (founded in 1990). The research teams study the spectrum of biotic components of the environment (mainly plants, fungi, insects, and fish), formulate hypotheses to discover new knowledge, bring it to the society, and to contribute to improving life in various spheres (e.g. environment, economy, education). Researchers are also involved in the pedagogical process, especially in educating students at all levels of higher education – bachelor's, master's and doctoral and duly popularizing the results of their research. On national level, PSBC SAS coordinates research of flora, keeps the second largest herbarium and fungal collection in Slovakia, curates the plant database DataFlos, publishes two major monograph series – Flora of Slovakia (Flóra Slovenska) and Vegetation of Slovakia (Rastlinné spoločenstvá Slovenska). Researchers are editors of WOS journals Biologia and Plant Systematics and Evolution.

Our **mission towards society** is to help solve complex problems, while providing mainly knowledge about biodiversity – flora, vegetation, mycobiota and animals in relation to their distribution range, evolution or abiotic factors. This is important for recognizing and safeguarding the irreplaceable functions of these organisms in ecosystems. Through ecosystem services they provide invaluable economic benefits to society. We challenge the frontiers of knowledge, explore unique natural values, draw attention to them and put the knowledge into a broader context. We study the components of biodiversity in terms of ecology, genetics, physiology, molecular biology, or biotechnology. This paves the way for applications of the results of research e. g. in agricultural and forestry practice, nature protection or in the production and

preparation of healthy food or materials with the required properties. With the growing human impact on the environment, it is essential to link sociological research with biologists and environmentalists to know these processes' effects on society as a whole. The challenges posed by global change, reflected in the distinction between the "social" and the "natural" world, require more than occasional multidisciplinary collaboration from scientists. That is why linking such cooperation is irreplaceable in our plans and projects to emphasize the role of various field branches concerning environmental change and identify the relationships between the people, institutions, technologies, and ecosystems that form a society. Combination of different scientific disciplines with the potential to solve the problems of adapting to a transforming world. It should bring a new perspective on detecting important biodiversity centres, the processes taking place in them, and the factors influencing their development, and help effectively monitor the environment or evaluate ecosystems and the services they provide. We support several Citizen Science activities.

PSBC SAS is an external educational institution and, in contractual cooperation with universities, participates in the implementation of several doctoral study programmes. Our mission is to educate a) well-prepared scientists who understand the concept of excellence of scientific work; who recognize scientific production of excellent international teams in their field; have experience with work in international teams and labs; and are able to prepare their own project; or b) well-prepared expert for the application sphere, including nature protection. The researchers are consultants of PhD theses of students from universities abroad. We establish cooperation with foreign universities for Cotutelle doctorate.

PSBC SAS at the national level, cooperates directly with decision-making bodies such as Ministry of the Environment SR, Ministry of the Interior SR, professional state institutions such as State Nature Protection SR, National Agricultural and Food Center, Research Institute of Water Management and also with several universities – Comenius University in Bratislava, Slovak University of Agriculture in Nitra, Constantine the Philosopher University in Nitra, Slovak University of Technology in Bratislava, Technical University in Zvolen, Pavel Jozef Šafárik University in Košice. The activities also focus on monitoring the interest and needs of practice in the field of plant biotechnology, or monitoring and evaluation of the state of biodiversity, and on offering services and knowledge PSBC SAS acts as a national focal point for the coordination of biodiversity activities (CBD-GTI, CETAF, GBIF, IAPT, KEW, IUCN). In terms of species, vegetation and other databases, it represents a key player not only on a European but also on a global scale, which duly reflects the numerous international cooperation and publication outputs of these major collaborations. PSBC SAS actively cooperates with NGOs that work on implementation of practical conservation actions focused on NATURA 2000 areas in Slovakia (e.g. Daphne – Institute of Applied Ecology and BROZ).

1.8. Summary of R&D activity pursued by the institute during the evaluation period in both national and international contexts. Describe the scientific importance and societal impact of each important result/discovery. Explain on general level – the information should be understandable for a non-specialist (recommended 5 pages, max. 10 pages for larger institutes with more than 50 average FTE researchers per year as per Table 1.5.1.)

The scientific activities of the PSBC SAS target **basic as well as applied research** in the fields of plant sciences as well as biological sciences with relevance to different groups of organisms and environments, where they live. The scope is focused to evolutionary processes, systematics, biodiversity, phylogeography, ecology, phytocoenology, population genetics, plant physiology, genetics, molecular biology, proteomics, biochemistry, as well as plant biotechnologies and their use in practice. **Our research addresses European research challenges**, i.e. 1) environment and climate, including the topics linked to biodiversity and digitization, ecosystems and natural resources; and 2) sustainability of production of food system linked to biotic and abiotic stress. The research is performed within the Centre in **two organizational units:**

1) **Institute of Botany**: Department of Biodiversity and Ecology, Department of Experimental Plant Biology, and Department of Evolution and Systematics

2) **Institute of Plant Genetics and Biotechnology**: Department of Molecular Biology and Biotechnology, and Department of Genetics and Reproduction Biology.

Below, we list a selection of the most important results in the international context, that advance the state of knowledge.

The most important results in Annual reports of SAS, Scientific Section 2 - Life, Chemical, Medical and Environmental Sciences

2020 International cooperation: Soybean recovery from stress imposed by multigenerational growth in contaminated Chernobyl environment. Researchers: Miroslav Perniš, Katarína Klubicová, Maksym Danchenko. FP7-PEOPLE-2013-IRSES

A comprehensive comparison of seed proteomes and photosynthetic indices of leaves between soybean grown in a radionuclide-contaminated field, followed by a clean ground recovery season, allowed us to formulate a hypothesis explaining the effects induced by chronic ionizing radiation. We suggested that low-quality seed provisioning caused a detrimental effect persisting in the offspring generation. Energy flow was restricted at least partially because of suboptimal photosynthesis in the vegetative stage. We proposed future experiments for direct functional testing of an idea about compromised immunity against phytopathogens in the field, but perhaps even primed in the clean ground. We envisioned a prospective study on post-translational modifications of proteins, particularly assays on oxidative stress-related carbonylation, to discover the mysterious nature of the damaging factor. The potential of data includes application in biotechnology, targeting the engineering of crops for the phytoremediation of contaminated areas.

2019 Basic research: Evolutionary mechanisms and taxonomy of the genus *Russula*. Researchers: Slavomír Adamčík, Miroslav Caboň. APVV-15-0210

Symbiosis is one of the most important ecological functions of fungi, and ectomycorrhiza is a particularly impotant symbiotic interaction for forest ecosystem. *Russula* is the most diverse and important genus of ectomycorrhizal fungi globally and is distributed in all forest types and continents. Its species diversity is estimated at at least 2,000 species worldwide. In many evolutionary lines of this genus, the species evolution has proceeded rapidly. We showed that the main driving force of evolution of the study group is adaptation to local climatic and ecological conditions in combination with geographical disjunctions.

2017 Problem solving for social practice: VISITOR – smartphone app for collection and sharing of data on invasive plants and animals with public involvement. Researchers: Jana Podroužková, Ladislav Pekárik, Denisa Bazalová, Katarína Botková, Tomáš Čejka, Ivan Jarolímek, Jana Májeková, Mária Šibíková, Mária Zaliberová. COST TD 1209

Biological invasions, closely connected with globalization, are growing geometrically. Alien (especially invasive) species represent a growing problem. They often cause considerable economic and biodiversity losses and their monitoring is of high importance to society. We acquired new data on the distribution, abundance and ecology of the selected alien species involving the public. We have created the VISITOR app (both for Android and IOS), where volunteers can send and store their findings. With an in-built smartphone camera, registered users record the occurrence of the monitored species and after filling out a simple form they send the finding to the database. Each finding is subsequently verified by an expert and verified findings are displayed on the map available to those registered on the website. The app is also a source of information on the monitored species, their descriptions and photos.

Main topics with selected results representing important contribution in international context (the relevant publications listed in the section 2.1.2)

- **Evolutionary processes and relationships with a link to taxonomy**

We worked on **ancestral state and ancestral area reconstructions analyses** of the genus *Picris* (Asteraceae). The specific goal was to **elucidate the role of intrinsic and extrinsic traits in the diversification dynamics and explanations of the bipolar transcontinental disjunctions** in this genus. Although the resulting nuclear and organellar phylogenies uncovered rather well-resolved phylogenies, several incongruent topologies, indicating the

presence of recent or ancestral reticulation events, have been identified. Reconstructions of ancestral states reveal that the most recent common ancestor of the genus was a semelparous and heterocarpic plant that lived in the unpredictable environmental conditions of North Africa and/or West Asia. Diversification analyses indicated that a dramatic shift in speciation occurred approximately 1 million years ago, most likely in conjunction with the start of the mid-Pleistocene revolution. Characteristics of longevity are associated **with the evolution of specific fruit kinds and with environmental factors. Heterocarpic** taxa are predominately semelparous herbs that grow in unpredictable environments, whereas **homocarpic** taxa are dominated by iteroparous plants that grow in predictable environments. Binary-state speciation and extinction analyses indicate that homocarpy, iteroparity, and predictability of habitats all contribute to the acceleration of diversification. Although multiple lineages exhibited homocarpy and iteroparity, only members of the *P. hieracioides* group colonized Eurasia and expanded to Australia by transoceanic dispersal.

We explored **links between assumed heteroploid gene flow and the evolution of sexual polymorphism** (**gynodioecy** – simultaneous presence of female and hermaphrodite individuals within a single species) in the diploid-tetraploid *Stellaria graminea*. **We hypothesized** that gynodioecy is present only in polyploid cytotypes and thus tested whether it contributes to the establishment of polyploid cytotypes in *S. graminea* by triggering differential evolution of floral shape, genome size, and shifts in ecological niches. We confirmed diploid and tetraploid levels for this species, with both cytotypes often co-occurring in heteroploid populations. Nevertheless, with a single exception, no odd ploidy level cytotypes were discovered and can not explain the male (complete sterility) of some individuals in populations. Contrary to predictions, gynodioecy occurs equally in diploids and tetraploids, implying that this reproductive strategy was most likely not engaged in the polyploid establishment. We found that in *S. graminea*, gynodioecy results in floral morphological divergence between females and hermaphrodites, most likely as a result of sexual selection. Females with diploid or tetraploid genomes have larger genomes than hermaphrodites, which might indicate the evolution of (proto) sex chromosomes. Ecology differs between cytotypes, and to a lesser extent, between sexes, suggesting that the link between environment and the presence of females is indirect and likely explained by other aspects of the species' life history.

We **searched for mechanisms** that have shaped evolution and diversification of **recently diverged** species complexes characterized by **substantial ancestral variation, still ongoing interspecific gene flow, and common polyploidization events**. Integrating several approaches – i. e. molecular markers (conventional and NGS techniques), analyses of chromosome numbers, flow cytometry, multivariate morphometrics, ecological niche analyses, and modelling we **highlighted the role of allopatric divergence and ecological diversification** as well as of auto- and allopolyploidization events. We reconstructed polyploid origins and evolution, addressed the role of range dynamics and secondary contacts during the Pleistocene that triggered hybridization and polyploid speciation. We also explored species diversity patterns and evolutionary processes in major biodiversity hotspots, such as the Mediterranean and mountain areas (the Alps, Carpathians, Balkan Mts), showing their significance both as cradles and reservoirs of plant diversity. We have **developed genus-specific Hyb-Seq probes (RNA baits) from transcriptomes and genome skim data**, which target hundreds of low-copy orthologous nuclear loci in these genera, and optimized laboratory protocols. We have used several bioinformatics tools to analyse the Hyb-Seq data, as well as developed new ones to deal with polyploid genomes more efficiently. **AlleleSorting is a newly published pipeline** that performs allele sorting of polyploids into homeologs, corresponding to the subgenomes inherited from different progenitors. This work fully corresponds to current trends in plant systematics and evolutionary biology, as evidenced by published papers.

We have focused on *Cardamine occulta*, an Asian polyploid typically growing in rice fields in Eastern Asia, which has spread as a weed throughout the world, including Europe. Using genomic *in situ* hybridization and comparative chromosome painting, we found that the **octoploid *C. occulta* arose by hybridization** between the allotetraploid *C. scutata* and the autotetraploid *C. kokaiensis*. Except for a few species-specific chromosome rearrangements that likely occurred after the polyploidization events, the parental subgenomes in the

allopolyploids remained stable. We concluded that **the combination of different parental subgenomes adapted to distinct habitats gave the newly evolved polyploids an evolutionary advantage and allowed them to become established and invade new ecological niches**. We identified reliable morphological traits to distinguish all these Asian species from their European relatives. This is particularly useful for tracking the increasing spread of invasive *C. occulta* in Europe.

We also focused on the diploid-polyploid lineages of *Cardamine pratensis* from Central Europe. **We revealed that polyploid species and cytotypes have multiple, spatially and temporally recurrent origins**. Geographically structured genetic lineages that were also ecologically divergent represent descendants from different source populations in multiple glacial refugia. Postglacial range expansion was accompanied by substantial genetic admixture between the lineages, which is reflected by diffuse borders in their contact zones. In conclusion, **we identified an interplay of diverse processes that have driven the evolution of this species complex**, including allopatric and ecological divergence, hybridization, multiple polyploid origins, and genetic reshuffling caused by Pleistocene climate-induced range dynamics.

Balkan biodiversity hotspot harbours numerous *Cardamine* endemics, including the tetraploid stenoendemic *C. barbaraeoides*, we **explored the challenges of phylogenomic analyses of polyploid species**. **We developed a new approach of allele sorting into homeologs** that allows identification of subgenomes inherited from different progenitors. An allopolyploid origin was inferred for *C. barbaraeoides*, highlighting the role of mountains in the Balkan Peninsula as both refugia and melting pots that favoured species contacts and polyploid evolution in response to Pleistocene climate-induced range dynamics. We demonstrated the importance of a thorough phylogenomic approach in studying the evolution of recently diverged species complexes affected by reticulation events at both diploid and polyploid levels.

We **assessed the evolutionary importance of hybridization** showing that *Alyssum* allopolyploids (originating via hybridization) demonstrated higher rates of niche evolution and expanded into different climates than those of their diploid or autopolyploid congeners. The geographical pattern of cytotypes, origin of polyploids and intricate phylogenetic relationships between diploid and polyploid populations and geographic lineages were analyzed to elucidate 1) the origin of tetraploids and hexaploids in *A. montanum* and *A. rhodanense* in western Europe; 2) morphological differentiation of cytotypes, genetic-geographic groups and origin of polyploids in *A. repens* in Southeastern Alps and Carpathians; and 3) the role of glacial range dynamics and secondary contacts between previously isolated diploid lineages, triggering introgression and polyploid evolution and largely contributing to intraspecific genetic diversity.

The Balkan represents the most prominent evolutionary centre of perennial species of *A. montanum-A. repens* complex. We clarified its genetic diversity, distribution and phylogenetic relationships and made substantial changes in taxonomy. Evolutionary relationships and origin of polyploids in 17 annual *Alyssum* species distributed in the Mediterranean and especially in its Aegean diversity hotspot were addressed. Because several of these species, including the closest relatives, occur sympatrically without apparent niche differences, we could reject simple allopatric speciation via vicariance as well as ecological speciation for most cases. We suggested more complex speciation scenarios involving repeated range shifts in response to sea-level oscillations and recurrent land connections and disconnections since the Pliocene.

- **Molecular Ecology and Mycology**

We focused on **distribution potential of the ectomycorrhizal genus *Russula***. We confirmed that ***Russula* members migrated in various time periods and diversified based on geographical and climate disjunctions**. *Russula dryadicola* is a species widely spread in boreal, arctic and alpine areas because its habitats show continuous distribution in the Northern hemisphere, but we also identified a sister taxon *R. tengii* in alpine areas of the south-eastern Himalayas that is probably an endemic species with limited distribution. Studies on biogeography and ecology of ectomycorrhizal fungi require international collaboration which is often inhibited by different approaches caused by isolated research. **To boost collaboration**, we organised international workshop for mycologists and material from 9 countries and 4 continents. **We proposed standards for species description** and applied them to **describe 26 *Russula* species, 22 of them as new to science,** in one single publication. Nearly all studies after this publication have used proposed description standards, which allow **consistent**

comparison of morphological and molecular data globally. As proof of the positive feedback, four students (Colombia, Germany, Pakistan, the USA) visited our lab in 2020 and 2021 and their stays resulted in 7 studies published during the evaluation period.

- **Diversity and distribution of plants and vegetation, large-scale studies**

a) International activities

Since 2006, the Institute of Botany has collaborated with the **Royal Botanic Gardens Kew** on **conservation of the endemic flora of the Carpathians**. The network of six institutions was established (Slovakia, Czech Republic, Poland, Ukraine, and Romania), coordinated by our institute. The primary objective was to save seeds from 500 wild, endangered, and endemic Carpathians species at the **Millennium Seed Bank** Kew by 2022. Additional aims covered biosystematic studies on Carpathian endemics, a database of the endemic flora, and preparing the monograph **Flora Endemica Carpatica**. Between 2019 and 2021, seeds of 269 taxa were collected in Slovakia, Ukraine, and Romania. We collected climatic and phenological data on *Daphne arbuscula* and material from hybrid populations of the genus *Soldanella* as part of our evolutionary and biosystematics studies. A working version of the website for endemic vascular plants in the Carpathians has been created and will be released publicly. International cooperation resulted in a **monograph High mountain vascular plants of the Carpathians - Atlas of distribution** with synthetic maps of high mountain taxa across the Carpathians – an important contribution to Central European phytogeography.

b) National activities

The year 2021 was very important since the long-term project **Plant Communities of Slovakia** was completed. **The final volume 6** summarizes the results of the **research on forest and shrub vegetation**. It comprises a total of 128 associations based on analyzed databased relevés, with synoptic tables, descriptions of their species composition, ecology, and threat. It is an essential reference for researchers, naturalists, conservationists, teachers and students interested in biodiversity. National vegetation survey **is a part of international efforts under the European Vegetation Survey,** merging the knowledge of regional vegetation in European perspective.

Another multivolume series of monographs **Flora of Slovakia** integrates research capacities dealing with plant diversity. It is of particular national and regional importance, summarizing what is known about plant diversity of the Carpathians and Pannonia in the territory of Slovakia; being essential to researchers, naturalists, conservationists, teachers and students interested in biodiversity. We **published Volume VI/4**, covering ca 180 taxa (Amaranthaceae, Polygonaceae, Plumbaginaceae, Primulaceae). We have also completed work on the **Volume VI/2, Part 1** covering ca 200 taxa (Asteraceae). Published volumes are available online via the Biodiversity Heritage Library.

c) Biodiversity e-infrastructures (databases)

Biodiversity e-infrastructures are an essential part of biodiversity science and support education and effective public policies. Effective thematic and geographically delimited databases provide a framework for networking and collaboration among data providers and users. They ensure that all the data is easily **F**indable, **A**ccessible, **I**nteroperable and **R**eusable (**FAIR principles**).

A revision of the vascular plant diversity of Slovakia during 2017–2021 resulted in the **1) monograph The Compendium of the Flora of Slovakia – The Identification Key of Vascular Plants**; and 2) a **new checklist of vascular plant taxa** of Slovakia available as an online database SlovPlantList (https://slovplantlist.sav.sk/). The updated information on origin and invasion status, endemism, category of threat and legal protection is provided. The current database of the distribution data on the Slovak vascular plants (DATAflos), which currently operates on rather outdated software, will be soon replaced by the database Pladias-SK, which will be a clone of the well-established Czech database Pladias (https://pladias.cz/). **We did the first steps to integrate Pladias-SK** within the e-infrastructure. The server with numerous reference indices for Pladias-SK was already installed and currently we are working on the user interface software that will enable the use of the database by the scientific community and public.

Biodiversity studies of water beetles (see the section on aquatic ecosystems) include **building a reference database of DNA barcodes** (application of NGS sequencing and DNA

metabarcoding) **of aquatic biota in Slovakia** (www.aquabol.sk). Recently, we have joined **the European Reference Genome Atlas Initiative (ERGA)**, aiming to sequence whole genomes of European species. So far, we have **provided samples of the unique and rare mayfly *Palingenia longicauda***, whose genome is being analysed in collaboration with the University of Florence.

- **Vegetation ecology – grasslands**

In the study of long-term field experiments with a focus on **mulching of species-rich grasslands** we applied **interdisciplinary approach** employing also environmental DNA data and metabarcoding analyses for soil fungi (CHEGD fungi). This fungal group is **suitable indicator of microbial community changes**, since it prefers natural habitats. **Fungal and vascular plant diversity and richness were lower on plots where mulching or no management were imposed**, suggesting that such management regimes would have a negative impact on grassland fungi. However, not a single treatment covered the total CHEGD diversity of the study, indicating that the **localized use of mulching in addition to traditional managements can enhance the overall diversity of grasslands**. Our results also suggest that **the impact of mulching depends on the mulching season** and it might be reduced by combination with other management treatments. Importance of the study is highlighted by the increased frequency of mulching used as a low-cost method for maintaining remote or abandoned grasslands. Our results provided an **important scientific base to the national working groups for programming of a new Common Agriculture Policy period** (2023-2027).

Protection, enhancement, and potential extension of the biodiversity-rich areas are globally a top priority of policies. The most recent EU Green Deal Call identified biodiversity and ecosystems as key areas capable of improving the quality of the landscape and mitigating the effects of climate change. **Semi-natural habitats** including **grasslands** are among focal ones. We explored **traditional farming practices as promising approaches to support grassland biodiversity** and their sustainable use. We **developed a sampling methodology** to survey traditionally managed grasslands holistically, including abiotic, biological and cultural phenomena, and reflecting the multidimensionality of traditional farming. **Our main objective** was **to search for the connection** between management practices and plant diversity. The **multitaxon vegetation sampling** at seven spatial scales combined with **soil analyses**, detailed **land-use information** derived from interviews with the land parcel owners, **satellite images and historical materials** provide valuable data for several scientific disciplines, including environmental anthropology and ethnology. Examples of grassland management practices based on traditional ecological knowledge can help to **develop** adequate **biodiversity conservation strategies** applicable to rural regions. The data (identifier ID EU-00-032) are stored in the *Grassland with Tradition* database, registered in the Global Index of Vegetation-Plot Databases (GIVD). Currently, they include 38 study sites in 8 countries (Austria, Czech Republic, Slovakia, Hungary, Poland, Romania, Serbia and Ukraine).

Saline grasslands in Slovakia are threatened by both intensification of land use and land abandonment. Using **manipulative field experiments** and **long-term survey** on permanent plots we gathered a **strong evidence that the regular management by grazing** is an important prerequisite for long-term conservation of the habitat type. Study on the regeneration of saline grasslands showed their **vulnerability to any strong disturbance**, but also provided evidence of their **regeneration ability**.

- **Remote vegetation survey**

In collaboration with the Slovak University of Technology we have combined knowledge in satellite image processing, computer modelling, and long-term vegetation research, to **develop the software for habitat** exploration. The software enables **accurate location and classification of Natura 2000 habitats and combines their dynamics with the possibility of immediate detection of sudden changes**. In Slovakia, 642 SACs (Special Area of Conservation; EU Habitats Directive) are included in the Natura 2000. **NaturaSat software can replace field habitat mapping with accurate and fast algorithm work.** It supports **the use of Sentinel-2 multispectral data together with various vegetation databases in a customized environment**, such as vegetation scientists, field experts, and conservationists. NaturaSat software includes powerful new tools e.g. semi-automatic and automatic segmentation methods,

and natural numerical networks, along with validated examples comparing software results and field surveys outputs. The software is robust enough for researchers, decision-makers and stakeholders to **identify target unit boundaries, even at habitat level, as well as to identify new habitat occurrence automatically.** The deep-learning algorithm developed for the classification of habitats within NaturaSat software can also be used for other various research tasks or nature conservation practices, such as the **identification of ecosystem services and conservation value**. Accurate habitat maps obtained from the project can improve many other studies of phytosociology and landscape ecology.

- **Aquatic ecosystems – biodiversity and ecology**

Complex syntaxonomical revision of aquatic vegetation in Slovakia using New Cocktail method revealed the presence of 55 associations. **Macrophytes diversity in four types of water bodies** – rivers, streams, canals and ponds showed that **alpha diversity** was highest in the canals, followed by ponds, while rivers and streams had much smaller diversity. **Beta diversity** was highest in canals and streams, and lowest in ponds, and gamma diversity was highest in ponds. **The most important ecological factors** for the highest alpha diversity of aquatic plants in studied water bodies represented water reaction (rivers), soil conductivity (streams), sand cover (canals) and water turbidity and water depth (ponds). **Twenty aquatic alien plant species (AAP) were found in the territory of Slovakia** with an expected increase to 34 species in next years. Among regional ecological factors, **air temperature had positive effect on AAP species richness** and the occurrence of (semi)natural habitats had negative effect on species richness of AAP. The findings of the **vegetation-ecology studies** demonstrated that **local environmental characteristics**, mainly hydrological connectivity and the presence of water habitats in the surroundings of studied lentic habitats **were the most important variables for nature conservation** management and all water bodies play an important role in the preservation of aquatic plants in the Pannonian-Carpathian region.

Current **rapid loss of natural freshwater habitats** and the unprecedented loss of freshwater biodiversity urge us to study, discover and describe their biodiversity to secure their effective protection. We **summarized worldwide knowledge of aquatic beetles (Elmidae)** in the published **catalogue of Elmidae** and **two chapters** in the monograph. **We updated the taxonomy, number of genera and species of the world fauna of Elmidae and their distributions** and **summarized the latest knowledge of the morphology and systematics**. We have described one new genus and 15 new species from South America. We complemented the descriptions with molecular data (DNA barcoding) in order to analyze biodiversity and monitor its status more efficiently and accurately.

The analysis of population structure and genetic diversity of freshwater arthropods in **Alpine lakes of the Tatry Mts** showed, that these habitats, so far little affected by human activities, can serve as an **important source of genetic diversity**. We demonstrated **significant genetic diversity of the Western Carpathians populations of riffle beetles, caddisflies and amphipod** and the presence of cryptic diversity, which significantly supports the need to protect the studied freshwater habitats as they play an important role in the maintenance of the genetic diversity of the species.

The **sterlet habitats and basic migration patterns in the Danube River** were studied by **acoustic telemetry**. Sterlet displays a migrative behaviour and changes habitats within the year. We demonstrated that **sterlet use habitats that are 5 m and deeper**. We also find out that the **sterlet population is ageing in the Middle Danube, which is negative for its population recovery**. This can also be followed by **low genetic diversity**, especially of stocked sterlets that are stocked regularly. **Climate change** that results in low Danube discharges can **negatively influence the habitat availability for the sterlet**.

Diploid-polyploid complexes of *Cobitis* sp. in Central Europe use asexual gynogenesis alongside sexual reproduction. We studied **habitat differences of available biotypes** where we found slight differences in habitat use in Slovakia. Based on these results, we focused on the Odra River basin in Poland, where both pure diploid parental species are present. We **confirmed the differences in habitat use**; furthermore, we have found out that **species differ in their phenotype, and more surprisingly, also in gene expression**. A detailed look at the gene expression profiles in hybrids uncovered an important pattern, why **the phenotype of hybrids is average**. Instead of reduced gene expression of parental genomes, the gene from one parent is silenced, and the same gene of the second parent is fully expressed

and vice versa. This forms **a mosaic gene expression which results in an average phenotype**. We also contributed to the knowledge of **the karyotype stability in asexual biotypes**.

- **Invasive species and ecosystem synanthropization**

Our research in the hybrid *Solidago* × *niederederi* aimed at **1) survey of historical circumstances** of hybrid discovery, **2)** current **distribution and habitat preferences**, **3) testing the effectiveness of flow cytometry to detect hybrids**, **4) confirmation of the hybrid origin and identification of maternal species**. We showed that the hybrid was first recorded at the very end of the 19th century, recently its occurrence is reported in 17 European countries. *Solidago* × *niederederi* and the parental taxa differ in genome size and that DAPI flow cytometry is suitable to detect these taxa karyologically, although they do not differ in chromosome number. Molecular analyses showed that *S.* × *niederederi* plants are mainly F1 hybrids that appear to have arisen from multiple recent hybridization events and that hybridization between *S. canadensis* and *S. virgaurea* s.s. can occur in both directions.

The genus ***Fallopia*** **(knotweed) is one of the most aggressive invasive groups in Europe**. We studied the distribution of this group in northwestern Slovakia. Our research revealed that the knotweeds include three taxa. Each of them is represented by only one cytotype. The most reliable distinguishing character of *Fallopia* sect. *Reynoutria* taxa is **leaf indumentum**. Analyses showed similarities in leaf morphology between the treated taxa, outlined the most frequent confusions in identification and **clarified ecological preferences** of *F. japonica* var. *japonica* towards habitats along watercourses, due to its exclusively vegetative propagation.

Level of invasion of forest habitats in Slovakia was evaluated. The highest number and cover of aliens were found **in floodplain forests** near watercourses and alien tree **plantations**. Native broadleaved, mixed and especially coniferous forests at higher elevations and ecologically strictly limited forests were less (or un-) invaded. Using the **twin-plot method,** we found out, that **plantations of alien trees** (e.g. *Robinia pseudoacacia*, *Pinus nigra*, *Populus* × *canadensis*) **change microclimatic and edaphic conditions of habitats and consequently affect species composition of original vegetation.** Many native forest specialists retreat and the plantations create suitable environment for numerous alien (also invasive) species and support their spreading and potentially endanger neighbouring forest stands. We proved that **forest management, mainly planting alien trees, could play a key role in the homogenization process because alien trees can act as habitat 'transformers' influencing vegetation through creating different environmental conditions**. Several types of native forests (hardwood floodplain forests, oak forests, and oak-hornbeam forests) have in many Pannonian and Carpathian regions been replaced by *Robinia pseudoacacia* plantations. The replacement plays a crucial role in the homogenization of forest vegetation by unifying microenvironmental conditions of stands, removing the geographically specified variability of plant communities, reducing the total species pool and supporting the occurrence of widespread, generalist plant species in the undergrowth.

- **Plant responses to biotic and abiotic stress and biology of the cell wall in the developmental context**

Parasitic plants represent a specific type of **biotic stress for plants**. Several *Striga* (witchweed), *Phelipanche* and *Orobanche* species (broomrapes), are economically important parasitic weeds with a **negative impact on crop production**. We studied the molecular basis of the interaction between the host plant and the parasite and on key signaling molecules involved in their interactions. The seeds of these parasitic plants will only germinate after induction by a chemical signal exuded from the host plant's roots. **Strigolactones**, a new class of carotenoid-derived **phytohormones**, play a key function in this interaction, although other compounds exuded from the roots of the host may be involved in the interaction. We investigated the biosynthesis of the strigolactones, their detection and functions in the plants and their role in communication with the parasitic plants and other microorganisms.

We studied **tolerance to plant viruses**, frequently causing drastic yield losses. Exploring proteomes of sensitive and resistant cucumber (*Cucumis sativus*) cultivars inoculated with **Cucumber mosaic virus** (CMV), we confirmed existing knowledge and pinpointed new promising targets for future functional characterisation. These target proteins may enhance the

biotechnology arsenal to create host plant genotypes with durable resistance against CMV. Deepening our knowledge of abiotic stress adaptation, we comprehensively compared **seed proteomes and photosynthetic indices of leaves** between soybean (*Glycine max*) grown in a radionuclide-contaminated field, followed by a clean ground recovery season. We suggested that low-quality seed provisioning caused a detrimental effect on the offspring generation. This may contribute to the more robust environmental radioprotection. We envisioned a prospective study on post-translational modifications of proteins, particularly assays on oxidative stress-related carbonylation, to discover the nature of the damaging factor.

We were interested in **how plants overcome** the **toxic effect of heavy metals (HMs)** such as Cd, Sb, As and Ni. We have discovered that **reactive oxygen species** (ROS) generated in barley roots under Cd excess **originate in mitochondria**. Cd generates superoxide by blocking the mitochondrial electron transport chain at complex III. In turn, the site of Cd-induced nitric oxide (NO) generation in roots is not associated with complex III, but ROS originated in mitochondria could be involved in the NO generation under Cd stress. We established that an auxin precursor, indole-3-butyric acid, improves the tolerance of plants to Cd by increasing the glutathione peroxidase activity and the amount of NO. We concluded that NO reduces the superoxide level under the severe Cd stress, leading to the accumulation of less toxic peroxynitrite, thus **reducing the superoxide-mediated cell death**. We found that an **alteration in gene expression** evoked by **mild Cd stress** is **mediated mainly via indole-3-acetic acid signaling**, followed by elevated jasmonic acid and ROS levels. **ROS plays a central role in the early gene expression response** of barley root tip to **severe Cd stress**.

Our previous studies have shown that **Si alleviates the toxicity** of various HMs and metalloids. We studied the role of Si in **phytotoxicity caused by the excess of Ni, As and Sb**. In young maize seedlings, the excess of Ni negatively affected root growth and **evoked the development of root barriers**, which control the uptake and transport of elements into the upper parts of plants. The **application of Si reversed the negative impact** of Ni on root anatomy. We also recorded improved cell membrane integrity, declined ROS production and electrolyte leakage, and enhanced ascorbate-based antioxidant system activity. We focused on the **uptake, translocation and accumulation of As and Sb** in maize, sorghum and *Arundo donax*, a fast-growing perennial grass with potential for **phytoremediation of heavily contaminated sites**. Si enhanced the growth of plants exposed to Sb and restricted the shoot Sb uptake, suggesting that **Si might be used as a component to improve the phytostabilisation efficiency of Sb polluted areas**. We hypothesized that Sb and Si might share the same uptake and translocation pathways. Our results suggested that Lsi1, a protein from the NIPIII aquaporin family responsible for Si uptake in plants, is also involved in Sb uptake since the reduced level of Sb has been detected in the sorghum *lsi1* mutant. Our experiments contributed to understanding the role of Si in alleviating abiotic stress in plants.

We studied **AtIRT1 and AtIRT2 transporters of iron** (Fe) and **other divalent ions** in the *Arabidopsis* root. We showed that AtIRT1 is also expressed in aerial parts, i.e. the phloem companion cells, and that AtIRT2 is more or less root-specific. In aerial organs, Fe did not play such a substantial role in regulating *AtIRT1* expression as in the roots. AtIRT1 was detected in the plasma membrane and organelle membrane fractions of roots under Fe deficiency, but in leaves, the protein was detected mainly in organelle membrane fraction regardless of the Fe status. **We demonstrated the presence of two splicing forms of AtIRT1** from which the long one encodes the plasma membrane protein and the short form of the protein localized in the endomembrane system. In collaboration with IPK Gatersleben, we investigated the interaction of Fe and several HMs. **The excess of these elements mimics effects induced by Fe deficiency**, indicating a disturbance in Fe homeostasis. However, the impact of HMs on Fe homeostasis varied from element to element. These studies suggest that AtIRT1 plays a role in aerial parts and provides a new perspective on how Fe deficiency contributes to the toxic action of individual HMs.

Ni induces gravitropic defects and locally inhibits root growth by suppressing cell elongation via inhibiting shootward auxin distribution via rapidly reducing levels of auxin influx carrier PIN-FORMED (PIN) 2. We studied PINs also in the context of their intercellular trafficking. Using the innovative photoconvertible fluorescence protein technique, we demonstrated that auxins do not inhibit endocytosis of PINs, as it has been believed, and that cycling of both forms of proteins, internalized from the plasma membrane and newly synthesized, was sensitive to Endosidin 2 and Brefeldin A inhibitors.

We studied *Arabidopsis* synaptotagmins, homologs of animal calcium sensors. Most abundantly expressed AtSYT1 is involved in responses to different **biological and abiotic attacks**. We explored how the absence of ATSYT1 affects photosynthesis efficiency under **salt stress**. Almost all parameters (net photosynthesis, the effective photochemical quantum yield of photosystem II, stomatal conductance, photochemical and non-photochemical quenching) were significantly impaired by salt stress, and the *atsyt1* mutant showed inferior parameters to WT. We studied the difference in the abundance of photosynthetic proteins, chlorophylls, carotenoids, and flavonoids. Analysis of stomata indicated that the reduction in photosynthesis was mainly driven by gas availability. AtSYT1 intercellular dynamics were altered by salt stress but not by BFA and Endosidin 2 inhibitors. We characterized by Orbitrap Elite mass spectrometry changes in the proteomic profile of leaf rosette and roots of the WT and *atsyt1* mutant under salt stress. Finally, we examined the previously undescribed *Arabidopsis* synaptotagmins AtSYT3, AtSYT4, and AtSYT5. We revealed that the promoters of individual AtSYTs genes are organ, even cell-specific, and their activities were affected by different physical and chemical factors in both directions. The results were validated at the transcriptional level. Localization studies were performed using the fluorescence protein approach. We isolated several mutant alleles for each synaptotagmin and performed molecular biological analysis and studies on the phenotype of the mutant lines after treatment with different factors.

Molecular function of DEFECTIVE KERNEL 1 (DEK1) calpain protease. Land plants contain the single gene encoding this protease. DEK1 is a multi-domain membrane protein with essential roles in plant growth and development, including embryo patterning, organ morphogenesis, epidermal cell fate maintenance, mechano-sensitive cell wall remodeling and cereal endosperm development. Using targeted mutagenesis via homologous recombination and CRISPR/Cas9 in the model plant *Physcomitrium patens*, **we explored how individual domains contribute to DEK1 activity and hence the progression of distinct developmental programs**. We used inducible gene expression systems combined with proteomics to identify yet unknown substrates of DEK1 calpain protease. For resolving the DEK1 3D structure by X-ray crystallography, we produced recombinant DEK1 domains in heterologous expression systems. The long-term effort was focused on the expression and purification of full-length 240 kDa DEK1 protein, aiming for structure determination using cryo-electron microscopy.

- **unexplored genetic resources – genes with potential in biotechnology**

To find genes for hydrolytic enzymes with potential in biotechnology, we have long been involved in the isolation and characterisation of genes for chitinases and β-1,3-glucanases in carnivorous plants (*Drosera*). We aimed to confirm the role of the isolated genes in digestive processes, to characterize the biochemical properties of the purified proteins, and to test their antimicrobial properties *in vitro* assays and transgenic model tobacco plants. Our results indicate that the genes for the hydrolases can be used for plant protection against phytopathogenic fungi (e.g. *Rhizoctonia solani*, *Alternaria solani*, *Fusarium poae*). The products of chitin cleavage by the chitinase of *Drosera rotundifolia* were a mixture of chitooligomers (tri-, tetra-, and pentamers), of which mainly the pentamers have **potential use in the pharmaceutical industry**.

2. Partial indicators of main activities:

2.1. Research output

2.1.1. Principal types of research output of the institute: basic research/applied research, international/regional (in percentage)

basic / applied: 80%/20%
international / regional: 80%/20%

2.1.2 List of selected publications documenting the most important results of basic research. The total number of publications should not exceed the number of average FTE researchers per year. The principal research outputs (max. 10% of the total number of selected publications, including Digital Object Identifier – DOI if available) should be

underlined. Authors from the evaluated organizations should be underlined.

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1. JÄCH, Manfred A. - KODADA, Ján - BROJER, Michaela - SHEPARD, William D. - ČIAMPOR, Fedor, ml.. *World Catalogue of Insects. Volume 14, Coleoptera: Elmidae and Protelmidae*. Leiden : Brill, 2016. 318 p. Dostupné na: https://doi.org/10.1163/9789004291775. ISBN 978-90-04-29176-8

2. MIREK, Zbigniew - NIKEL, Agnieszka - PIĘKOŚ-MIRKOWA, Halina - COLDEA, Gheorghe - CRISTEA, Vasile - OPREA, Adrian - PUSCAS, Mihai - URSU, Tudor - LETZ, Dominik Roman - MARHOLD, Karol - KAGALO, Olexandr Olexandrovych. *High mountain vascular plants of the Carpathians : Atlas of distribution*. Editor Zbigniew Mirek. Kraków : W. Szafer Institute of Botany, Polish Academy of Sciences, 2020. 406 p. ISBN 978-83-62975-41-9

3. MUŁENKO, Wiesław - BACIGÁLOVÁ, Kamila - KOZLOWSKA, Monika - ŚWIDERSKA-BUREK, Urszula - WOŁCZAŃSKA, Agata - CHMIEL, Maria Alicja. *The Microfungi of the Tatra Mountains and Surrounding Areas. An Annotated Catalogue*. Recenzent Adam Flakus. Kraków : W. Szafer Institute of Botany, Polish Academy of Sciences, 2020. 484 p. ISBN 978-83-89648-70-9

2.1.4. List of monographs/books published in Slovakia

1. Rastlinné spoločenstvá Slovenska : 6. Vegetácia lesov a krovín = Plant communities of Slovakia. 6. Forest and shrub vegetation. Editori Milan Valachovič, Ján Kliment, Katarína Hegedüšová Vantarová ; recenzenti Ladislav Mucina, Milan Chytrý. 1. vyd. Bratislava : VEDA, 2021. 768 s. Vegetácia Slovenska, 6. ISBN 978-80-224-1917-8
2. *Flóra Slovenska VI/4 : Caryophyllales (2. časť), Ericales*. Editori Kornélia Goliašová, Eleonóra Michalková ; recenzenti Ján Kliment, Vladimír Řehořek. Bratislava : Veda, 2016. 778 s. ISBN 978-80-224-1501-9
3. ŠOLTÉS, Rudolf - MIŠÍKOVÁ, Katarína - KLIMENT, Ján - DÍTĚ, Daniel - HOMOLOVÁ, Zuzana - MÚTŇANOVÁ, Marta. *Atlas machorastov Slovenska*. Recenzenti Pavel Širka, Zbyněk Hradílek. Bratislava : VEDA, 2021. 248 s. ISBN 978-80-224-1898-0
4. ČEJKA, Tomáš - ČAČANÝ, Juraj - DVOŘÁK, Libor. *Mäkkýše Bratislavy*. Recenzenti Jitka Horáčková, Marek Čiliak. 1. vyd. Bratislava : Slovenské národné múzeum, 2020. 175 s. Museion, 3. zv. ISBN 978-80-8060-462-2

2.1.5. List of other scientific outputs specifically important for the institute, max. 10 items for institute with less than 50 average FTE researchers per year, 20 for institutes with 50 – 100 average FTE researchers per year and so on

a) Important international collaborations:

1. NOVIKOVA, Polina Yu - HOHMANN, Nora - NIZHYNSKA, Viktoria - TSUCHIMATSU, Takashi - ALI, Jamshaid - MUIR, Graham - GUGGISBERG, Alessia - PAAPE, Tim - SCHMID, Karl - FEDORENKO, Olga M. - HOLM, Svante - SÄLL, Torbjörn - SCHLÖTTERER, Christian - MARHOLD, Karol - WILDMER, Alex - SESE, Jun - SHIMIZU, Kentaro K. - WEIGEL, Detlef - KRÄMER, Ute - KOCH, Marcus A. - NORDBORG, Magnus. Sequencing of the genus Arabidopsis identifies a complex history of nonbifurcating speciation and abundant trans-specific polymorphism. In *Nature Genetics*, 2016, vol. 48, no. 9, p. 1077-1082. (2015: 31.616 - IF, Q1 - JCR, 24.157 - SJR, Q1 - SJR, Current Contents - CCC). (2016 - Current Contents). ISSN 1061-4036. Dostupné na: https://doi.org/10.1038/ng.3617
2. HÁJEK, Michal** - JIMÉNEZ-ALFARO, Borja** - HÁJEK, Ondřej - BRANCALEONI, Lisa - CANTONATI, Marco - CARBOGNANI, Michele - DEDIĆ, Anita - DÍTĚ, Daniel - GERDOL, Renato - HÁJKOVÁ, Petra - HORSÁKOVÁ, Veronika - JANSEN, Florian - KAMBEROVIĆ, Jasmina - KAPFER, Jutta - KOLARI, Tiina Hilkka Maria - LAMENTOWICZ, Mariusz - LAZAREVIĆ, Predrag - MAŠIĆ, Ermin - MOESLUND, Jesper Erenskjold - PÉREZ-HAASE, Aaron - PETERKA, Tomáš - PETRAGLIA, Alessandro - PLADEVALL-IZARD, Eulàlia - PLESKOVÁ, Zuzana - SEGADELLI, Stefano - SEMENIUK, Yuliya - SINGH, Patrícia - ŠÍMOVÁ, Anna - ŠMERDOVÁ, Eva - TAHVANAINEN, Teemu - TOMASELLI, Marcello - VYSTAVNA, Yuliya - BIȚĂ-NICOLAE, Claudia - HORSÁK, Michal. A European map of groundwater pH and calcium. In *Earth System Science Data*, 2021, vol. 13, no. 3,

p. 1089-1105. (2020: 11.333 - IF, Q1 - JCR, 4.066 - SJR, Q1 - SJR, Current Contents - CCC). (2021 - Current Contents). ISSN 1866-3508. Dostupné na: https://doi.org/10.5194/essd-13-1089-2021

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2.1.6. List of patents, patent applications, and other intellectual property rights registered abroad

With an aim to commercialize the protected research results effectively, two „Applications for community plant variety right“ together with „Technical questionnaires“ were sent to the Community Plant Variety Office (CPVO), Angers, France for technical examination (DUS examination) for new varieties 'ZOBOR' and 'PRIBINA' bre by the Institute of Plant Genetics and Biotechnology, PSBC SAS.

1) Application number: A202102479
Breeder's reference: sav-nr-279
Botanical taxon: *A. hypochondriacus* L. x *Amaranthus hybridus* L.
Proposed denomination: 'ZOBOR'
Date of receipt at the Office: 11. 08. 2021

2) Application number: n°A202102086
Breeder's reference: SAV-NR-2
Species name: *Amaranthus cruentus* L.
Proposed denomination: 'PRIBINA'
Date of receipt at the Office: 06. 12. 2021

2.1.7. List of patents, patent applications, and other intellectual property rights registered in Slovakia

The Institute of Plant Genetics and Biotechnology SAS (since 2017 organisational unit of PSBC SAS) acquired a collection of prospective breeding material of *Amaranthus* spp. as

a result of several scientific research projects. The cultivars 'PRIBINA' and 'ZOBOR' have been recognised on the national level as the first variety of amaranth being legally protected in Slovakia in 2016 and 2018, respectively. After decision to merge the Institute of Plant Genetics and Biotechnology SAS with the Institute of Botany SAS under Plant Science and Biodiversity Centre SAS, the right to the variety passed from the Institute of Plant Genetics and Biotechnology SAS to the Plant Science and Biodiversity Centre SAS. The activities in the field of protection of intellectual property rights and technology transfer of the new amaranth varieties are being carried out in cooperation with the Office for Technology Transfer of the Slovak Academy of Sciences.

- The variety **'PRIBINA'** (*A. cruentus* L.) - recorded in a Register of protected varieties under the number **731** on 08. 02. 2016 (https://ktt.sav.sk/en/amaranth-variety-pribina/)
- The variety **'ZOBOR'** (*A. hypochondriacus* L. x *A. hybridus* L.) - recorded in a Register of protected varieties under the number **771** on 21. 03. 2018 (https://ktt.sav.sk/en/amaranth-variety-zobor/)

2.1.8. Narrative on the most important research outputs of the institute – especially focused on their importance for society (3-5 pages)

In the evaluated period, the staff of the PSBC SAS cooperated with domestic and foreign scientific institutions (including COST project networks) and public organisations (State Nature Conservancy, NGOs) in solving a number of research tasks for society. The list of relevant publications is attached, in case not listed in the sections 2.1.2 – 2.1.7.

Freshwater ecosystems: molecular diversity and biomonitoring facilitating novel genetic tools

Freshwater ecosystems are extremely important in terms of global biodiversity. At the same time, they are probably suffering the most from the impact of increasing anthropogenic pressures. The most important part of the research was the analysis of the possibility to use **innovative genetic approaches** in the assessment and monitoring of the biodiversity status of European waters, especially to improve the situation in the implementation of the water- related European Framework Directives (Water Framework Directive, Marine Strategy Frameork Directive). Within international cooperation, we reviewed the current state of monitoring the ecological status of FW ecosystems of Europe, the approaches used, their limits and weaknesses, and evaluated the possibilities of using innovative approaches based on DNA metabarcoding. We reviewed the status of reference databases that allow the identification of FW biota species through **DNA barcodes** and proposed the necessary steps to complete and improve their quality. In addition, we analyzed the genetic diversity of several species (mostly aquatic macroinvertebrates) of FW fauna of the Western Carpathians as an important biodiversity hotspot of Europe, confirming the presence of a significant proportion of cryptic diversity, highlighting the value of the whole area in terms of biodiversity conservation and preservation in the European area.

- LEESE, Florian** - BOUCHEZ, Agnès - ABARENKOV, Kessy - ALTERMATT, Florian - BORJA, Ángel - BRUCE, Kat - EKREM, Torbjørn - **ČIAMPOR, Fedor, ml. - ČIAMPOROVÁ-ZAŤOVIČOVÁ, Zuzana** - COSTA, Filipe - DUARTE, Sofia - ELBRECHT, Vasco - FONTANETO, Diego - FRANC, Alain - GEIGER, Matthias F. - HERING, Daniel - KAHLERT, Maria - STROIL, Belma Kalamujic - KELLY, Martyn G. - KESKIN, Emre - LISKA, Igor - MERGEN, Patricia - MEISSNER, Kristian - PAWLOWSKI, Jan - PENEV, Lyubomir - REYJOL, Yorick - ROTTER, Ana - STEINKE, Dirk - WAL, Bas van der - VITECEK, Simon - ZIMMERMANN, Jonas - WEIGAND, Alexander M. Why We Need Sustainable Networks Bridging Countries, Disciplines, Cultures and Generations for Aquatic Biomonitoring 2.0: A Perspective Derived From the DNAqua-Net COST Action. In Advances in Ecological Research, 2018, vol. 58, p. 63-99. (2017: 4.912 - IF, Q1 - JCR, 2.524 - SJR, Q1 - SJR). ISSN 0065-2504. https://doi.org/10.1016/bs.aecr.2018.01.001

Long-term monitoring: Danube inland delta – operation of the Gabčíkovo waterworks

The results of long-term (23 years) monitoring of structural changes in land snail communities in the area affected by **the operation of the Gabčíkovo waterworks show a direct and long-lasting effect on the direction of the succession of terrestrial molluscan assemblages**, especially in the by-pass section. The changes in the soil moisture led to significant changes in the species and functional composition of these assemblages. The proportion of the generalists preferring dry biotopes increased, the number of moisture-demanding species decreased. Our results indicate that the current artificial flooding system cannot fully replace natural floods once typical in the Danube inland delta, and it is insufficient for restoration and preservation of the humidity in the softwood floodplain forests similar to the pre-operation period of the waterworks. The results are **a solid base to predict the trends in the hydropedological regime of large European rivers**.

- **ČEJKA, Tomáš**** – BERACKO, Pavel – MATEČNÝ, I. The impact of the Gabčíkovo hydroelectric power barrier on the Danube floodplain environment—the results of long-term monitoring of land snail fauna. In Environmental Monitoring and Assessment, 2020, vol. 192, no. 1, art. no. 30. (2019: 1.903 – IF, Q3 – JCR, 0.571 – SJR, Q2 – SJR, CCC). (2020 – Current Contents). ISSN 0167-6369.https://doi.org/10.1007/s10661-019-8008-9

Air pollution: response of sensitive organisms to atmospheric conditions and potential conservation strategies

Biomonitoring of air pollution may help for the implementation of environmental policy on air quality and atmospheric pollution control. How long does it take a lichen to respond to changes (worsening or improvement) of atmospheric conditions is still debated. In the study, a **closure of a solid waste landfill was simulated** by removing lichen thalli from sampling sites subject to different intensities of pollution and exposing them in a remote unpolluted area for 12 months. On the contrary, clean samples taken from the remote area were exposed around the landfill and heavy metals were analysed. The study aimed to find out to which extent the content of heavy metals in lichen samples decreased after the exclusion of the pollution source and oppositely, to which extent the content of heavy metals in samples from the remote area increased after the exposure around the source; whether lichen thalli are able to recover a physiological healthy status and which would be in the long-term the condition of the samples when they remain exposed around the source. We also focused on **sensitive macrolichen**s. The hypothesis that for sensitive forest macrolichens the **translocation is effective** for the conservation of single healthy individuals only in unpolluted environments was verified. The translocation to remote unpolluted areas ensured an effective survival of the thalli after one year only where native thalli were already present, or in remote areas suitable for a well-developed lichen colonization. In such situations, the transplants were successful and did not show evident morphological and ultrastructural alterations. Lichen translocation was not effective to support recolonization where the model species disappeared during 20th century (most of the sites in the Western Carpathians) in presence of current air pollution, as reflected by heavy metals accumulated and the damage endured by the transplants. It should be clear that the translocation of samples might ensure only the conservation of single individuals and/or enhance the colonization of potentially suitable habitats, but requires careful evaluation of niche demands of the target species.

- PAOLI, Luca** - **GUTTOVÁ, Anna*** - SORBO, Sergio - **LACKOVIČOVÁ, Anna** - RAVERA, Sonia - LANDI, Sara - LANDI, Marco - BASILE, Adriana - SANITÀ DI TOPPI, L. - VANNINI, Andrea - LOPPI, Stefano - **FAČKOVCOVÁ, Zuzana***. Does air pollution influence the success of species translocation? Trace elements, ultrastructure and photosynthetic performances in transplants of a threatened forest macrolichen. In Ecological Indicators, 2020, vol. 117, art. no. 106666. (2019: 4.229 - IF, Q1 - JCR, 1.331 - SJR, Q1 - SJR, CCC). (2020 - Current Contents). ISSN 1470-160X. https://doi.org/10.1016/j.ecolind.2020.106666
- PAOLI, Luca - VANNINI, Andrea - **FAČKOVCOVÁ, Zuzana** - GUARNIERI, Massimo - BAČKOR, Martin - LOPPI, Stefano. One year of transplant: Is it enough for lichens to reflect the new atmospheric conditions? In Ecological Indicators, 2018, vol. 88, p. 495-502. (3.983 - IF2017). (2018 - Current Contents). ISSN 1470-160X

Genetic resources – outreach: crop for food security and woody species for economic vitality

The challenge to meet the requirements and ensure the welfare of consumers is to produce and develop high nutritional quality, safe and value-added products. Besides traditional sources, we also **exploit new genetic resources with high content of nutritional components and health-promoting substances**. **Amaranth** is an underutilized crop gaining popularity in the recent past due to its numerous agronomic and nutritional properties. The multidisciplinary research was primarily focused on the identification of advanced mutant lines with an emphasis on their food and environmental utilisation, and search for their potential commercial application. The application of gamma-ray mutagenesis resulted in breeding of the second Slovak variety of this important gluten-free pseudocereal, **preferentially used for food purposes**. After the variety „Pribina" (reported for previous evaluation) a **new variety „Zobor" was registered** (currently property rights at national level). Both of varieties are suitable for Central European cultivation. They exhibit consistently superior performance of principal seed traits over the original and several commercial varieties. The nutrition value is stable, well balanced and comparable to existing varieties. They show long-term high content of oil, squalene and some essential amino acids. We also **tested the potential of new varieties for environmental use in decontamination of heavy metal polluted soils**, which is associated with use of amaranth as food. Varieties were classified as Cd-hypertolerant and can be used in the phytomanagement of Cd-loaded soils. Limited root-to-shoot translocation of this contaminant is important for safe consumption of product made from grain of tested varieties that are preferentially used for food production. In 2020, in the Krásin Agricultural Cooperative, Dolná Súča, the cultivation of amaranth mutant line was performed on an area of 10 ha for silage purposes. The quality of the silage mixture was evaluated as in very high quality. Evaluation and selection of mutagenesis-obtained amaranth lines were carried out in **long-time cooperation with the Prešov University in Prešov** and the **Slovak University of Agriculture in Nitra**. The facilities of the **AgroBioTech**, as the **regional competent center of applied research and development** in the field of agro-bio-technologies, were extensively used. During the evaluation, period we have closely cooperated with the Office for Technology Transfer of the Slovak Academy of Sciences on protection of intellectual property rights and technology transfer of the new amaranth varieties.

- **Andrea HRICOVÁ**, Jozef FEJÉR, **Gabriela LIBIAKOVÁ, Monika SZABOVÁ**, Ján GAŽO, **Alena GAJDOŠOVÁ**, 2016. Characterization of phenotypic and nutritional properties of valuable Amaranthus cruentus L. mutants. Turk J Agric For, 40, (2016), p. 761-771, doi:10.3906/tar-1511-31
- **LANCÍKOVÁ, Veronika** - TOMKA, Marián - ŽIAROVSKÁ, Jana - GAŽO, Ján - **HRICOVÁ, Andrea**. Morphological responses and gene expression of grain amaranth (Amaranthus spp.) growing under Cd. In Plants, 2020, vol. 9, no. 5, art. no. 572, doi: https://doi.org/10.3390/plants9050572

One of the important directions in **horticulture woody plant** growing is the expansion of species diversity through the introduction of low-abundant plant species which are characterized by a complex of economically valuable properties, high content of biologically active substances in the fruit and resistance to stress factors, pests and diseases. In the frame of research focused on clonal propagation of non-traditional small fruit species an effective and long-term collaboration was established with Fruit Research Institute Čačak in Serbia (collaboration in framework of APVV mobility project), Research and Breeding Institute of Pomology Holovousy in Czech Republic. The micropropagation procedures which have been elaborated are directly applicable in horticulture practice for mass propagation of non-traditional berry species using tissue culture.

- **HUNKOVÁ, Júlia - GAJDOŠOVÁ, Alena**. In vitro rooting and acclimatization of *Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roem: Testing of auxin, spermidine, and gibberellin for overcoming dormancy. In Journal of Berry Research, 2019, vol. 9, no. 3, p. 549-561. (2.379 - IF2018).

Research in **woody species** addressed ***in vitro* reproduction process and long-term conservation of rare genotypes** by cryopreservation using somatic embryogenesis (SE) as model system especially in *Pinus* spp. and interspecific hybrids of firs (*Abies* spp.). SE is *in vitro*

technique suitable not only for mass propagation and long-term storage of embryogenic callus but also for the investigation of molecular processes occurring during embryogenesis, mainly on the proteomic level. Along with the study of physiological and structural aspects of SE, the study of secretome influence on increasing embryogenic capacity of selected conifer species was performed. This research was the first one presenting a list of proteins secreted during SE of conifers. On the basis of a comparative analysis of secreted proteins from cell lines with different embryogenic capacity (EC), several potential markers of somatic embryogenesis were proposed. One of them is the peroxidase (POX) activity in the culture medium. In cell lines with high EC, the POX activity showed considerably higher values in comparison to cell lines with low EC.

Based on our previous proteomic results, we started to study **extracellular proteins (EPs) with a potential role of cell wall proteins in SE**. Somatic embryogenesis represents an efficient regenerative system suitable for studying fundamental questions of plant development and a method for the vegetative propagation of conifers using *in vitro* cultures. Cell suspension cultures are suitable for isolating extracellular proteins in non-destructive ways. We focused on studying changes in extracellular protein accumulation that occur during SE in *Pinus nigra* using proteomic and biochemical methods. Our results may lead to a better understanding of the process of SE and suggest the potential markers of embryogenic capacity.

Hybrid swarms are considered **evolutionarily important elements** of world dendroflora. This is primarily due to unique gene pool and, therefore, the ability to respond differently under almost the same selection pressures as those applying in parental habitats. Genetic diversity, adaptive potential and evolutionary prospects of such hybrids are of considerable theoretical and ecological importance. In Europe, this is specifically related to an extremely problematic species or aggregate of microspecies, e. g. *P. mugo* agg. Spontaneous hybridization occurs also with *P. sylvestris*, forming intermediate populations that are phenotypically unstable and hard to delimit. Of the four putative hybrid swarms of *P. sylvestris* and *P. mugo* occurring in northern Slovakia, the three swarms grow on peat-bogs and one on calcareous towers with relic pines. Our **artificial pollination experiments proved partial compatibility of the reciprocal crosses** between *P. sylvestris* and *P. mugo*. In spite of the low efficiency of crossings, it justifies using it for a reasonable basis for emerging the hybrid swarms of the parental species in the nature. The reciprocal crosses were found to exhibit **bimodal inheritance of their chloroplast DNAs**. In the cross *P. sylvestris* × *P. mugo*, cpDNA is inherited paternally, whereas in *P. mugo* × *P. sylvestris* cross, the maternal inheritance was found to operate. As to the crossability between putative hybrid swarm individuals and the parental species, a higher efficiency of crossing of hybrid swarm individuals was exhibited towards *P. mugo* species than to *P. sylvestris*. **Pollen fertility** of the four putative hybrid swarms was found to be lowered considerably with respect to the pollen tube length as compared with an average pollen tube length in the parental species *P. sylvestris* and *P. mugo.* The same is true of seed germination from open pollination. It is believed **that lowered viability of hybrid swarms** is due to **increased frequencies of both meiotic irregularities and abortive embryogenesis** which is a phenomenon of common occurrence in the interspecific hybrids of plants. Inter-Primer Binding Site amplification approach was used in **study of genetic structure and diversity** of 13 populations including parental species and their hybrid swarms. The hybrid nature of putative hybrid swarms was confirmed also on the basis of Simple Sequence Repeats.

Parasitic weeds: problems in agriculture

Parasitic weeds cause large crop losses in many parts of the world. A significant knowledge on parasitic plant life cycle and an explanation for some phenomena that have been observed for the host-parasitic plant interaction were brought during international cooperation under the COST project FA1206. In cooperation with colleagues from the Czech Republic, we have **developed a certified methodology** "Set of laboratory *in vitro* bioassays for testing of bioactive substances from microalgae". The obtained data are related to the issue of biological plant protection with respect to application against serious fungal pathogens, to obtain information on the presence of specific molecules inducing seed germination of parasitic plants, and to detect phytotoxic or phytostimulatory effects on plants. Cooperation with the National Research and Development Institute for Chemistry and Petrochemistry-ICECHIM, Romania, brought important

results in the field of synthesis and characterisation of mimics of strigolactones. This collaboration resulted in an approved joint project funded under the EU FP7 ERA-NET INCOMERA in 2017.

- SMÝKALOVÁ, Iva - SOUKUP, Aleš - ONDRÁČKOVÁ, Eliška - **MATÚŠOVÁ, Radoslava** - HROUZEK, Pavel. Soubor laboratorních testů pro testování bioaktivních látek z mikrořas : certifikovaná metodika (Set of laboratory *in vitro* bioassays for testing of bioactive substances from microalgae – certified methodology). Šumperk: Agritec Plant Research, 2016. 28 p. ISBN 978-80-87360-48-4

Protection of stone monuments from biodeterioration: devitalization of lichens through applicatoin of biocides

Stone monuments – part of cultural heritage, are biodeteriorated by different organisms, including lichens. The effect caused by many epilithic lichen species challenges the aesthetic and threatens the durability of heritage surfaces. Some lichen species are recognized for certain bioprotective effect, as they overgrow the substrate of certain lithologies. However, generally accepted approach is to remove the lichen thalli to preserve the stone monument surfaces. This makes part of standard practice in conservation and restoration plans. As a follow up to activities „Adopt a monument“ (Licheni e Beni Culturali: Adotta un Monument) of the Working Group For Biology (Beni culturali), Società Lichenologica Italiana, research activities targeted the sandstone of the Roman Archaeological site of Luni (Italy). The primary hypothesis that (a) biocide application tools, (b) pre-treatment hydration step, and (c) post-treatment washing may, either singularly or in combination, affect the effectiveness against lichens of biocides having different active principles and dilution solvents was challenged. It was confirmed that the importance of the application tool, with cellulose poultice is more effective than brush. Hydration influenced the biocide absorption by thalli. It also modified the metabolic activity and susceptibility to the available toxic compound, hindering lichens from entering a dormant state to tolerate stress. Depending on the preparation solvent, the biocide application benefited from pre-treatment hydration and/or a post-treatment washing. It was shown that different sandstones variously adsorb the biocides and potentially contribute as a reservoir for their long-term release at low concentrations during successive hydration events.

- FAVERO-LONGO, Sergio Enrico - VANNINI, Andrea - BENESPERI, Renato - BIANCHI, Elisabetta - **FAČKOVCOVÁ, Zuzana** - GIORDANI, Paolo** - MALASPINA, Paola - MARTIRE, Luca - MATTEUCCI, Enrica - PAOLI, Luca - RAVERA, Sonia - ROCCARDI, Ada - TONON, Chiara - LOPPI, Stefano. The application protocol impacts the effectiveness of biocides against lichens. In International Biodeterioration & Biodegradation, 2020, vol. 155, art. no. 105105. (2019: 4.074 - IF, Q1 - JCR, 1.172 - SJR, Q1 - SJR, CCC). (2020 Current Contents). ISSN 0964-8305. https://doi.org/10.1016/j.ibiod.2020.105105

2.1.9. Table of research outputs

Papers from international collaborations in large-scale scientific projects (Dwarf team, ALICE Collaboration, ATLAS collaboration, CD Collaboration, H1 Collaboration, HADES Collaboration, and STAR Collaboration) have to be listed separately

Scientific publications	2016			2017			2018			2019			2020			2021			total			
	number	No. / FTE researches	No. / one million total salary budget	number	No. / FTE researches	No. / one million total salary budget	number	No. / FTE researches	No. / one million total salary budget	number	No. / FTE researches	No. / one million total salary budget	number	No. / FTE researches	No. / one million total salary budget	number	No. / FTE researches	No. /1 million total salary budget	number	averaged number per year	av. No. / FTE researches	av. No. / one million total salary budget
Scientific monographs and monographic studies in journals and proceedings published abroad *(AAA, ABA)*	2	0,032	1,201	0	0,000	0,000	0	0,000	0,000	0	0,000	0,000	2	0,029	0,849	0	0,000	0,000	**4**	**0,667**	**0,010**	**0,329**
Scientific monographs and monographic studies in journals and proceedings published in Slovakia *(AAB, ABB)*	2	0,032	1,201	1	0,015	0,568	0	0,000	0,000	0	0,000	0,000	1	0,014	0,424	9	0,129	3,801	**13**	**2,167**	**0,033**	**1,069**
Chapters in scientific monographs published abroad *(ABC)*	3	0,047	1,802	1	0,015	0,568	**3**	0,046	1,604	1	0,016	0,468	0	0,000	0,000	3	0,043	1,267	**11**	**1,833**	**0,028**	**0,905**
Chapters in scientific monographs published in Slovakia *(ABD)*	8	0,126	4,805	0	0,000	0,000	0	0,000	0,000	1	0,016	0,468	0	0,000	0,000	7	0,101	2,956	**16**	**2,667**	**0,040**	**1,316**
Scientific papers published in journals registered in Current Contents Connect *(ADCA, ADCB, ADDA, ADDB)*	67	1,056	40,240	61	0,899	34,659	49	0,745	26,203	78	1,227	36,500	76	1,091	32,244	81	1,163	34,206	**412**	**68,667**	**1,030**	**33,890**
Scientific papers published in journals registered in Web of Science Core Collection and SCOPUS not listed above *(ADMA, ADMB, ADNA, ADNB)*	31	0,489	18,619	15	0,221	8,523	12	0,183	6,417	14	0,220	6,551	12	0,172	5,091	16	0,230	6,757	**100**	**16,667**	**0,250**	**8,226**
Scientific papers published in other foreign journals (not listed above) *(ADEA, ADEB)*	19	0,300	11,411	4	0,059	2,273	10	0,152	5,348	11	0,173	5,147	7	0,100	2,970	12	0,172	5,068	**63**	**10,500**	**0,158**	**5,182**
Scientific papers published in other domestic journals (not listed above) *(ADFA, ADFB)*	29	0,457	17,417	19	0,280	10,795	10	0,152	5,348	9	0,142	4,212	12	0,172	5,091	9	0,129	3,801	**88**	**14,667**	**0,220**	**7,239**
Scientific papers published in foreign peer-reviewed proceedings *(AECA)*	2	0,032	1,201	1	0,015	0,568	1	0,015	0,535	0	0,000	0,000	0	0,000	0,000	3	0,043	1,267	**7**	**1,167**	**0,018**	**0,576**
Scientific papers published in domestic peer-reviewed proceedings *(AEDA)*	30	0,473	18,018	2	0,029	1,136	4	0,061	2,139	2	0,031	0,936	4	0,057	1,697	0	0,000	0,000	**42**	**7,000**	**0,105**	**3,455**
Published papers (full text) from foreign scientific conferences *(AFA, AFC)*	2	0,032	1,201	6	0,088	3,409	2	0,030	1,070	5	0,079	2,340	0	0,000	0,000	0	0,000	0,000	**15**	**2,500**	**0,038**	**1,234**
Published papers (full text) from domestic scientific conferences *(AFB, AFD)*	15	0,236	9,009	13	0,192	7,386	7	0,106	3,743	8	0,126	3,744	10	0,144	4,243	7	0	3	**60**	**10**	**0**	**5**

2.2. Measures of research outputs (citations, etc.)

2.2.1. Table with citations per annum (without self-citations)

Citations of papers from international collaborations in large-scale scientific projects (Dwarf team, ALICE Collaboration, ATLAS collaboration, CD Collaboration, H1 Collaboration, HADES Collaboration, and STAR Collaboration) are listed separately

Citations, reviews	2015		2016		2017		2018		2019		2020		total		
	number	No. / FTE researchers	number	No. / FTE researchers	number	No. / FTE researchers	number	No. / FTE researchers	number	No. / FTE researchers	number	No. / FTE researchers	number	averaged number per year	av. No. / FTE researchers
Citations in Web of Science Core Collection (1.1, 2.1)	1 883	29,69	2 147	31,63	2 001	30,44	2 232	35,11	2 575	36,97	2 836	40,72	**13 674**	**2 279,00**	**34,19**
Citations in SCOPUS (1.2, 2.2) if not listed above	106	1,67	140	2,06	133	2,02	111	1,75	224	3,22	291	4,18	**1 005**	**167,50**	**2,51**
Citations in other citation indexes and databases (not listed above) (3.2,4.2)	5	0,08	3	0,04	3	0,05	8	0,13	25	0,36	11	0,16	**55**	**9,17**	**0,14**
Other citations (not listed above) (3.1, 4.1)	439	6,92	733	10,80	615	9,36	238	3,74	209	3,00	192	2,76	**2 426**	**404,33**	**6,07**
Reviews (5,6)	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00	**0**	**0,00**	**0,00**

2.2.2. List of 10 most-cited publications published any time with the address of the institute, with number of citations in the assessment period (2015 – 2020)

1. MCNEILL, John - BARRIE, Fred R. - BUCK, Wiliam R. - DEMOULIN, V. - GREUTER, Werner - HAWKSWORTH, David L. - HERENDEEN, Patrick S. - KNAPP, S. - **MARHOLD, Karol** - PRADO, Jefferson - PRUD'HOMME VAN REINE, W. F. - SMITH, G. F. - WIERSEMA, John H. - TURLAND, N. J. *International Code of Nomenclature for algae, fungi, and plants (Melbourne Code) : adopted by the Eighteenth International Botanical Congress Melbourne, Australia, July 2011*. Königstein : Koeltz Scientific Books, 2012. 208 p. Regnum Vegetabile, 154. [Published in Spanish language as Código Internacional de Nomenclatura para algas, hongos y plantas (Código de Melbourne), Madrid: CSIC, 2012]. ISBN 978-3-87429-425-6 **1472 citations**

2. TURLAND, Nicholas J. - WIERSEMA, John H. - BARRIE, Fred R. - GREUTER, Werner - HAWKSWORTH, David L. - HERENDEEN, Patrick S. - KNAPP, Sandra - KUSBER, Wolf-Henning - LI, De-Zhu - **MARHOLD, Karol** - MAY, Tom W. - MCNEILL, John - MONRO, Anna M. - PRADO, Jefferson - PRICE, Michelle J. - SMITH, Gideon F. *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017*. Glashütten : Koeltz Botanical Books, 2018. 254 p. Regnum Vegetabile, Vol. 159. ISBN 978-3-946583-16-5 **936 citations**

3. MUCINA, Ladislav - BÜLTMANN, Helga - DIERßEN, Klaus - THEURILLAT, Jean-Paul - RAUS, Thomas - ČARNI, Andraž - ŠUMBEROVÁ, Kateřina - WILLNER, Wolfgang - DENGLER, Jürgen - GAVILÁN, Rosario García - CHYTRÝ, Milan - HÁJEK, Michal - PIETRO, Romeo Di - IAKUSHENKO, Dmytro - PALLAS, Jens - DANIËLS, Fred J. A. - BERGMEIER, Erwin - GUERRA, Arnoldo Santos - ERMAKOV, Nikolai - **VALACHOVIČ, Milan** - SCHAMINÉE, Joop H. J. - LYSENKO, Tatiana - DIDUKH, Yakiv - PIGNATTI, Sandro - RODWELL, John S. - CAPELO, Jorge - WEBER, Heinrich E. - SOLOMESHCH, Ayzik - DIMOPOULOS, Panayotis - AGUIAR, Carlos - HENNEKENS, Stephan M. - TICHÝ, Lubomír. Vegetation of Europe: hierarchical floristic classification systemof vascular plant, bryophyte, lichen, and algal communities. In *Applied Vegetation Science*, 2016, vol. 19, suppl. 1, p. 3-264. (2015: 2.308 - IF, Q1 - JCR, 1.015 - SJR, Q1 - SJR, CCC). (2016 - Current Contents). ISSN 1402-2001. https://doi.org/10.1111/avsc.12257 **375 citations**

4. DENGLER, Jürgen - **JANIŠOVÁ, Monika** - TÖRÖK, Péter - WELLSTEIN, Camilla. Biodiversity of Palaearctic grasslands: a synthesis. In *Agriculture, Ecosystems & Environment*, 2014, vol. 182, p. 1-14. (2013: 3.203 - IF, Q1 - JCR, 1.653 - SJR, CCC). (2014 - Current Contents). ISSN 0167-8809. https://doi.org/10.1016/j.agee.2013.12.015 **215 citations**

5. *Zoznam nižších a vyšších rastlín Slovenska* = Checklist of non-vascular plants of Slovakia. Editori Karol Marhold, František Hindák. 1. vyd. Bratislava: Veda, 1998. 687 s. < http://ibot.sav.sk/checklist/>. ISBN 80-224-0526-4 **198 citations**

6. RUYTER-SPIRA, Carolien - KOHLEN, Wouter - CHARNIKHOVA, Tatsiana - VAN ZEIJL, Arjan - VAN BEZOUWEN, Laura - DE RUIJTER, Norbert - CARDOSO, Catarina - LOPEZ-RAEZ, Juan Antonio - **MATÚŠOVÁ, Radoslava** - BOURS, Ralph - VERSTAPPEN, Francel - BOUWMEESTER, Harro. Physiological effects of the synthetic strigolactone analog GR24 on root system architecture in *Arabidopsis* : another Belowground Role for Strigolactones? In *Plant Physiology*, 2011, vol. 155, no. 2, p. 721-734. (2010: 6.451 - IF, Q1 - JCR, 3.826 - SJR, Q1 - SJR, CCC). (2011 - Current Contents). ISSN 0032-0889. https://doi.org/10.1104/pp.110.166645 **168 citations**

7. HATTORI, Taiichiro - INANAGA, Shinobu - ARAKI, H. - AN, P. - MORITA, S. - **LUXOVÁ, Miroslava** - LUX, Alexander. Application of silicon enhanced drought tolerance in Sorghum bicolor. In *Physiologia Plantarum : International Journal for Experimental Plant Biology*. - Wiley Blackwell, 2005, vol. 123, no. 4, p. 459-466. (2004: 2.017 - IF). ISSN 0031-9317.
158 citations

8. **MATÚŠOVÁ, Radoslava** - RANI, Kumkum - VERSTAPPEN, Francel W.A. - FRANSSEN, Maurice C.R. - BEALE, Michael H. - BOUWMEESTER, Harro J. The strigolactone germination stimulants of the plant-parasitic Striga and Orobanche spp. are derived from the carotenoid pathway. In *Plant Physiology*, 2005, vol. 139, no. 2, p. 920-934. (2004: 5.881 - IF, CCC). (2005 - Current Contents). ISSN 0032-0889 **150 citations**

9. HABEL, Jan Christian - DENGLER, Jürgen - **JANIŠOVÁ, Monika** - TÖRÖK, Péter - WELLSTEIN, Camilla - WIEZIK, Michal. European grassland ecosystems: threatened hotspots of biodiversity. In *Biodiversity and Conservation*, 2013, vol. 22, no. 10, p. 2131-2138. (2012: 2.264 - IF, Q2 - JCR, 1.205 - SJR, Q1 - SJR, CCC). (2013 - Current Contents). ISSN 0960-3115. https://doi.org/10.1007/s10531-013-0537-x **132 citations**

10. **MEDVECKÁ, Jana** - KLIMENT, Ján - **MÁJEKOVÁ, Jana** - HALADA, Ľuboš - **ZALIBEROVÁ, Mária** - GOJDIČOVÁ, Ema - **FERÁKOVÁ, Viera** - **JAROLÍMEK, Ivan**. Inventory of the alien flora of Slovakia = Přehled nepůvodní flóry Slovenska. In *Preslia : časopis České botanické společnosti*, 2012, vol. 84, no. 2, p. 257-309. (2011: 2.521 - IF, Q2 - JCR, 1.476 - SJR, Q1 - SJR, CCC). (2012 - Current Contents). ISSN 0032-7786
125 citations

2.2.3. List of 10 most-cited publications published any time with the address of the institute, with number of citations obtained until 2020

1. MCNEILL, John - BARRIE, Fred R. - BUCK, Wiliam R. - DEMOULIN, V. - GREUTER, Werner - HAWKSWORTH, David L. - HERENDEEN, Patrick S. - KNAPP, S. - **MARHOLD, Karol** - PRADO, Jefferson - PRUD'HOMME VAN REINE, W. F. - SMITH, G. F. - WIERSEMA, John H. - TURLAND, N. J. *International Code of Nomenclature for algae, fungi, and plants (Melbourne Code) : adopted by the Eighteenth International Botanical Congress Melbourne, Australia, July 2011*. Königstein : Koeltz Scientific Books, 2012. 208 p. Regnum Vegetabile, 154. [Código Internacional de Nomenclatura para algas, hongos y plantas (Código de Melbourne), Madrid: CSIC, 2012]. ISBN 978-3-87429-425-6
1937 citations

2. MCNEILL, John - BARRIE, Fred R. - BURDET, H. M. - DEMOULIN, V. - HAWKSWORTH, David L. - **MARHOLD, Karol** - NICOLSON, Dan H. - PRADO, Jefferson - SILVA, Paul C. - SKOG, J. E. - WIERSEMA, John H. - TURLAND, N. J. *International Code of Botanical Nomenclature (Vienna Code) adopted by the Seveteenth International Botanical Congress Vienna, Austria, July 2005*. Ruggell : A. R. G. Gantner, 2006. 658 p. Regnum Vegetabile, 146. ISBN 0080-0694 **1297 citations**

3. TURLAND, Nicholas J. - WIERSEMA, John H. - BARRIE, Fred R. - GREUTER, Werner - HAWKSWORTH, David L. - HERENDEEN, Patrick S. - KNAPP, Sandra - KUSBER, Wolf-Henning - LI, De-Zhu - **MARHOLD, Karol** - MAY, Tom W. - MCNEILL, John - MONRO, Anna M. - PRADO, Jefferson - PRICE, Michelle J. - SMITH, Gideon F. *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017*. Glashütten : Koeltz Botanical Books, 2018. 254 p. Regnum Vegetabile, Vol. 159. ISBN 978-3-946583-16-5
936 citations

4. *Zoznam nižších a vyšších rastlín Slovenska* = Checklist of non-vascular plants of Slovakia. Editori Karol Marhold, František Hindák. 1. vyd. Bratislava : Veda, 1998. 687 s. < http://ibot.sav.sk/checklist/>. ISBN 80-224-0526-4 **579 citations**

5. MUCINA, Ladislav - BÜLTMANN, Helga - DIERßEN, Klaus - THEURILLAT, Jean-Paul - RAUS, Thomas - ČARNI, Andraž - ŠUMBEROVÁ, Kateřina - WILLNER, Wolfgang - DENGLER, Jürgen - GAVILÁN, Rosario García - CHYTRÝ, Milan - HÁJEK, Michal - PIETRO, Romeo Di - IAKUSHENKO, Dmytro - PALLAS, Jens - DANIËLS, Fred J. A. - BERGMEIER, Erwin - GUERRA, Arnoldo Santos - ERMAKOV, Nikolai - VALACHOVIČ, Milan - SCHAMINÉE, Joop H. J. - LYSENKO, Tatiana - DIDUKH, Yakiv - PIGNATTI, Sandro - RODWELL, John S. - CAPELO, Jorge - WEBER, Heinrich E. - SOLOMESHCH, Ayzik - DIMOPOULOS, Panayotis - AGUIAR, Carlos - HENNEKENS, Stephan M. - TICHÝ, Lubomír. Vegetation of Europe: hierarchical floristic classification systemof vascular plant, bryophyte, lichen, and algal communities. In *Applied Vegetation Science*, 2016, vol. 19, suppl. 1, p. 3-264. (2015: 2.308 - IF, Q1 - JCR, 1.015 - SJR, Q1 - SJR, Current Contents - CCC). (2016 - Current Contents). ISSN 1402-2001. https://doi.org/10.1111/avsc.12257
375 citations

6. **MATÚŠOVÁ, Radoslava** - RANI, Kumkum - VERSTAPPEN, Francel W.A. - FRANSSEN, Maurice C.R. - BEALE, Michael H. - BOUWMEESTER, Harro J. The strigolactone germination stimulants of the plant-parasitic Striga and Orobanche spp. are derived from the carotenoid pathway. In *Plant Physiology*, 2005, vol. 139, no. 2, p. 920-934. (2004: 5.881 - IF, Current Contents - CCC). (2005 - Current Contents). ISSN 0032-0889.
348 citations

7. FERÁKOVÁ, Viera - **MAGLOCKÝ, Štefan** - **MARHOLD, Karol**. Červený zoznam papraďorastov a semenných rastlín Slovenska (December 2001). In *Červený zoznam rastlín a živočíchov Slovenska*. - Banská Bystrica : Štátna ochrana prírody Slovenskej republiky, Centrum ochrany prírody a krajiny, 2001, s. 44-77. ISBN 80-89035-05-1. In Ochrana prírody, roč. 20, supl. (2001)
322 citations

8. **MARHOLD, Karol** - **GOLIAŠOVÁ, Kornélia** - **HEGEDÜSOVÁ, Zuzana** - **HODÁLOVÁ, Iva** - JURKOVIČOVÁ, Viera - KMEŤOVÁ, Eva - **LETZ, Dominik Roman** - **MICHALKOVÁ, Eleonóra** - MRÁZ, Patrik - **PENIAŠTEKOVÁ, Magdaléna** - **ŠÍPOŠOVÁ, Helena** - **ŤAVODA, Ondrej**. Papraďorasty a semenné rastliny. In *Zoznam nižších a vyšších rastlín Slovenska*. 1. vyd. - Bratislava : Veda, 1998, s. 333-687. ISBN 80-224-0526-4.
294 citations

9. RUYTER-SPIRA, Carolien - KOHLEN, Wouter - CHARNIKHOVA, Tatsiana - VAN ZEIJL, Arjan - VAN BEZOUWEN, Laura - DE RUIJTER, Norbert - CARDOSO, Catarina - LOPEZ-RAEZ, Juan Antonio - **MATÚŠOVÁ, Radoslava** - BOURS, Ralph - VERSTAPPEN, Francel - BOUWMEESTER, Harro. Physiological effects of the synthetic strigolactone analog GR24 on root system architecture in Arabidopsis : another Belowground Role for Strigolactones? In *Plant Physiology*, 2011, vol. 155, no. 2, p. 721-734. (2010: 6.451 - IF, Q1 - JCR, 3.826 - SJR, Q1 - SJR, Current Contents - CCC). (2011 - Current Contents). ISSN 0032-0889. Dostupné na: https://doi.org/10.1104/pp.110.166645
273 citations

10. HATTORI, Taiichiro - INANAGA, Shinobu - ARAKI, H. - AN, P. - MORITA, S. - **LUXOVÁ, Miroslava** - LUX, Alexander. Application of silicon enhanced drought tolerance in Sorghum bicolor. In *Physiologia Plantarum : International Journal for Experimental Plant Biology*. - Wiley Blackwell, 2005, vol. 123, no. 4, p. 459-466. (2004: 2.017 - IF). ISSN 0031-9317.
239 citations

2.2.4. List of 10 most-cited publications published during the evaluation period (2016-2021) with the address of the Institute, with number of citations obtained until 2021

1. TURLAND, Nicholas J. - WIERSEMA, John H. - BARRIE, Fred R. - GREUTER, Werner - HAWKSWORTH, David L. - HERENDEEN, Patrick S. - KNAPP, Sandra - KUSBER, Wolf-Henning - LI, De-Zhu - **MARHOLD, Karol** - MAY, Tom W. - MCNEILL, John - MONRO, Anna M. - PRADO, Jefferson - PRICE, Michelle J. - SMITH, Gideon F. *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth*

International Botanical Congress Shenzhen, China, July 2017. Glashütten : Koeltz Botanical Books, 2018. 254 p. Regnum Vegetabile, Vol. 159. ISBN 978-3-946583-16-5
1432 citations

2. MUCINA, Ladislav - BÜLTMANN, Helga - DIERßEN, Klaus - THEURILLAT, Jean-Paul - RAUS, Thomas - ČARNI, Andraž - ŠUMBEROVÁ, Kateřina - WILLNER, Wolfgang - DENGLER, Jürgen - GAVILÁN, Rosario García - CHYTRÝ, Milan - HÁJEK, Michal - PIETRO, Romeo Di - IAKUSHENKO, Dmytro - PALLAS, Jens - DANIËLS, Fred J. A. - BERGMEIER, Erwin - GUERRA, Arnoldo Santos - ERMAKOV, Nikolai - **VALACHOVIČ, Milan** - SCHAMINÉE, Joop H. J. - LYSENKO, Tatiana - DIDUKH, Yakiv - PIGNATTI, Sandro - RODWELL, John S. - CAPELO, Jorge - WEBER, Heinrich E. - SOLOMESHCH, Ayzik - DIMOPOULOS, Panayotis - AGUIAR, Carlos - HENNEKENS, Stephan M. - TICHÝ, Lubomír. Vegetation of Europe: hierarchical floristic classification systemof vascular plant, bryophyte, lichen, and algal communities. In *Applied Vegetation Science*, 2016, vol. 19, suppl. 1, p. 3-264. (2015: 2.308 - IF, Q1 - JCR, 1.015 - SJR, Q1 - SJR, CCC). (2016 - Current Contents). ISSN 1402-2001. https://doi.org/10.1111/avsc.12257 **504 citations**

3. SINGH, Shweta - TRIPATHI, Durgesh Kumar - SINGH, Swati - SHARMA, Shivesh - DUBEY, Nawal Kishore - CHAUHAN, Devendra Kumar - **VACULÍK, Marek**. Toxicity of aluminium on various levels of plant cells and organism: A review. In *Environmental and Experimental Botany*, 2017, vol. 137, p. 177-193. (2016: 4.369 - IF, Q1 - JCR, 1.491 - SJR, Q1 - SJR, CCC). (2017 - Current Contents). ISSN 0098-8472. https://doi.org/10.1016/j.envexpbot.2017.01.005 **155 citations**

4. KATTGE, Jens** - BÖNISCH, Gerhard - DÍAZ, Sandra - LAVOREL, Sandra - PRENTICE, Iain Colin - **SVITKOVÁ, Ivana**. TRY plant trait database – enhanced coverage and open access. In *Global Change Biology*, 2020, vol. 26, no. 1, p. 119-188. (2019: 8.555 - IF, Q1 - JCR, 4.198 - SJR, Q1 - SJR, CCC). (2020 - Current Contents). ISSN 1354-1013. https://doi.org/10.1111/gcb.14904 **111 citations**

5. JANSSEN, John A. M. - RODWELL, John S. - GARCÍA CRIADO, M. - GUBBAY, S. - HAYNES, T. - NIETO, Ana - SANDERS, N. - LANDUCCI, Flavia - LOIDI, Javier - SSYMANK, Axel - TAHVANAINEN, Teemu - VALDERRABANO, Marcos - ACOSTA, Alicia - ARONSSON, Mora - ARTS, Gertie - ATTORRE, Fabio - BERGMEIER, Erwin - BIJLSMA, Rienk-Jan - BIORET, Frédéric - BIŢA-NICOLAE, Claudia - BIURRUN, Idoia - CALIX, M. - CAPELO, Jorge - ČARNI, Andraž - CHYTRÝ, Milan - DENGLER, Jürgen - DIMOPOULOS, Panayotis - ESSL, Franz - GARDFJELL, Hans - GIGANTE, Daniela - GIUSSO DEL GALDO, Gianpietro - HÁJEK, Michal - JANSEN, F. - JANSEN, J. - KAPFER, Jutta - MICKOLAJCZAK, Alexis - MOLINA, J. A. - MOLNÁR, Z. - PATERNOSTER, David - PIERNIK, A. - POULIN, Brigitte - RENAUX, Benoit - SCHAMINÉE, Joop H. J. - ŠUMBEROVÁ, Kateřina - TOIVONEN, Heikki - TONTERI, Tiina - TSIRIPIDIS, Ioannis - TZONEV, Rossen - **VALACHOVIČ, Milan** - **JANIŠOVÁ, Monika** - **ŠIBÍK, Jozef**. *European Red List of Habitats. Part 2. Terrestrial and freshwater habitats*. Luxembourgh : European Union, 2016. 38 p. ISBN 978-92-79-61588-7 **95 citations**

6. CROUS, P.W. - WINGFIELD, M.J. - BURGESS, T.I. - CARNEGIE, A.J. - HARDY, G.E.St.J. - SMITH, D. - SUMMERELL, B.A. - CANO-LIRA, J.F. - GUARRO, Joan - HOUBRAKEN, J. - LOMBARD, L. - MARTÍN, M.P. - SANDOVAL-DENIS, M. - ALEXANDROVA, A.V. - BARNES, C.W. - BASEIA, I.G. - BEZERRA, J.D.P. - GUARNACCIA, V. - MAY, Tom W. - HERNÁNDEZ-RESTREPO, M. - STCHIGEL, A.M. - MILLER, A.N. - ORDOÑEZ, M.E. - ABREU, V.P. - ACCIOLY, T. - AGNELLO, C. - COLMÁN, A. Agustin - ALBUQUERQUE, C.C. - ALFREDO, D.S. - ALVARADO, P. - ARAÚJO-MAGALHÃES, G.R. - ARAUZO, S. - ATKINSON, T. - BARILI, A. - BARRETO, R.W. - BEZERRA, J.L. - CABRAL, T.S. - CAMELLO RODRÍGUEZ, F. - CRUZ, R.H.S.F. - DANIËLS, P.P. - DA SILVA, B.D.B. - DE ALMEIDA, D.A.C. - DE CARVALHO JÚNIOR, A.A. - DECOCK, C.A. - DELGAT, L. - DENMAN, S. - DIMITROV, R.A. - EDWARDS, J. - FEDOSOVA, Anna G. - FERREIRA, R.J. - FIRMINO, A.L. - FLORES, J.A. - GARCÍA, D. - GENÉ, J. - GIRALDO, A. - GÓIS, J.S. - GOMES, A.A.M. - GONÇALVES, C.M. -

GOULIAMOVA, D.E. - GROENEWALD, M. - GUÉORGUIEV, B.V. - GUEVARA-SUAREZ, M. - GUSMÃO, L.F.P. - HOSAKA, K. - HUBKA, V. - HUHNDORF, S.M. - JADAN, M. - JURJEVIĆ, Ž. - KRAAK, B. - **KUČERA, Viktor** - KUMAR, T.K.A. - KUŠAN, I. - LACERDA, S.R. - LAMLERTTHON, S. - LISBOA, W.S. - LOIZIDES, M. - LUANGSA-ARD, J.J. - LYSKOVÁ, P. - CORMACK, W.P. Mac - MACEDO, D.M. - MACHADO, Alexandre R. - MALYSHEVA, E.F. - MARINHO, P. - MATOČEC, N. - MEIJER, M. - MEŠIĆ, Armin - MONGKOLSAMRIT, S. - MOREIRA, K.A. - MOROZOVA, O.V. - NAIR, K.U. - NAKAMURA, N. - NOISRIPOOM, W. - OLARIAGA, I. - OLIVEIRA, R.J.V. - PAIVA, L.M. - PAWAR, P. - PEREIRA, Olinto L. - PETERSON, S.W. - PRIETO, M. - RODRÍGUEZ-ANDRADE, E. - ROJO DE BLAS, C. - ROY, M. - SANTOS, E.S. - SHARMA, R. - SILVA, G.A. - SOUZA-MOTTA, C.M. - TAKEUCHI-KANEKO, Y. - TANAKA, C. - THAKUR, A. - SMITH, M.Th. - TKALČEC, Z. - VALENZUELA-LOPEZ, N. - KLEIJ, P. van der Kleij - VERBEKEN, Annemieke - VIANA, M.G. - WANG, X.W. - GROENEWALD, J.Z. Fungal Planet description sheets: 625-715. In *Persoonia*, 2017, vol. 39, p. 270-467. (2016: 7.511 - IF, Q1 - JCR, 4.487 - SJR, Q1 - SJR, CCC). (2017 - Current Contents). ISSN 0031-5850. https://doi.org/10.3767/persoonia.2017.39.11 **95 citations**

7. NOVIKOVA, Polina Yu - HOHMANN, Nora - NIZHYNSKA, Viktoria - TSUCHIMATSU, Takashi - ALI, Jamshaid - MUIR, Graham - GUGGISBERG, Alessia - PAAPE, Tim - SCHMID, Karl - FEDORENKO, Olga M. - HOLM, Svante - SÄLL, Torbjörn - SCHLÖTTERER, Christian - **MARHOLD, Karol** - WILDMER, Alex - SESE, Jun - SHIMIZU, Kentaro K. - WEIGEL, Detlef - KRÄMER, Ute - KOCH, Marcus A. - NORDBORG, Magnus. Sequencing of the genus Arabidopsis identifies a complex history of nonbifurcating speciation and abundant trans-specific polymorphism. In *Nature Genetics*, 2016, vol. 48, no. 9, p. 1077-1082. (2015: 31.616 - IF, Q1 - JCR, 24.157 - SJR, Q1 - SJR, CCC). (2016 - Current Contents). ISSN 1061-4036. https://doi.org/10.1038/ng.3617 **83 citations**

8. WEIGAND, Hannah - BEERMANN, Arne - ČIAMPOR, Fedor, ml. - COSTA, Filipe - CSABAI, Zoltán - DUARTE, Sofia - GEIGER, Matthias F. - GRABOWSKI, Michael - RIMET, Frédéric - RULIK, Björn - STRAND, Malin - SZUCSICH, Nikolaus - WEIGAND, Alexander M. - WILLASSEN, Endre - WYLER, Sofia A. - BOUCHEZ, Agnès - BORJA, Ángel - **ČIAMPOROVÁ-ZAŤOVIČOVÁ, Zuzana** - FERREIRA, Sónia - DIJKSTRA, Klaas-Douwe B. - EISENDLE, Ursula - FREYHOF, Jörg - GADAWSKI, Piotr - GRAF, Wolfram - HAEGERBAEUMER, Arne - HOORN, Berry B. van der - JAPOSHVILI, Bella - KERESZTES, Lujza - KESKIN, Emre - LEESE, Florian - MACHER, Jan N. - MAMOS, Tomasz - PAZ, Guy - PEŠIĆ, Vladimír - PFANNKUCHEN, Daniela Maric - PFANNKUCHEN, Martin Andreas - PRICE, Benjamin W. - RINKEVICH, Buki - TEIXEIRA, Marcos A.L. - VÁRBÍRÓ, Gábor - EKREM, Torbjørn**. DNA barcode reference libraries for the monitoring of aquatic biota in Europe: Gap-analysis and recommendations for future work. In *Science of the Total Environment*, 2019, vol. 678, p. 499-524. (2018: 5.589 - IF, Q1 - JCR, 1.536 - SJR, Q1 - SJR, CCC). (2019 - Current Contents). ISSN 0048-9697. https://doi.org/10.1016/j.scitotenv.2019.04.247 **80 citations**

9. CHYTRÝ, Milan - HENNEKENS, Stephan M. - JIMÉNEZ-ALFARO, Borja - KNOLLOVÁ, Ilona - DENGLER, Jürgen - JANSEN, Florian - LANDUCCI, Flavia - SCHAMINÉE, Joop H. J. - AĆIĆ, Svetlana - AGRILLO, Emiliano - AMBARLI, Didem - ANGELINI, Pierangela - APOSTOLOVA, Iva - ATTORRE, Fabio - BERG, Christian - BERGMEIER, Erwin - BIURRUN, Idoia - BOTTA-DUKÁT, Zoltán - BRISSE, Henry - CAMPOS, Juan Antonio - CARLÓN, Luis - ČARNI, Andraž - CASELLA, Laura - CSIKY, János - ĆUŠTEREVSKA, Renata - DAJIĆ-STEVANOVIĆ, Zora - DANIHELKA, Jiří - BIE, Els de - RUFFRAY, Patrice de - SANCTIS, Michele De - DICKORÉ, W. Bernhard - DIMOPOULOS, Panayotis - DUBYNA, Dmytro - DZIUBA, Tetiana - EJRNÆS, Rasmus - ERMAKOV, Nikolai - EWALD, Jörg - FANELLI, Giuliano - FERNÁNDEZ-GONZÁLEZ, Federico - FITZPATRICK, Úna - FONT, Xavier - GARCÍA-MIJANGOS, Itziar - GAVILÁN, Rosario - GOLUB, Valentin - GUARINO, Riccardo - HAVEMAN, Rense - INDREICA, Adrian - IŞIK GÜRSOY, Deniz - JANDT, Ute - JANSSEN, John A. M. - JIROUŠEK, Martin - KĄCKI, Zygmunt - KAVGACI, Ali - KLEIKAMP, Martin - KOLOMIYCHUK, Vitaliy - KRSTIVOJEVIĆ-ĆUK, Mirjana -

KRSTONOŠIĆ, Daniel - KUZEMKO, Anna - LENOIR, Jonathan - LYSENKO, Tatiana - MARCENÒ, Corrado - MARTYNENKO, Vassiliy - MICHALCOVÁ, Dana - MOESLUND, Jesper Erenskjold - ONYSHCHENKO, Viktor - PEDASHENKO, Hristo - PÉREZ-HAASE, Aaron - PETERKA, Tomáš - PROKHOROV, Vadim - RAŠOMAVIČIUS, Valerijus - RODRÍGUEZ-ROJO, Maria Pilar - RODWELL, John S. - ROGOVA, Tatiana - RUPRECHT, Eszter - RŪSIŅA, Solvita - SEIDLER, Gunnar - **ŠIBÍK, Jozef** - ŠILC, Urban - ŠKVORC, Željko - SOPOTLIEVA, Desislava - STANČIĆ, Zvjezdana - SVENNING, Jens-Christian - SWACHA, Grzegorz - TSIRIPIDIS, Ioannis - TURTUREANU, Pavel-Dan - UĞURLU, Emin - UOGINTAS, Domas - **VALACHOVIČ, Milan** - VASHENYAK, Yulia - VASSILEV, Kiril - VENANZONI, Roberto - VIRTANEN, Risto - WEEKES, Lynda - WILLNER, Wolfgang - WOHLGEMUTH, Thomas - YAMALOV, Sergei. European Vegetation Archive (EVA): an integrated database of European vegetation plots. In *Applied Vegetation Science*, 2016, vol. 19, no. 1, p. 173-180. (2015: 2.308 - IF, Q1 - JCR, 1.015 - SJR, Q1 - SJR, CCC). (2016 - Current Contents). ISSN 1402-2001. https://doi.org/10.1111/avsc.12191 **63 citations**

10. CROUS, P.W.** - WINGFIELD, M.J. - BURGESS, T.I. - HARDY, G.E.St.J. - GENE, J. - GUARRO, Joan - BASEIA, I.G. - GARCIA, D. - GUSMAO, L.F.P. - SOUZA-MOTTA, C.M. - THANGAVEL, R. - **ADAMČÍK, Slavomír** - BARILI, A. - BARNES, C.W. - BEZERRA, J.D.P. - BORDALLO, J.J. - CANO-LIRA, J.F. - OLIVEIRA, R.J.V. - ERCOLE, Enrico - HUBKA, V. - ITTURIETA-GONZALEZ, I. - KUBÁTOVÁ, A. - MARTIN, M.P. - MOREAU, Pierre-Arthur - MORTE, A. - ORDONEZ, M.E. - RODRIGUEZ, A. - STCHIGEL, A.M. - VIZZINI, Alfredo - ABDOLLAHZADEH, J. - ABREU, V.P. - ADAMČÍKOVÁ, Katarína - ALBUQUERQUE, G.M.R. - ALEXANDROVA, A.V. - DUARTE, E. Alvarez - ARMSTRONG-CHO, C. - BANNIZA, S. - BARBOSA, R.N. - BELLANGER, J.M. - BEZERRA, J.L. - CABRAL, T.S. - **CABOŇ, Miroslav** - CAICEDO, E. - CANTILLO, T. - CARNEGIE, A.J. - CARMO, LT - CASTANEDA-RUIZ, R.F. - CLEMENT, C.R. - CMOKOVÁ, Adela - CONCEICAO, L.B. - CRUZ, R.H.S.F. - DAMM, U. - DA SILVA, B.D.B. - DA SILVA, R.M.F. - SANTIAGO, A.L.C.M. de A. - DE SOUZA, C.A.F. - DENIEL, F. - DIMA, Bálint - DONG, G. - EDWARDS, J. - FELIX, C.R. - FOURNIER, F. - GIBERTONI, T.B. - HOSAKA, K. - ITURRIAGA, T. - JADAN, M. - JANY, J.L. - JURJEVIC, Z. - KOLAŘÍK, Miroslav - KUSAN, I. - LANDELL, M.F. - CORDEIRO, T.R.L. - LIMA, D.X. - LOIZIDES, M. - LUO, S. - MACHADO, Alexandre R. - MADRID, H. - MAGALHAES, O.M.C. - MARINHO, P. - MATOTEC, N. - MESIC, A. - MILLER, Andrew N. - MOROZOVA, O.V. - NEVES, R.P. - NONAKA, K. - NOVÁKOVÁ, A. - OBERLIES, N.H. - OLIVEIRA-FILHO, J.R.C. - OLIVEIRA, T.G.L. - PAPP, V. - PEREIRA, Olinto L. - PERRONE, G. - PETERSON, S.W. - PHAM, T.H.G. - RAJA, H.A. - RAUDABAUGH, D.B. - REHULKA, J. - RODRIGUEZ-ANDRADE, E. - SABA, M. - SCHAUFLEROVÁ, A. - SHIVAS, R.G. - SIMONINI, G. - SIQUEIRA, J.P.Z. - SOUSA, J.O. - STAJSIC, V. - SVETASHEVA, T. - TAN, Y.P. - TKALCEC, Z. - ULLAH, S. - VALENTE, P. - VALENZUELA-LOPEZ, N. - ABRINBANA, M. - MARQUES, D. A. Viana - WONG, P.T.W. - DE LIMA, V. Xavier - GROENEWALD, J.Z. Fungal Planet description sheets: 716-784. In *Persoonia*, 2018, vol. 40, p. 240-393. (2017: 8.182 - IF, Q1 - JCR, 5.633 - SJR, Q1 - SJR, CCC). (2018 - Current Contents). ISSN 0031-5850. https://doi.org/10.3767/persoonia.2018.40.10 **60 citations**

2.2.5. List of most-cited authors from the Institute (at most 10 % of average FTE researchers per year) and their number of citations in the assessment period (2015– 2020). The cited papers must bear the address of the institute

1. Marhold Karol: 4 154 citations
2. Valachovič Milan: 1 185 citations
3. Janišová Monika: 946 citations
4. Hrivnák Richard: 818 citations
5. Luxová Miroslava: 734 citations
6. Zozomová Judita: 676 citations
7. Jarolímek Ivan: 663 citations
8. Mistrík Igor: 611 citations
9. Šibík Jozef: 570 citations

10. Hindák František: 569 citations
11. Zaliberová Mária: 563 citations
12. Tamás Ladislav: 562 citations
13. Dítě Daniel: 503 citations

2.2.6. List of most-cited authors from the Institute (at most 10 % of average FTE researchers per year) and their number of citations obtained until 2020. The cited papers must bear the address of the Institute

1. Marhold Karol: 7700 citations
2. Valachovič Milan: 2357 citations
3. Hindák František: 1938 citations
4. Jarolímek Ivan: 1723 citations
5. Hrivnák Richard: 1543 citations
6. Zaliberová Mária: 1364 citations
7. Mistrík Igor: 1318 citations
8. Janišová Monika: 1312 citations
9. Oťaheľová Helena:1226 citations
10. Luxová Miroslava: 1154 citations
11. Zozomová Judita: 1150 citations
12. Tamás Ladislav: 1094 citations
13. Huttová Jana: 1008 citations

2.2.7. List of most-cited authors from the Institute (at most 10 % of average FTE researchers per year) and their number of citations obtained until 2021 of their papers published <u>during</u> the evaluation period (2016– 2021). The cited papers must bear the address of the Institute

1. Karol Marhold: 1753 citations
2. Milan Valachovič: 713 citations
3. Jozef Šibík: 349 citations
4. Fedor Čiampor: 259 citations
5. Marek Vaculík: 213 citations
6. Monika Janišová: 187 citations
7. Richard Hrivnák: 169 citations
8. Slavomír Adamčík: 157 citations
9. Zuzana Čiamporová-Zaťovičová:140 citations
10. Mária Šibíková: 111 citations

2.3. Research status of the institute in international and national context

- **International/European position of the institute**

2.3.1. List of the most important research activities demonstrating the international relevance of the research performed by the institute, incl. major projects (details of projects should be supplied under Indicator 2.4). Max. 10 items for institute with less than 50 average FTE researchers per year, max. 20 for institutes with 50 – 100 average FTE researchers per year and so on

1) PSBC SAS – Institute of Botany **hosts the Secretariat of the International Association for Plant Taxonomy – IAPT (for the periods 2011–2017 and 2017–2023)**. Prof. Karol Marhold acts as a Secretary General of the IAPT, the chief executive officer of the IAPT. The managing secretary of IAPT is Dipl. Ing. Eva Kráľovičová. IAPT c/o PSBC SAS – Institute of Botany publishes the bi-monthly scientific journal TAXON. It is the leading international journal devoted to systematics, phylogeny and taxonomy of algae, fungi, and plants. It also publishes papers on methodology, botanical history, biography, bibliography and related subjects, opinion pieces, commentaries and new perspectives, and publishes a number of regular columns including. It is the only place to publish proposals to amend the International Code of

Nomenclature for algae, fungi and plants or nomenclatural proposals. The association currently has more than 1,500 individual and collective members, 39% of the membership comes from Europe, the same percentage from the Americas, 15% from Asia and the rest from Africa and Australia. The association was founded in 1950 at the International Botanical Congress in Stockholm and until 1988 its secretariat was located at the University of Utrecht in the Netherlands. The other headquarters of the secretariat were (West) Berlin and Vienna. The association awards twenty grants each year to young researchers, mostly from developing countries.

2) PSBC SAS – Institute of Botany, within a **national consortium** including Comenius University – Faculty of Natural Sciences Bratislava, Pavol Jozef Šafárik University Košice, Natural History Museum Bratislava and Institute of Zoology SAS; has been a **member of Consortium of European Taxonomic Facilities** (CETAF; www.cetaf.org) since in 2005. CETAF is a European network of Natural Science Museums, Natural History Museums, Botanical Gardens and Biodiversity Research Centres with their associated biological collections and research expertise. CETAF promotes training, research and understanding in systematic biology and palaeobiology, and facilitates access to information (collections) and the expertise of its member institutions across Europe. The CETAF network comprises members representing 71 of the largest taxonomic institutions from 22 countries. Alltogether, the collections comprise an estimated 1.5 billion specimens and represent more than 80% of the world's described species. CETAF provides a platform for researchers from a wide variety of scientific disciplines who carry out pioneering research and develop innovative knowledge exchange pathways. The consortium actively participates on implementation of European legislation in the sphere of "Access and Benefit Sharing", which is linked to the conservation of genetic resources (plants and animals) on international as well as national level.

3) PSBC SAS – Institute of Botany is a **national focal point for Global Taxonomy Initiative (GTI),** working under the Convention on Biological Diversity (CBD; www.cbd.int). The GTI is a set of activities and objectives agreed to by governments. These activities highlight issues, facilitate exchange of information and promote technical cooperation. GTI provides guidance to governments, taxonomists, non-government and international organizations, responsible for implementing the GTI. The purpose of the GTI is to remove or reduce this taxonomic impediment – i. e. the knowledge gaps in our taxonomic system (including those associated with genetic systems), the shortage of trained taxonomists and curators, and the impact these deficiencies have on our ability to conserve, use and share the benefits of our biological diversity.

4) PSBC SAS – Institute of Botany **has been the seat of editors and editorial office of the international journal Plant Systematics and Evolution** (Springer Nature, Heidelberg) since 2014, which is one of the oldest (almost 170 years of tradition) journals in the field of plant systematics and evolution. The journal aims to bring together different areas and methodological approaches, publishing evolutionary, phylogenetic, genomic, biogeographical, karyological, anatomical-morphological, reproductive-biological, palynological and paleontological studies from population to the highest taxonomic levels. Taxonomic emphasis is placed on all groups of plants in a broad sense, including fungi, algae and lichens. Prof. Karol Marhold, together with two foreign colleagues (Prof. Marcus A. Koch and Prof. Martin A. Lysák), is the editor-in-chief. Katarína Skokanová and Barbora Šingliarová provide general management and copy-editing for the magazine.

5) PSBC SAS – Institute of Botany **manages and builds internationally recognized scientific collection of plants (herbarium) and fungi** included in the international list **Index Herbariorum** under the abbreviation **SAV** (http://sweetgum.nybg.org/science/ih/herbarium-details/?irn=124852). Index Herbariorum is a worldwide index of 3,100 herbaria and 12,000 associated staff where a total of 390 million botanical specimens are permanently housed, curated by the New York Botanical Garden. The collection SAV represents an object of significant scientific, cultural-historical and financial value. Scientists and collections management specialists visit the collections and borrow specimens for research. Digitalization

of the collection continues, and we work together with major European natural history collections in order to achieve their recognition as ESFRI infrastructure.

6) **Horizont 2020: Distributed System of Scientific Collections – Preparatory Phase Project (ESFRI – DiSSCo – Distributed System of Scientific Collections). Principal investigator from PSBC SAS**: Karol Marhold

The aim is to ensure the preparatory phase of the ESFRI project DiSSCo. DiSSCo will directly address the current fragmentation of European collections documenting biodiversity by transforming a network of institutions into a coherent research community infrastructure: single point of contact for European collections, for data on localities of origin herbarium documents, zoological and geological collection items and related professional knowledge. DiSSCo will mobilize, link and make available the currently fragmented information on biodiversity and geodiversity to the required scale, form and accuracy. This new research infrastructure introduces a gradual change by significantly improving and expanding access to information and thus the ability of scientists to discover and analyze complex and previously separated information derived from the study of large-scale science collections in Europe. In the first year of project we focused on the specification of project objectives for the Slovak Republic, we created national consortium of Slovak institutions under the leadership of the PSBC SAS and we participated in formulation of the Slovak Road Map of Research Infrastructures (SK VI Roadmap 2020 – 2030), which is currently following an interdepartmental comment procedure and is among the unclassified materials for the conduct of the defect of the Slovak Republic. We started preparing for the reconstruction database system for mapping the distribution of higher plant species in Slovakia.

7) **7th Framework Programme: EU-BON - Building the European Biodiversity Observation Network. Principal investigator from PSBC SAS**: Karol Marhold

We participated in the task 1.2 "Harmonization of European taxonomic backbone and analysis of taxonomic coverage", which is part of WP 1, we modified the Euro + Med PlantBase database. The modifications consisted in supplementing the records of the spread of the occurrence of higher plant species in individual countries, which were lost during the import from the MedChecklist database. MedChecklist keeps records of extensions in a specific format, which for each added data had to be fragmented and then assigned the correct abbreviations for extension data to the Euro + Med database and add additional information about the origin of the occurrence. As part of task 2.2 “Improving data standards and interoperability”, which is part of WP 2, we examined the available botanical and zoological databases that could serve as checklists in the EU BON project. At the same time, we explored the web services that these databases provide, their capabilities - the completeness of the information required, the scalability of the data requirements, and the standards that are required and with which these services work. We completed the programming of the software of the analytical tool for the visualization of the distribution of species in space and time in Europe (Species Richness) for the needs of the EU BON portal. The application according to user-specified criteria - higher taxon, spatial boundary, spatial resolution, time resolution, range of years - displays the numbers of occurrences and the numbers of species belonging to the higher taxon. The data is grouped into cells on the map, which include the coordinates of specific records. The individual cells are further grouped into the years in which the records were found. The data comes from the GBIF database, currently the tool supports birds (Aves class), mammals (Mammalia class), frogs (Anura class), bony fish (Actinopterygii class), beetles (Coleoptera class), butterflies and plagues (Lepidoptera class), fungi (Basidiomycota strain) and vascular plants (Magnoliophyta strain). After creating this application, we focused on improvements and modifications, whether in terms of functionality or visuals. We implemented the REST API to use the tool without visualization, displaying the number of species, refactoring the code. The application in the final version shows the ratio of the occurrence of one species to all occurrences in the specified higher taxon.

8) **ESA: NaturaSat - software for exploring Natura 2000 habitats by satellite data**
Principal investigator from PSBC SAS: Mária Šibíková.

The project represents convergence research solving complex questions requiring a multidisciplinary approach. It integrates knowledge of fieldwork scientists, mathematicians, and

stakeholders focusing on habitat use and nature conservancy – especially the Natura 2000 network. The project objective is to build up the NaturaSat software allowing botanists, environmentalists, and nature conservationists across Europe to explore Natura 2000 habitats by using Sentinel-2 optical data. Achieving the project goals will guarantee the accurate area identification and classification of European protected habitats and continuous monitoring of their Spatio-temporal distribution and quality by the NaturaSat software. The project builds on the successful solution of the first phase, supported by ESA. We created a software prototype - NATURASAT, which should now be completed and tested in practice for its subsequent use by interested organizations or the private sector.

9) **ESA: Software tools for monitoring NATURA 2000 habitats by satellite images. Principal investigator from PSBC SAS**: Mária Šibíková
Pilot project supported creation of the NaturaSat software, which integrates various image processing techniques together with vegetation data, into one multipurpose tool that is designed for performing facilities for all requirements of habitat exploration, all in one place. It provides direct access to multispectral Sentinel-2 data provided by the European Space Agency. It supports using these data with various vegetation databases, in a user-friendly environment, for, e.g., vegetation scientists, fieldwork experts, and nature conservationists.

10) **Royal Botanic Gardens, Kew, Richmond: Contribution of IB SAS to the international project Millenium Seed Bank. Coordinator:** PSBC SAS, Jaromír Kučera, **Principal investigator from PSBC SAS**: Jaromír Kučera
The project focused on endangered plant species and the plant species that will be most needed in the future. The harvested plant seeds are stored in seed banks as a safeguard against the extinction of plant species in the wild. In cooperation with 80 different countries of the world, more than 13% of all plant species in the world have been collected and stored in the seed bank. The main goal of the project is to preserve 25% of all plant species in the world by 2020 (which represents about 75,000 species). The project focuses on plant species and regions that are most at risk from the ever-increasing impact of human activities, including land use and climate change. For many years PSBC SAS (IB SAS) coordinated the collection of seeds within Slovakia in the two biogeographical regions of the Carpathians and Pannonia. The target species for harvest are endemic, endangered and invasive wild plant species. The harvested seeds are stored in seed banks at MSB Kew (UK) and at the Gene Bank in Piešťany (Slovakia); several species are also stored at the Pannonian Seed Bank in Vácratót (Hungary). During 10 years of harvesting activities from the territory of Slovakia, the scientific team managed to collect and store 752 taxa, which represents approximately 16% of the total number of taxa of higher plants in the flora of Slovakia. Of this number, 80 are taxa from the category of critically endangered species, 76 taxa from endangered species, 91 taxa from vulnerable species and 49 from less endangered plant species. In terms of biogeographical regions, 33 taxa belong to the Carpathian endemics / subendemites and 16 to the Pannonian endemics / subendemites. In addition to collection activities, the project supported several studies focusing on Carpathian elements, such as: phylogeography and taxonomy of taxa *Cyclamen fatrense* (West Carpathian endemic) and *C. purpurascens*, ecology and conservation status of *Pilosella alpicola* (*P. ullepitschii* - Carpathian endemic) karyology, morphology and ecology of *Sesleria tatrae* (West Carpathian endemic) and *S. caerulea*, or taxonomic revision of *Tephroseris longifolia* agg. (*Tephroseris longifolia* subsp. *moravica* - West Carpathian endemic), cytogeography of European species of the genus *Centaurea* of the protocyanus section (several taxa are endemic to the Carpathians) and a system of reproduction and hybridization of species of the *Centaurea triumfetti* and *C. montanus* groups in the Carpathians.

11) **Royal Botanic Gardens, Kew, Richmond: Conserving the endemic flora of the Carpathian region. Coordinator:** PSBC SAS, Jaromír Kučera, **Principal investigator from PSBC SAS**: Jaromír Kučera
The Carpathian Mountains, an iconic centre of biodiversity in temperate Europe, harbour a remarkable number of endemic vascular plants. Current knowledge on their taxonomic status, spatial distribution and genetic diversity is, however, incomplete. Research and conservation efforts have mostly been country-specific, resulting in contrasting chorological knowledge and

taxonomic acceptance between neighbouring countries, and differing conservation policies. Urgent synchronisation of cross-border conservation measures is required. The international project addressed these issues, outlining the current state of knowledge and theoretical background concerning Carpathian subendemics and endemics in order to improve their conservation status. The project involved partners from eight countries, working collaboratively in conservation, research and sharing of standardised data for the Carpathian flora. PSBC SAS acted as coordinator of the project. Research focused on the biosystematics of selected taxa will increase our knowledge of the evolutionary processes involved in the origin of the Carpathian flora. Finally, the establishment of the Carpathian Research Network (CRN) provides an official framework for pooling, sharing and standardising scientific data on Carpathian endemics from different countries. The CRN is developing an online database of the distribution of selected species (The Carpathian Endemics Distribution Database, CEDD) including their intrinsic and extrinsic traits and current opinion on their taxonomic status.

12) **7th Framework Programme: PlantDNAtolerance -** Plant adaptation to heavy metal and radioactive pollution; **Registration number:** 612587; **Duration:** 1.1.2014 - 31.10.2017; **Coordinator:** Institute of Biological, Environmental & Rural Sciences Aberystwyth University, UK, **investigator from PSBC SAS:** Martin Hajduch
Collaborative research was primarily focused on plant responses to several abiotic factors, such as ionizing radiation, heavy metals, salinity, and genetic transformation. We showed unique proteomic patterns in response to cadmium for natural ecotypes of *Arabidopsis thaliana* collected from areas with different levels of contamination with radionuclides. Also, our team demonstrated affected genetic variability in crops suffering from chronic ionizing radiation in the Chernobyl region. However, these agricultural plants showed a normal level of DNA damage but a slight increase in global DNA methylation, suggesting heritable adaptation mechanisms. Finally, we quantified and identified leaf proteins affected by genetic modification of *Populus* × *euroamericana* with a reporter and selective traits. All these results were published in international peer-reviewed journals. The effort was focused also on improving the professional skills of research personnel in collaborating laboratories. Specifically, both young and experienced scientists from partner organizations (Institute Cell Biology and Genetic Engineering of NAS of Ukraine, Institute of Botany of the NAS of Ukraine, and Belarusian State University) visited the Institute of Plant Genetics and Biotechnology at Nitra (unit of PSBS SAS). During these internships, they learned and practised advanced proteomic methods, including gel-based separation and quantification of proteins, followed by identification using tandem mass spectrometry.

13) **7th Framework Programme: SYNTHESIS3; topics:** Taxonomic revisions in Placynthiaceae **registration number:** AT-TAF-4805 **research period:** 25. 9. 2016–30. 9. 2016 **investigator from PSBC SAS:** Alica Košuthová; How ecologically plastic are symbiotic associations linked to mediterranean-type biotopes in Pannonia and Western Carpathians?: case study on Solenopsora candicans Synthesys **registration number:** HU-TAF-6340 **research period:** 25.6.2017–4.7.2017 **investigator from PSBC SAS:** Zuzana Fačkovcová (http://www.nhmus.hu/en/xplore/differently_about_our_research/zuzana-fackovcova-interview); Genetic and ecological differentiation within Tephroseris longifolia agg **registration number:** DE-TAF-6507; **research period:** 20.2.2017–4.3.2017 **investigator from PSBC SAS:** Katarína Skokanová
Participation in short term visits to utilize collections, staff expertise, and analytical facilities at one of the 21 partner institutions (natural history collections) around Europe. The visits in three institutions enabled to to do a revision of the herbarium collection and work with the material in molecular labs.

14) **Evolutionary legacy of the Turkish flora and its influence on formation of the European plant diversity: Evidence from genome to ecology; Programme:** JRP **registration number**: 475542; **research period: 1**.7.2021 / 30.6.2024**; principal investigator from PSBC SAS:** Karol Marhold

15) **Restoration of sterlet populations in the Austrian Danube – LIFE; registration number**: LIFE14 NAT/AT/000057; **research period:** 1.1.2015 / 31.12.2021; **investigator from PSBC SAS**: Ladislav Pekárik

16) **Program ERA.NET: A next generation plant biostimulant based on strigolactones included into stimuli responsive nanoformulation. Registration number:** ERA.NET-INCOMERA; **Duration:** 01.01.2018 - 31. 12. 2019; **Coordinator:** Institutul National de Cercetare-Dezvoltare pentru Chimie si Petrochimie ICECHIM, **investigator from PSBC SAS:** Radoslava Matúšová

17) **Utilisation of RAD sequencing in plant systematics and evolution. A case study of the genus *Soldanella*.** SAIA Aktion Austria - Slovakia, **research period:** 1. 9. 2015 / 31. 8. 2016. **Principal investigator from PSBC SAS**: Andrea Melichárková and Marek Slovák; cooperation with University of Vienna, Faculty of Life Sciences, Department of Botany and Biodiversity Research, Austira.

18) **Program JRP: Investigate the mechanism of male sterility regulated by DEFECTIVE IN ANTHER DEHISCENCE1 (DAD1) – Activating Factor (DAF), a RING-finger E3 ligase gene and its agricultural application; Registration number:** SAS-NSC JRP 2013/16; **Duration:** 1.1.2014 - 31.12.2016; **Coordinator:** Institute of Plant Genetics and Biotechnology SAS, **investigator from PSBC SAS:** Martin Hajduch

2.3.2. List of international conferences (co)organised by the institute

1. **First international conference DNAQUA** (https://symposium.inrae.fr/dnaqua-conference-evian2021; online), **09.03.–11.03.2021**.
   The Conference provided the opportunity for scientists and stakeholders to present and discuss the latest research outputs on DNA-based monitoring from DNAqua-Net and beyond. While methods are leaving the labs where they have been developed, and being tested in real life, it is now time to deepen the dialogue between academia, industry and stakeholders from countries all around the world to find solutions to implement new methods in a standardized way to improve environmental monitoring world-wide.
   Number of participants: 1000
   Responsible for PSBC SAS: Fedor Čiampor (organizer, member of scientific committee)

2. **Workshop on Arctic biodiversity and ecosystem functioning – moving forward with the Arctic Vegetation Archive (AVA), Arkhangelsk**, **Russia, 21. 05. 2019**.
   Oral and poster presentations discussed progress of the national databases, with a focus on Russian data, and potential applications of AVA data. The following topics were addressed 1) practical questions of data integration into AVA (with a focus on Russian territories), 2) methods and standardization for vegetation classification, 3) strategies of how to move forward with the Arctic vegetation work in international programmes, and 4) to collect materials for a central website linking to national data bases. Major outcomes: 1) an integrated vision for circumpolar vegetation science that includes mapping, surveying, archiving, classification and analysis of Arctic vegetation as expressed in the Prague Resolution; 2) a new raster version of the Circumpolar Arctic Vegetation Map; 3) a major review of the progress and status of circumpolar arctic vegetation classification; 4) revitalized interest, funding and progress toward the AVA and AVC as a result of both workshops.
   Number of participants: 32
   Responsible for PSBC SAS: Jozef Šibík

3. **Botanical collections and databases and their use in research and application** [Botanické sbírky a databáze a jejich využití ve výzkumu a praxi], **Praha, Czech Republic, 30. 11. – 01. 12. 2019.**
   The topic addressed electronic infrastructure (databases) and collections and their use in plant science research..
   Number of participants: 100
   Responsible for PSBC SAS: Jozef Šibík

4. **Biotechnology and quality of raw materials and foodstuffs** [Biotechnológie a kvalita surovín a potravín], **Smolenice, Slovakia, 16. 09. - 18. 09. 2018.**
   The purpose of the conference was to present current results in the field of quality, safety and hygiene of raw materials and food hygiene, plants, animals and also microbial biotechnology, genetic sources, molecular markers of properties with perspective for breeding and a quality of production. The sessions covered the following topics: Biotechnology and Molecular Biology; Food Design and Innovation; Personalized Nutrition and Health, and Innovation Trends in Food Industry. Special session was devoted to The Young Scientist Award.
   Number of participants: 100
   Responsible for PSBC SAS: Alena Gajdošová and Gabriela Libiaková (organizing committee), Ján Salaj (international scientific committee)

5. **International Russulales Workshop 2018, Borgsjö, Sweden, 26. 08. – 01. 09. 2018.**
   The focus was on fungi of the Russulales, which encompasses the large genera *Russula* and *Lactarius* and a few smaller ones. The event's aim was to gather in one place mycologists, researchers, hobbyists and everyone with an interest in the study of this specific group of fungi. This created an opportunity for people scattered across the continent and elsewhere to meet, interact, share their knowledge and experience and form a community while taking part in the study of the local species and environment. PSBC SAS organized the event together with University of Ghent (Belgium) and Sudsvall Mykologiska Sällskap (Sweden) Adamčík (CBRB SAV)
   Number of participants: 66
   Responsible for PSBC SAS: Slavomír Adamčík

6. **CETAF 44 General Meeting, Bratislava, Slovakia, 14. 11. – 15. 11. 2018**
   The aim of the meeting was to prepare the CETAF research agenda, to present an opinion on the "Horizon Europe" framework program, as well as a workshop on "CETAF's vision for taxonomic and systematic research in 2030". An important point was the adoption of two documents prepared for the meeting of the Global Taxonomy Initiative. This is a joint position of CETAF and the Global Biodiversity Information Facility (GBIF) on post-2020 taxonomies with regard to the Vision for Biodiversity up to 2050, with key assumptions that biodiversity is valued, preserved, restored and wisely used. The second document is the Bratislava Declaration on the Vision of the Convention on Biological Diversity until 2050 (https://attachments.cbd.int/The_CETAF_Bratislava_Declaration_on_the_CBD_2050_Vision_15_11_2018_WEB.pdf). Sixty signatory institutions from 21 countries recall the irreplaceable role of taxonomic research and its results for sound management and conservation of biodiversity, the international context and the importance of collections and knowledge of institutions underlines the urgency to develop and make available taxonomic experience and knowledge on biodiversity, thus contributing to the timely and reliable implementation of the Convention on Biological Diversity. In addition, discussions took place in working groups to obtain input for other joint projects, namely the Biodiversity Monitoring Working Group, the Electronic Publishing Working Group and the Steering Committee of the European Journal of Taxonomy. The event was attended by more than 60 representatives of institutions that manage scientific collections.
   Number of participants: 60
   Responsible for PSBC SAS: Karol Marhold

7. **Young taxonomists meeting** [Stretnutie mladých taxonómov]**, Senica, Slovakia, 09. 11. – 11. 11. 2018**
   The aim of the meeting of biosystematics is the presentation of workplaces dealing with botany and systematics in the Czech and Slovak Republics and the presentation of the topics covered by the students and young researchers.
   Number of participants: 42
   Responsible for PSBC SAS: Miroslav Caboň, Eliška Gbúrová Štubňová, Michaela Vrbová

8. **Ecology and evolution of plants in anthropogenic habitats of Central Europe** [Ekologie a evoluce rostlin na antropogenních stanovištích střední Evropy], **Praha, Czech Republic, 25.11.–26.11.2017**
   The conference addressed research in anthropogenic vegetation, including specific habitats e.g. dumps, sludge ponds, non-native tree plantations, urban habitats, parks, etc. The aim was to exchange information, gain experience about the dynamics and specifics of these habitats, long-term changes in connection with changes in their use due to changes in society, networking and identification of white spaces in the knowledge of this type of vegetation.
   Number of participants: 150
   Responsible for PSBC SAS: Jana Podroužková Medvecká

9. **Arctic Vegetation Archive and Classification Workshop, Praha, Czech Republic, 30.03.–31.03.2017**
   An event organized by the University of Alaska Fairbanks as part of the "An IASC Terrestrial Working Group and CAFF Flora Group Workshop" working groups. The participants concluded that common language and data sharing for Arctic researchers is essential to achieving several key aspects of the next five-year Scientific Plan of the International Arctic Science (IASC), including: (i) assessing the diverse impacts of climate change and human activities on Arctic biodiversity; its implications for ecosystem services and societal impacts; (ii) linking studies in all spheres: the biosphere, the social sphere and the physical spheres of the Arctic; (iii) support for international efforts to make data and metadata easily accessible in the Arctic, such as the Sustainable Arctic Observation Network (SAON) and the Arctic Data Data Committee (ADC IASC).
   Number of participants: 30
   Responsible for PSBC SAS: Jozef Šibík

10. **Ecological implications of strigolactones** [Ekologické implikácie strigolaktónov]**, Nitra, Slovakia 20.07.–22.07.2016**
    The participants highly appreciated the lectures of the invited scientists. Daniel Joel (Israel) and Chris Parker (UK) presented historical overviews of parasitic plants, which the present experts followed with lectures and discussions with the latest knowledge about strigolactones, the possibilities of their applications in agriculture and the ecological implications of strigolactones.
    Number of participants: 18
    Responsible for PSBC SAS: Radoslava Matúšová

11. **The joint meeting of 2nd INPPO World Congress 2016 and COST Action: The quest for tolerant varieties - Phenotyping at plant and cellular level, Bratislava, Slovakia, 04.09.–08.09.2016**
    Institute of Plant Genetics and Biotechnology SAS together with Biomedical Research Centre SAS co-organized the the joint meeting of congress of International Plant Proteomics Organization, INPPO, http://www.inppo2016.sav.sk/inppo-2016) and COST The quest for tolerant varieties - Phenotyping at plant and cellular level. The contributions covered the topics dealing with the latest knowledge and scientific results in the field of proteomics and its use in systems biology, plant growth and development research, posttranslational protein modification studies, biotic and abiotic stress research or proteomics applications in breeding. A special section was devoted to the use of proteomic approaches in shaping the regulatory rules of (bio) safety assessment.
    Number of participants: 121
    Responsible for PSBC SAS: Martin Hajduch, Katarína Klubicová

12. **Plant Biology Europe EPSO/FESPB 2016 Congress, Praha, Czech Republic, 26.06.–30.06.2016**
    The largest European "Plant Science" conference, organized at traditional biennial intervals under the auspices of two major organizations European Plant Science Organisation and Federal European Societas of Plant Biology.

Number of participants: 900
Responsible for PSBC SAS: Marek Vaculík (member of Local organizing committee)

13. **Russulales Workshop 2016, Piombino, Italy, 07.11.–12.11.2016**
The event organized by Institute of Botany SAS, University of Ghent, Belgium and local club Associazione Micologica Bresadolana. The agenda included field excursions, commented exposition of findings, workshop and lectures on phylogeny, biodiversity, evolution, ecology and other aspects of the research in ectomycorhizal fungi of Russulales.
Number of participants: 41
Responsible for PSBC SAS: Slavomír Adamčík

2.3.3. List of edited proceedings from international scientific conferences

1. 2nd INPPO World Congress in Bratislava : book of abstracts, September 4-8, 2016. Eds.:**M. Hajduch, K. Klubicová, Ľ.** Škultéty. Bratislava: Institute of Plant Genetics and Biotechnology, Slovak Academy of Sciences and Biomedical Research Center, Slovak Academy of Sciences, 2016. ISBN 978-80-970662-3-9.
2. 14th International Student Conference on Experimental Plant Biology, 7th to 8th September 2017, Bratislava, Slovakia. Book of Abstracts. Editori Albrechtová Jana, Krekule Jan, **Vaculík Marek**. In Bulletin České společnosti experimentální biologie rostlin a Fyziologické sekce Slovenské botanické společnosti, 2017, roč. 17, č. 1, p. 1-60. ISSN 1213-6670.

2.3.4. List of journals edited/published by the institute and information on their indexing in WOS, SCOPUS, other database or no database, incl. impact factor and other metrics of journals in each year of the assessment period

Biologia (Section Botany): WOS
IF 2021: 1,653
IF 2020: 1,350
IF 2019: 0,811
IF 2018: 0,728
IF 2017: 0,696
IF 2016: 0,759

TAXON: WOS
IF 2021: 2,586
IF 2020: 2,430
IF 2019: 2,817
IF 2018: 3,823
IF 2017: 2,680
IF 2016: 2,447

- ## National position of the institute

On national level PSBC SAS represents a central hub for research of flora of Slovakia, houses the second largest herbarium and fungal collection in Slovakia (http://sweetgum.nybg.org/science/ih/herbarium-details/?irn=124852; https://cbrb.sav.sk/en/for-public/collections-of-organisms-herbarium/), curates the plant database DataFlos, publishes two major monograph series – Flora of Slovakia (Flóra Slovenska) and Vegetation of Slovakia (Rastlinné spoločenstvá Slovenska). Researchers are editors of WOS journals Biologia and Plant Systematics and Evolution. PSBC SAS cooperates with four scientific societies: Slovak Botanical Society (http://sbs.sav.sk/), Slovak Mycological Society (http://mykospol.sk/), Slovak Limnological Society (https://limnospol.sk/), and Slovak Zoological Society (http://www.szs.sav.sk/).

2.3.5. List of selected activities of national importance

2017: Memorandum of Cooperation on Biodiversity, Ecology and the Environment
Representatives of the Ministry of the Environment of the Slovak Republic – the Minister, and the Plant Science and Biodiversity Centre SAS – the director, **signed a Memorandum of Cooperation on 28 April 2017**. Both parties expressed awareness of the irreplaceable importance of science, education and their connection with practice; interest in deepening cooperation and engagement in mutual cooperation in addressing biodiversity, ecology and the environment. This includes mainly the obligations as a signatory of the Convention on Biological Diversity and its protocols, and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. The cooperation shall support also assistance in drafting and preparing legislative processes and concepts in the field of nature and landscape protection, water management, air protection, spatial planning, environmental impact assessment, environmental monitoring.

Comprehensive analysis of pathways of unintentional introduction and unintentional spread of invasive alien species of Union concern and invasive alien species of concern to the Slovak Republic and elaboration of draft action plans to address this issue (Work Contract) 2021. Ministry of Environment SR
Principal investigators: Pavol Mereďa jun., Dobromil Galvánek, Tomáš Čejka, Fedor Čiampor, Richard Hrivnák, Jana Májeková, Ladislav Pekárik, Katarína Skokanová, Barbora Šingliarová, Jozef Šibík. Collaboration with Institute of Landscape Ecology SAS
Our team prepared two extensive studies for the needs of the Ministry of the Environment of the Slovak Republic and the State Nature Conservancy of the Slovak Republic. As part of a comprehensive analysis, we identified pathways for the introduction and unintentional spread of invasive alien species to the territory of the Slovak Republic and to areas of the European Union through Slovakia. A total of 43 species of plants and 40 species of animals were analyzed (of which 12 species of mammals, five species of birds, 10 species of fish) included in European and national legislation. The second study contained a draft action plan to address the issue of penetration routes of unintentional introduction and unintentional spread of given invasive non-native species to the territory of the Slovak Republic and to the territory of the EU through the territory of the Slovak Republic. In the action plan, o.i. identified range of responsible entities, as well as a draft schedule of activities and a description of the measures that will need to be taken to address the issue. The action plan also included monitoring the effectiveness of the proposed measures and estimating the overall level of financial security for the proposed groups of responsible entities. The Action Plan was the basis for the Legislative Process LP / 2021/788, which was discussed by the Government of the Slovak Republic following an interdepartmental comment procedure.

Cooperation in the preparation of the amendment draft Decree of the Ministry of the Environment SR, which implements Act n. 543/2002 Coll. on nature and landscape protection, as amended.
Cooperation with Ministry of Environment SR, State Nature Conservancy SR
In cooperation with the State Nature Conservancy SR, we prepared an amended draft of Decree no. 170/2021 Collections of the Act of the Ministry of Environment of the Slovak Republic, which implements Act no. 543/2002 on Nature and Landscape Protection, as amended. We have prepared and commented documents for the following parts of the Decree: Annex no. 1: List of habitats of European importance and habitats of national importance and their social value, and Annex no. 4: List of protected plants (incl. fungi, lichens and bryophytes). A record number was included in the Annex no. 4 – more than 2100 species of different organisms, of which are 89 fungi, 44 lichens, 220 bryophytes, 796 vascular plants, and more than 960 animals.

Discussion on the attractiveness of botanical data for the public and their further use in various forms within the initiative of open government Government body. Cooperation with the Office of the Plenipotentiary of the Government of the Slovak Republic for Civil Society Development, Ministry of the Interior of the Slovak Republic. **Principal investigator:** Jozef Šibík
The aim of the initiative was to find out about a demand from civil society for publicly available data to help develop an informed society. This is high value data such as climatic data, background maps and their layers, floristic databases, etc., which need to be discussed with their owners and creators. Within the theme of open government, of which this initiative is a part, the ambition is to make available materials, whether in the form of original "raw" data and statistics, but also research or scientific information.

Test and evaluation of the use of DNA metabarkcoding for monitoring the Danube biota within the 4th Joint Danube Survey.
Cooperation with Water Research Institute.
Principal investigators: Fedor Čiampor, Zuzana Čiamporová-Zaťovičová
Processing and evaluation of water (environmental DNA) and benthos samples taken in 2019 within JDS4 we obtained metabarkcoding data from 11 localities, which are also monitored as part of standard Danube monitoring. The results confirmed the high sensitivity of DNA metabarking methods as well as the ability to determine the composition of invertebrate fauna and other taxonomic groups. The results will be part of an international report from the JDS.
Barcoding of Slovakia (SK-BOL)
Cooperation with Slovak National Museum – Natural History Museum Bratislava
Principal investigators: Jaromír Kučera, Pavol Mereďa, Eliška Gbúrová-Štubňová
Building of reference nation-wide database with DNA sequences of Orchidaceae species and invasive plant species as a contribution to world-wide Barcode of Life Data Systems (BOLD).

Cooperation with regional expert institutions – Slovak Museum of Nature Protection and Speleology (SMOPAJ)
Cooperation dates back to 1999 by identification of study sites in Nízke Tatry Mts. In 2009–2011 institutions cooperated in compilation of The Atlas of Species of European Interest for NATURA 2000 Sites in Slovakia. During the evaluation period (since 2018), the cooperation included membership of PSBC SAS representative in Scientific board of the SMOPAJ – advisory body of the director. This included comments on mid-term or final reports from research topic related to botany or lichenology. PSBC SAS provides consultancy for SMOPAJ staff (mainly curators of botanical collections) on identification of plant material.

E- infrastructure

Botanical information systems
Principal investigators: Jaromír Kučera, Karol Marhold, Matúš Kempa, Stanislav Španiel**,** Pavol Mereďa, Milan Valachovič, Katarína Vantarová, Jozef Šibík
Maintenance, building, upgrading and updating a series of thematical databases:

- **Database of Flora of Slovakia (Dataflos):** Displays the occurrence of taxa on background maps, stores and displays photographs of documented items, searching and sorting data according to various criteria (name of species, genus, family, municipality, phytogeographical district, etc.), export of selected literary and herbarium data from the database. It is used to collect literary and herbarium data on the occurrence of lower plants in Slovakia and for the needs of processing other volumes of the Flóra Slovenska edition. https://dataflos.sav.sk/
- **Checklist of vascular plants of Slovakia**
- **Database of chromosome numbers of plants of Slovakia:** https://www.chromosomes.sav.sk/
- **Aly-Base Database of names, chromosome numbers and ploidy levels of Alysae**

https://www.alysseae.sav.sk/

- **Carda-Base Datababase of names, chromosome numbers, ploidy levels and genome sizes of the tribe Cardamineae**

https://www.cardamine.sav.sk/

- **CDF Central Database of Phytocenological Relevés of Slovakia (Vegetation Database)**

https://ibot.sav.sk/cdf/

- **DAAS – Database of non-native plant species of Slovakia**

http://dass.sav.sk/en/

Zoological information systems
Principal investigators: Zuzana Čiamporová-Zaťovičová, Fedor Čiampor

- **AquaBOL-SK: barcoding aquatic biota of Slovakia**

https://aquabol.sk/en/home/

2.3.6. List of journals (published only in the Slovak language) edited/published by the institute and information on their indexing in WOS, SCOPUS, other database or no database, incl. impact factor and other metrics of journals in each year of the assessment period

Not included in databases:

- Bulletin Slovenskej botanicke spoločnosti pri SAV (http://sbs.sav.sk/SBS1/content.html)
- Spravodajca Slovenskej mykologickej spoločnosti pri SAV (http://mykospol.sk/publikacna-cinnost/)
- Cathathelasma (http://mykospol.sk/publikacna-cinnost/)
- Limnologický spravodajca

• Position of individual researchers in the international context

2.3.7 List of invited/keynote presentations at international conferences, as documented by programme or invitation letter

Adamčík S., Adamčíková K., **Caboň M., Shapkin V.,** Jančovičová S. How to deal with recent tremendous changes in systematics of agaricoid Clavariaceae. Deutsche Gesellschaft für Mykologie e.V. Jubiläumstagung 2021: Blaubeuren, Germany, 4–7 October 2021

Čiampor F. Jr., Čiamporová-Zaťovičová Z. Biomonitoring 2.0 – nový „vietor" v hodnotení stavu a kvality našich vôd, XVIII. Konference České limnologické společnosti a Slovenskej limnologickej spoločnosti., Kořenov, Czech Republic, 25–29 June 2018

Danchenko M. Proteomics for the elucidation of plant-virus interactions. International Webinar on Omics in Agriculture, Samastipur, India – online, 7–9 October 2020

Demko V., Perroud P.F., Messerer M., Belova T., Hvidsten T., Johansen W., Soltysova A., Bokor B., Mayer K.F.X., Olsen O.A., Lang D. Membrane-anchored calpain DEK1 governs developmental transitions in plants and is regulated at multiple levels. 16th Student Days of Plant Biology CS 2021, České Budějovice, Czech Republic – online; 7–8 September 2021

Fačkovcová Z., Slovák M., Vďačný P., Melichárková A., Zozomová-Lihová J. & Guttová A. Pandemonium or hidden structuring buried under ubiquitous diversity? Disentangling evolutionary history and biogeographic pattern of Mediterranean dwelling lichen *Solenopsora candicans*. 58th Congress of the Polish Botanical Society – Botany

without borders, Kraków, Poland, 1–7 July 2019. In Botany without borders (Botanika bez granic). Streszczenia Referatów i Plakatów 58. Zjazdu PTB, Kraków, 1-7 lipca (July) 2019. - Warszawa ; Kraków : Polskie Towarzystwo Botaniczne : Instytut Botaniki im. W. Szafera, 2019, p. 172. ISBN 978-83-954123-0-1).

Fialová I., Vaculík M., Vaculíková M., Luxová M.. Kremík v živote rastlín. Praha, Czech Republic, 12–14 September 2017. In Vliv abiotických a biotických stresorů na vlastnosti rostlin 2017 : sborník recenzovaných vědeckých prací. Editor František Hnilička ; recenzenti Jan Novák, Jana Šlégrová. - Praha ; Zvolen : Česká zemědelská univerzita v Praze : Ústav ekológie lesa Slovenskej akadémie vied, 2017, s. 31-35. ISBN 978-80-213-2767-2, 978-80-89408-27-6

Janišová M. Grasslands, their threats and management in Europe. SER Europe Summer School on Ecological Restoration 2018: Best practice in management and restoration of European dry grasslands, Vácrátot, Hungary, 20–24 August 2018

Janišová M. Grassland research and conservation within the Eurasian Dry Grassland Group (EDGG). 7th Balkan Botanical Congress, Novi Sad, Serbia,10–14 September 2018

Janišová M. Carpathian bio-cultural heritage - a well of wisdom for modern biodiversity conservation. "Visions for Transition - How agriculture and cities of the future can save biodiversity". On-line congress of GLOBAL 2000, Vienna, Austria, 11–12 May 2020

Jásik J. Photoconvertible Fluorescence Proteins as Reporters to Monitor Intracellular Dynamics of Plasma Membrane Proteins. International Conference VISCEA 2017: Plant Transformation & Biotechnology IV., Vienna, Austria, 29–30 June 2017

Lancíková V. When size does matter: mutation breeding brought more nutritionally valuable amaranth grains. EUROBIOTECH 2019, Kraków, Poland, 23–26 September 2019

Marhold K. Central European and Carpathian phylogeography: evidence for cryptic refugia? The Second Interdisciplinary Symposium "Biogeography of the Carpathians: Ecological and evolutionary facets of biodiversity", Cluj-Napoca, Romania, 28–30 September 2017. In Studia Universitatis Babeş-Bolyai, Biologia : The Second Interdisciplinary Symposium "Biogeography of the Carpathians: Ecological and evolutionary facets of biodiversity", 28-30 September 2017, Cluj-Napoca, Romania, 2017, vol. 62, sp. iss., p. 19. ISSN 1221-8103.

Marhold K. Polyploid complexes in the (Sub-) Mediterranean: examples from the genus Cardamine. 7th Balkan Botanical Congress, Novi Sad, Serbia, 10–14 September 2018

Marhold K. International Code of Nomenclature for algae, fungi and plants and its application in naming of vascular plants. European Cooperative Programme for Plant Genetic Resources, Training on identification of botanical varieties in *Triticum* species, Piešťany, Slovakia, 17–19 September 2019

Mucina L., **Šibík J.**, Daniels F. J. Arctic-alpine vegetation in the EuroVeg Checklist. 61st Annual IAVS Symposium: Natural Ecosystems as Benchmarks for Vegetation Science, Bozeman, Montana, USA, 22–27 July 2018

Španiel S., Zozomová-Lihová J., Marhold K. Traditional taxonomic treatment versus intricate patterns of genetic and morphological variation in the *Alyssum montanum–A. repens* complex (Brassicaceae). BioSyst.EU2017, Gothenburg, Sweden, 15–18 August 2017. In BioSyst.EU 2017, 15-18 August 2017, Gothenburg, Sweden. Abstracts for Presentations and Posters. - University of Gothenburg : Gothenburg, 2017, s. 59.

2.3.8. List of researchers who served as members of the organising and/or programme committees

2021 – organising and programme committees
Čiampor Fedor: 1st international conference DNAQUA, Bratislava, 9.3.–11.3.2021
Zuzana Čiamporová Zaťovičová: 1st international conference DNAQUA, Bratislava, Slovakia, 9.3.–11.3.2021
Vaculík Marek: 16th Student Days of Plant Biology CS 2021, České Budějovice, Czech Republic (online), member of scientific committee
Alena Gajdošová: XV EUCARPIA Fruit Breeding and Genetics Symposium in Prague, Czech Republic, 3. – 7. 6. 2019, member of programme committee

2019 – organising and programme committees
Viktor Kučera: 6th Czech-Slovak mycological conference, Stará Lesná, Slovakia, 19.8.–22.8. 2019
Jozef Šibík: Botanical collections and databases and their utilisation in research and practice, Praha, Czech Republic, 30. 11. – 1. 12. 2019
Marek Vaculík: Plant Biology CS 2019, České Budějovice, Czech Republic, member of scientific committee

2018 – organising and programme committees
Alena Gajdošová: Biotechnology and quality of raw materials and foodstuffs, Congress Centre Smolenice, Slovakia, 16.9.–18.9.2018
Gabriela Libiaková: Biotechnology and quality of raw materials and foodstuffs, Congress Centre Smolenice, Slovakia, 16.9.–18.9.2018

2017 – organising and programme committees
Jana Podroužková: Ecology and evolution of plants in anthropogenic habitats of Central Europe, Praha, Czech Republic, 25.11–26.11.2017
Marek Vaculík: 14th International Student Conference on Experimental Plant Biology, Bratislava, Slovakia, programme and organisation coordinator

2016 – organising committee
Martin Hajduch: 2nd INPO World Congress (International Plant Proteomics Organisation), Bratislava, Slovakia, 4.9.–8.9.2016; in collaboration with Biomedical Research Centre SAS
Katarína Klubicová: 2nd INPO World Congress (International Plant Proteomics Organisation), Bratislava, Slovakia, 4.9.–8.9.2016; in collaboration with Biomedical Research Centre SAS
Marek Vaculík: Plant Biology Europe EPSO/FESPB 2016 Congress, Praha, Czech Republic, 26.6.–30.6.2016
Radoslava Matúšová: Ecological implications of strigolactones Nitra, Slovakia 20.07.–22.07.2016 (organising and programme committee)

2.3.9. List of researchers who received an international scientific award

2021
Demecsová Loriana: Best talk award by The scientific committee of the 8th plant nitric oxide international meeting.

2019
Demecsová Loriana: CSEPB best student talk award – 2nd prize by the Czech Society of Experimental Plant Biology in collaboration with Physiological section of the Slovak Botanical Society and the University of South Bohemia, Faculty of Science; conference „Plant Biology CS 2019“.
Kováč Ján: Company of Biologists Young Researcher Award – Travel award by The Company of Biologists; conference „Plant Biology CS 2019“.

2018
Fačkovcová Zuzana: Josef Holub Award (Cena Josefa Holuba) by the Czech Botanical Society for the best research paper published in Czech Botanical Society Journals for 2017

2017
Hindák František: Honorary member of Bulgarian Society for Mycological and Algological Innovations“ award by Sofia University “St. Kliment Ohridski”

2016
Milan Valachovič: Honorary member of Czech Botanical Society

- **Position of individual researchers in the national context**

2.3.10. List of invited/keynote presentations at national conferences, as documented by programme or invitation letter

Bérešová A., Kempa M., Miháliková T. Zbierky Botanického ústavu Centra biológie rastlín a biodiverzity SAV. Špecifiká tvorby zbierok a zberateľstvo v prírodných vedách – konferencia s medzinárodnou účasťou, Slovenské múzeum ochrany prírody a jaskyniarstva v Liptovskom Mikuláši, 20 September 2017

Vaculík M. Antimón a jeho toxické účinky na rastliny. Geochémia 2018, Bratislava, 5 December 2018

2.3.11. List of researchers who served as members of organising and programme committees of national conferences

2021
Čiampor Fedor: organising and programme committee of eDNA biomonitoring - nové možnosti hodnotenia stavu vodných ekosystémov, Bratislava/on-line
Čiamporová-Zaťovičová Zuzana: organising and programme committee of eDNA biomonitoring - nové možnosti hodnotenia stavu vodných ekosystémov, Bratislava/on-line
Libantová Jana: programme committee of XIX. Vedecká konferencia študentov I. a II. stupňa na Fakulte biotechnológie a potravinárstva SPU v Nitre, Nitra

2018
Pekárik Ladislav: organising committee of congress Zoológia 2018, Zvolen

2.3.12. List of researchers who received a national scientific award

2021
Fačkovcová Zuzana: Pavel Sillinger Award for young scientists by the Slovak Botanical Society SAS for publication activity in 2020
Kormuťák Andrej: Medal for promotion of science by Slovak Academy of Sciences (Medaila SAV za podporu vedy)
Salaj Ján: Medal for promotion of science by Slovak Academy of Sciences (Medaila SAV za podporu vedy)
Valachovič Milan: Medal for promotion of science by Slovak Academy of Sciences (Medaila SAV za podporu vedy)

2020
Fačkovcová Zuzana: Štefan Schwarz Support Fund for excellent graduates of doctoral studies; awarded by SAS
Janišová Monika: Top SAS publicatoin – exceptionally high number of citations (Špičková publikácia SAV – publikácie s mimoriadne vysokým počtom citácií); awarded by SAS

Marhold Karol: Top SAS publicatoin – exceptionally high number of citations (Špičková publikácia SAV – publikácie s mimoriadne vysokým počtom citácií); awarded by SAS
Šibíková Mária: Honorable acknowledgement for the publication activity of young researchers (Čestné uznanie v súťaži mladých vedeckých pracovníkov); awarded by SAS
Valachovič Milan: Top SAS publicatoin – exceptionally high number of citations (Špičková publikácia SAV – publikácie s mimoriadne vysokým počtom citácií); awarded by SAS

2019
Caboň Miroslav: Štefan Schwarz Support Fund for excellent graduates of doctoral studies; awarded by SAS
Demecsová Loriana: Pavel Sillinger Award for young scientists by the Slovak Botanical Society SAS for publication activity; 1st place in the competition for the Best Student Scientific Work at the National Slovak Student Scientific Conference "Applied Natural Sciences 2019" (Celoslovenská študentská vedecká konferencia „Aplikované prírodné vedy 2019“)
Jarolímek Ivan: SAS Medal for Support of Research (Medaila SAV za podporu vedy)
Marhold Karol: Honorary plaque SAS for merits in biological sciences (Čestná plaketa SAV za zásluhy v biologických vedách)

2018
Caboň Miroslav: Pavel Sillinger Award for young scientists by the Slovak Botanical Society SAS for publication activity in 2017
Gbúrová Štubňová Eliška: Pavel Sillinger Award for young scientists by the Slovak Botanical Society SAS for publication activity in 2017
Marhold Karol: Top SAS publicatoin – exceptionally high number of citations (Špičková publikácia SAV – publikácie s mimoriadne vysokým počtom citácií); awarded by SAS

2017
Bérešová Anna: Award for long-term research activities (Ocenenie za dlhoročnú výskumnú činnosť); awarded by the Administration of the National Park Muránska planina on the occassion of 20th anniversary of the foundation of the National Park
Demecsová Loriana: Special Prize of Olchemim s.r.o. in Phytohormonal Research – 14th International Student Conference on Experimental Plant Biology, Bratislava, Slovakia
Dítě Daniel, Gbúrová Štubňová Eliška, Goliašová Kornélia, Hodálová Iva, Kochjarová Judita, Kučera Jaromír, Letz Dominik Roman, Májeková Jana, Mereďa Pavol, Miháliková Tatiana, Michalková Eleonóra, Slovák Marek, Ťavoda Ondrej, Zaliberová Mária: SAS award for research activities (Cena SAV za vedecko-výskumnú činnosť) – for the monograph Flora of Slovakia VI/4
Goliašová Kornélia: Honorary plaque of SAS for contribution to biological sciences awarded by SAS (Čestná plaketa SAV za zásluhy v biologických vedách)
Marhold Karol: Top SAS publicatoin (Špičková časopisecká publikácia SAV); awarded by SAS

2016
Jopčík Martin: Štefan Schwarz Support Fund for excellent graduates of doctoral studies; awarded by SAS
Valachovič Milan:
- Honorary plaque of SAS for contribution to biological sciences awarded by SAS (Čestná plaketa SAV za zásluhy v biologických vedách)
- Honorary member of the Slovak Botanical Society SAS

2.4. Research grants and other funding resources

(List type of project, title, grant number, duration, total funding and funding for the institute, responsible person in the institute and his/her status in the project, e.g. coordinator "C", work package leader "W", investigator "I". Add information on the projects which are interdisciplinary, and also on the joint projects with several participating SAS institutes)

- ### International projects

2.4.1. List of major projects of Framework Programmes of the EU (which pilar), NATO, COST, etc.

Horizont 2020: Distributed System of Scientific Collections – Preparatory Phase Project (ESFRI – DiSSCo – Distributed System of Scientific Collections)
Grant number: 871043
Duration: 1.2.2020–31.1.2023
Total funding: 3 999 730.90 (EU Contribution)
Funding for the Centre/Institute: European Comission: 909 EUR, for the whole duration of the project: 13 830 EUR; MVTS SAV: 6 023 EUR
Coordinator: Stichting Naturalis Biodiversity Center, Leiden
Principal investigator from PSBC SAS: Karol Marhold
The aim is to ensure the preparatory phase of the ESFRI project DiSSCo. DiSSCo will directly address the current fragmentation of European collections documenting biodiversity by transforming a network of institutions into a coherent research community infrastructure: single point of contact for European collections, for data on localities of origin herbarium documents, zoological and geological collection items and related professional knowledge. DiSSCo will mobilize, link and make available the currently fragmented information on biodiversity and geodiversity to the required scale, form and accuracy. This new research infrastructure introduces a gradual change by significantly improving and expanding access to information and thus the ability of scientists to discover and analyze complex and previously separated information derived from the study of large-scale science collections in Europe. In the first year of project we focused on the specification of project objectives for the Slovak Republic, we created national consortium of Slovak institutions under the leadership of the PSBC SAS and we participated in formulation of the Slovak Road Map of Research Infrastructures (SK VI Roadmap 2020 – 2030), which is currently following an interdepartmental comment procedure and is among the unclassified materials for the conduct of the defect of the Slovak Republic. We started preparing for the reconstruction database system for mapping the distribution of higher plant species in Slovakia.

7th Framework Programme: EU-BON - Building the European Biodiversity Observation Network
Grant number: 308454
Duration: 1.12.2012– 31.5.2017
Total funding: 8 999 806 (EU Contribution)
Funding for the Centre/Institute: European Comission: 50 885 EUR, for the whole duration of the project from EC: 143 782 EUR; APVV: 4 956 EUR, for the whole duration of the project 46 779 EUR; MVTS SAV: 5 775 EUR
Coordinator: Museum fuer Naturkunde - Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University Berlin
Principal investigator from PSBC SAS: Karol Marhold
We participated in the task 1.2 "Harmonization of European taxonomic backbone and analysis of taxonomic coverage", which is part of WP 1, we modified the Euro + Med PlantBase database. The modifications consisted in supplementing the records of the spread of the occurrence of higher plant species in individual countries, which were lost during the import from the MedChecklist database. MedChecklist keeps records of extensions in a specific format, which for each added data had to be fragmented and then

assigned the correct abbreviations for extension data to the Euro + Med database and add additional information about the origin of the occurrence. As part of task 2.2 “Improving data standards and interoperability”, which is part of WP 2, we examined the available botanical and zoological databases that could serve as checklists in the EU BON project. At the same time, we explored the web services that these databases provide, their capabilities - the completeness of the information required, the scalability of the data requirements, and the standards that are required and with which these services work. We completed the programming of the software of the analytical tool for the visualization of the distribution of species in space and time in Europe (Species Richness) for the needs of the EU BON portal. The application according to user-specified criteria - higher taxon, spatial boundary, spatial resolution, time resolution, range of years - displays the numbers of occurrences and the numbers of species belonging to the higher taxon. The data is grouped into cells on the map, which include the coordinates of specific records. The individual cells are further grouped into the years in which the records were found. The data comes from the GBIF database, currently the tool supports birds (Aves class), mammals (Mammalia class), frogs (Anura class), bony fish (Actinopterygii class), beetles (Coleoptera class), butterflies and plagues (Lepidoptera class), fungi (Basidiomycota strain) and vascular plants (Magnoliophyta strain). After creating this application, we focused on improvements and modifications, whether in terms of functionality or visuals. We implemented the REST API to use the tool without visualization, displaying the number of species, refactoring the code. The application in the final version shows the ratio of the occurrence of one species to all occurrences in the specified higher taxon.

7th Framework Programme: PlantDNAtolerance - Plant adaptation to heavy metal and radioactive pollution
Registration number: 612587
Duration: 1.1.2014 - 31.10.2017
Total funding for Institute 2014-2017: 49 958 EUR – 7RP; 16 332 EUR – national funding
Funding for the Centre/Institute 2016-2017: 20 776 EUR – 7RP; 7 665 EUR - national funding
Coordinator: Institute of Biological, Environmental & Rural Sciences Aberystwyth University, UK,
Principal investigator from PSBC SAS: Martin Hajduch
Collaborative research was primarily focused on plant responses to several abiotic factors, such as ionizing radiation, heavy metals, salinity, and genetic transformation. We showed unique proteomic patterns in response to cadmium for natural ecotypes of *Arabidopsis thaliana* collected from areas with different levels of contamination with radionuclides. Also, our team demonstrated affected genetic variability in crops suffering from chronic ionizing radiation in the Chernobyl region. However, these agricultural plants showed a normal level of DNA damage but a slight increase in global DNA methylation, suggesting heritable adaptation mechanisms. Finally, we quantified and identified leaf proteins affected by genetic modification of *Populus* × *euroamericana* with a reporter and selective traits. All these results were published in international peer-reviewed journals. The focus of the project was also improving the professional skills of research personnel in collaborating laboratories. Specifically, both young and experienced scientists from partner organizations (Institute Cell Biology and Genetic Engineering of NAS of Ukraine, Institute of Botany of the NAS of Ukraine, and Belarusian State University) visited the Institute of Plant Genetics and Biotechnology at Nitra (unit of PSBS SAS). During these internships, they learned and practised advanced proteomic methods, including gel-based separation and quantification of proteins, followed by identification using tandem mass spectrometry.

ESA: NaturaSat - software for exploring Natura 2000 habitats by satellite data
Grant number: ESA-IPL-PTS-PECS-LE-2020-160
Duration: 1.10.2020–30.9.2022
Funding for the Centre/Institute: ESA: 15 000 EUR, MVTS SAV: 3 820 EUR
Coordinator: Algoritmy: SK. s r. o., Bratislava

Principal investigator from PSBC SAS: Mária Šibíková
The project represents convergence research solving complex questions requiring a multidisciplinary approach. It integrates knowledge of fieldwork scientists, mathematicians, and stakeholders focusing on habitat use and nature conservancy – especially the Natura 2000 network. The project objective is to build up the NaturaSat software allowing botanists, environmentalists, and nature conservationists across Europe to explore Natura 2000 habitats by using Sentinel-2 optical data. Achieving the project goals will guarantee the accurate area identification and classification of European protected habitats and continuous monitoring of their Spatio-temporal distribution and quality by the NaturaSat software. The project builds on the successful solution of the first phase, supported by ESA. We created a software prototype - NATURASAT, which should now be completed and tested in practice for its subsequent use by interested organizations or the private sector.

ESA: Software tools for monitoring NATURA 2000 habitats by satellite images
Grant number: 4000122575/17/NL/SC
Duration: 1.12.2017–30.11.2019
Funding for the Centre/Institute: ESA: 26 000 EUR, MVTS SAV: 6 189 EUR
Coordinator: Algoritmy: SK. s r. o., Bratislava
Principal investigator from PSBC SAS: Mária Šibíková
Pilot project supported creation of the NaturaSat software, which integrates various image processing techniques together with vegetation data, into one multipurpose tool that is designed for performing facilities for all requirements of habitat exploration, all in one place. It provides direct access to multispectral Sentinel-2 data provided by the European Space Agency. It supports using these data with various vegetation databases, in a user-friendly environment, for, e.g., vegetation scientists, fieldwork experts, and nature conservationists.

Royal Botanic Gardens, Kew, Richmond: Contribution of IB SAS to the international project Millenium Seed Bank
Grant number: no specific number
Duration: 1.1. 2007–31.12. 2018
Total funding Kew: 27 164 EUR
Funding for the Centre/Institute: 27 164 EUR
Coordinator: PSBC SAS, Jaromír Kučera
Principal investigator from PSBC SAS: Jaromír Kučera
The project focused on endangered plant species and the plant species that will be most needed in the future. The harvested plant seeds are stored in seed banks as a safeguard against the extinction of plant species in the wild. In cooperation with 80 different countries of the world, more than 13% of all plant species in the world have been collected and stored in the seed bank. The main goal of the project is to preserve 25% of all plant species in the world by 2020 (which represents about 75,000 species). The project focuses on plant species and regions that are most at risk from the ever-increasing impact of human activities, including land use and climate change. For many years PSBC SAS (IB SAS) coordinated the collection of seeds within Slovakia in the two biogeographical regions of the Carpathians and Pannonia. The target species for harvest are endemic, endangered and invasive wild plant species. The harvested seeds are stored in seed banks at MSB Kew (UK) and at the Gene Bank in Piešťany (Slovakia); several species are also stored at the Pannonian Seed Bank in Vácratót (Hungary). During 10 years of harvesting activities from the territory of Slovakia, the scientific team managed to collect and store 752 taxa, which represents approximately 16% of the total number of taxa of higher plants in the flora of Slovakia. Of this number, 80 are taxa from the category of critically endangered species, 76 taxa from endangered species, 91 taxa from vulnerable species and 49 from less endangered plant species. In terms of biogeographical regions, 33 taxa belong to the Carpathian endemics / subendemites and 16 to the Pannonian endemics / subendemites. In addition to collection activities, the project supported several studies focusing on Carpathian elements, such as: phylogeography and taxonomy of taxa *Cyclamen fatrense* (West Carpathian endemic) and *C. purpurascens*, ecology and

conservation status of *Pilosella alpicola* (*P. ullepitschii* - Carpathian endemic) karyology, morphology and ecology of *Sesleria tatrae* (West Carpathian endemic) and *S. caerulea*, or taxonomic revision of *Tephroseris longifolia* agg. (*Tephroseris longifolia* subsp. *moravica* - West Carpathian endemic), cytogeography of European species of the genus *Centaurea* of the protocyanus section (several taxa are endemic to the Carpathians) and a system of reproduction and hybridization of species of the *Centaurea triumfetti* and *C. montanus* groups in the Carpathians.

Royal Botanic Gardens, Kew, Richmond: Conserving the endemic flora of the Carpathian region
Grant number: no specific number
Duration: 1.1.2019–30.06.2022
Total funding Kew: 52 328 EUR
Funding for the Centre/Institute: RBG Kew: 52 328 EUR, MVTS SAV: 7 232 EUR
Coordinator: PSBC SAS, Jaromír Kučera
Principal investigator from PSBC SAS: Jaromír Kučera
The Carpathian Mountains, an iconic centre of biodiversity in temperate Europe, harbour a remarkable number of endemic vascular plants. Current knowledge on their taxonomic status, spatial distribution and genetic diversity is, however, incomplete. Research and conservation efforts have mostly been country-specific, resulting in contrasting chorological knowledge and taxonomic acceptance between neighbouring countries, and differing conservation policies. Urgent synchronisation of cross-border conservation measures is required. The international project addressed these issues, outlining the current state of knowledge and theoretical background concerning Carpathian subendemics and endemics in order to improve their conservation status. The project involved partners from eight countries, working collaboratively in conservation, research and sharing of standardised data for the Carpathian flora. PSBC SAS acted as coordinator of the project. Research focused on the biosystematics of selected taxa will increase our knowledge of the evolutionary processes involved in the origin of the Carpathian flora. Finally, the establishment of the Carpathian Research Network (CRN) provides an official framework for pooling, sharing and standardising scientific data on Carpathian endemics from different countries. The CRN is developing an online database of the distribution of selected species (The Carpathian Endemics Distribution Database, CEDD) including their intrinsic and extrinsic traits and current opinion on their taxonomic status.

Visegrad Fund: How do non-native tree species influence the biodiversity and the level of invasion of undergrowth?
Grant number: 51602041
Duration: 01.09.2016–28.02.2017
Total funding: 3800 EUR
Funding for the Centre/Institute: 3800 EUR
Coordinator – Partner: Masaryk University, Brno, Czech Republic
Principal investigator from PSBC SAS: Katarína Botková
The project was focused on cooperation in the field of research on vegetation synanthropization and invasion of forest communities. Important was a support of PhD students to gather experience in foreign labs and working groups. Under the leadership of Zdenka Lososová and the entire research team of the Institute of Zoology and Botany, Masaryk University Brno, Czech Republic (headed by Milan Chytrý) localities were selected for seasonal imaging in the Czech Republic, suitable methods for data processing and mastered processing in statistical programs were sought. The findings were presented at the Training School "Making a difference in Invasion Biology: Improving links between research, policy and practice" in Marseille, France and the "Seventh Meeting of PhD students in Plant Ecology and Botany" in Tihany, Hungary.

ICGEB programme: Study of the dynamic behaviour of SnRK1.1 by advanced fluorescence microscopy techniques in planta
Grant number: S/ARG 17-02
Duration: 01.01.2018– 30.06.2018

Total funding: 2477 EUR
Funding for the Centre/Institute: 2477 EUR
Coordinator – Partner: Argentina
Principal investigator from PSBC SAS: Ján Jásik
The project was supported by the International Centre for Genetic Engineering and Biotechnology and was carried out during the study stay of Dr. Nico Blanco from Rosario National University, Argentina, at PSBC SAS. It was aimed at the study of the SnRK1 kinase complex. The heterotrimeric SnRK1 kinase complex is a member of the evolutionarily conserved SNF1/AMPK/SnRK1 serine-threonine kinase family and controls energy homeostasis in plant cells. Having a premise that SnRK1 might receive information about the energy level signal in a specific intracellular location, a thoughtful localization study of this kinase was conducted. The alpha subunit of the kinase complex was labeled with the photoconvertible fluorescent protein Dendra2. The protein dynamics were studied using transient and stable transgenic expression systems and confocal microscopy. With a pharmacological approach using different photosynthesis inhibitors, it was found that the fusion protein.

Restoration of sterlet populations in the Austrian Danube
Grant number: LIFE LIFE14 NAT/AT/000057
Duration: 01. 01. 2015–30.06.2022
Total funding: 907096 EUR
Funding for the Centre/Institute: 23000 EUR
Coordinator – Partner: University of Natural Resources and Life Sciences
Principal investigator from PSBC SAS: Ladislav Pekárik
Sturgeons are the most threatened animal family globally and an example of the drastic effects of human impacts on our river ecosystems. Four out of five sturgeons are extinct in the Austrian Danube. The main reasons are overfishing in the past and the interruption of migration routes. Only the sterlet, the smallest of the native sturgeon species, can still be found in small numbers in the Upper Danube. However, the remnant population is severely threatened due to its small size. The aim of the EU- project LIFE-Sterlet was to strengthen the wild population of the sterlet and to establish healthy, self-sustaining populations in the last free-flowing stretches of the Upper Danube. One of the main goals of the project, the release of a total of 150,000 juvenile sterlet during the project period, was not only achieved but far exceeded, with over 238,000 juveniles released. Several adult fish from the first releases have already been recorded again in the Danube as of 2021. Over a period of one and a half years, 75 sterlets equipped with transmitters were observed along the Danube, allowing to learn more about the migration patterns and preferred habitats. The most surprising result was the observation of at least three sterlets with transmitters downstream the Gabčíkovo dam that documents the possible downstream migration the Gabčíkovo dam. https://life-sterlet.boku.ac.at/files/opensauce/img/Bilder/Dokumente/MA45%20Sterlet_Laienbericht_EN_K2.pdf

Cross-border transfer and development of sustainable resource recovery strategies towards zero waste
Grant number: CA20133
Duration: 28.9.2021–27.9.2025
Funding for the Centre/Institute: MVTS SAV: 1435 EUR
Coordinator – Partner: University of Borås, Sweden
Principal investigator from PSBC SAS: Andrea Hricová; **Member of management committee:** Monika Szabóová
Participation in WG 3: Biological extraction of food and feed from residues and wastes.

Network on water-energy-food Nexus for a low-carbon economy in Europe and beyond
Grant number: CA20138
Duration: 25.5.2021–24.5.2025
Funding for the Centre/Institute: MVTS SAV: 1913 EUR

Coordinator – Partner: University of Thessaly, Greece
Principal investigator from PSBC SAS: Veronika Lancíková; **Member of management committee:** Monika Szabóová
Participation in WG 5: Organization and monitoring of events

EPIgenetic mechanisms of Crop Adaptation To Climate cHange
Grant number: CA19125
Duration: 17.9.2020–16.9.2024
Funding for the Centre/Institute: MVTS SAV: 4017 EUR
Coordinator – Partner: University of Florence, Firenze, Italy
Principal investigator from PSBC SAS: Veronika Lancíková; **Member of management committee:** Andrea Hricová
Participation in WG 4: Dissemination, communication and transfer of knowledge in plant epigenetics and epigenomics

Trace metal metabolism in plants
Grant number: CA19116
Duration: 8.10.2020–07.10.2024
Funding for the Centre/Institute: –
Coordinator – Partner: Biology Centre Czech Academy of Sciences, České Budějovice, Czech Republic
Principal investigator from PSBC SAS: Marek Vaculík – management committee member; deputy leader of WG3: Responses of plant TM metabolism to the environment: TM deficiency, TM toxicity, interactions with beneficial microorganisms and pathogens
Our workgroup actively participates in experiments related to solving tasks aimed at uptake, distribution, mechanisms of toxicity and physiological effect of some selected metals such as Ni, Cu, Zn, or semi-metals (As, Sb, Si), as well as presentation and dissemination of acquired knowledge and results to the professional and general public.

The European Aquatic Animal Tracking Network
Grant number: CA18102
Duration: 1.4.2019 / 31.3.2023
Funding for the Centre/Institute: MVTS SAV: 9158 EUR
Coordinator – Partner: Flanders Marine Institute, Oostende, Belgium
Principal investigator from PSBC SAS: Ladislav Pekárik – management committee member
Participation in WG1 Data management, requirements and policy and WG2: Technology.

An integrated approach to conservation of threatened plants for the 21st Century
Grant number: CA18201
Duration: 15.10.2019–14.10.2023
Funding for the Centre/Institute: MVTS SAV: 11648 EUR
Coordinator – Partner: University of Primorska, Koper, Slovenia
Principal investigators from PSBC SAS: Terézia Salaj, Mária Šibíková – members of management committee
Participation in WG 1: Improving knowledge in plant biology for appropriate in situ conservation and WG2: Sharing experience in plant ex situ conservation.
Outputs/achievements: Co-authored Action publications - peer-reviewed: ConservePlants: An integrated approach to conservation of threatened plants for the 21st Century. Research Ideas and Outcomes 7: e62810 (2021).

SOURDOugh biotechnology network towards novel, healthier and sustainable food and bioprocesses
Grant number: CA18101
Duration: 10.4.2019–9.4.2023
Funding for the Centre/Institute: MVTS SAV: 6598 EUR
Coordinator – Partner: Universidade do Porto, Porto, Portugal

Principal investigator from PSBC SAS: Andrea Hricová, member of the Core Group, Science Communication Coordinator and Grant Awarding Coordinator (in 1st and 2nd GP period 04/2019–04/2021)
In collaboration with project partners proposal for SFS-34-2019 H2020 - Societal Challenges – Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy project, was submitted. Title of the project: "Sustainable cereal-based food systems and better intercropping practices to fight undernourishment, improve livelihoods and boost local economies in Africa (Food4Africa)". After evaluation the project was not funded.
Outputs/achievements: Co-authored Action publications - peer-reviewed:

- **HRICOVÁ, Andrea** - ŽIAROVSKÁ, Jana - ŠUHAJ, Milan - **LANCÍKOVÁ, Veronika****. Significantly lower content of antinurtitional soluble oxalate in amaranth mutant lines developed by radiation mutagenesis. In Journal of Microbiology, Biotechnology and Food Sciences, 2020, vol. 9, no. 4, p. 820-823. (2019: 0.163 - SJR, Q4 - SJR). (2020 - WOS, SCOPUS). ISSN 1338-5178. na: https://doi.org/10.15414/jmbfs.2020.9.4.820-823
- **SZABÓOVÁ, Monika** - ZÁHORSKÝ, Michal - GAŽO, Ján - GEUENS, Jeroen - VERMOESEN, Ann - D´HONDT, Els - **HRICOVÁ, Andrea****. Differences in Seed Weight, Amino Acid, Fatty Acid, Oil, and Squalene Content in gamma-Irradiation-Developed and Commercial Amaranth Varieties (Amaranthus spp.). In Plants, 2020, vol. 9, no. 11, art. no. 1412. (2019: 2.762 - IF, Q1 - JCR, 0.877 - SJR, Q1 - SJR, CCC). (2020 - Current Contents). ISSN 2223-7747. https://doi.org/10.3390/plants9111412

Genomic biodiversity knowledge for resilient ecosystems
Grant number: CA18134
Duration: 1.3.2019–31.3.2023
Funding for the Centre/Institute: MVTS SAV: 9474 EUR
Coordinator – Partner: Fondazione Emund Mach, S. Michelle all´Adige, Italy
Principal investigator from PSBC SAS: Fedor Čiampor – member of management committee
Participation in WG 2: Monitoring of genetic diversity.

Genome editing in plants - a technology with transformative potential
Grant number: CA18111
Duration: 25.4.2019– 24.4.2023
Funding for the Centre/Institute: MVTS SAV: 10107 EUR
Coordinator – Partner: Swedish University of Agriculture Sciences, Alnarp, Sweden
Principal investigator from PSBC SAS: Martin Jopčík – member of management committee

Biodiversity of temperate forest taxa orienting management sustainability by unifying perspectives
Grant number: CA18207
Duration: 13.11.2019–12.11.2023
Funding for the Centre/Institute: MVTS SAV: 6943 EUR
Coordinator – Partner: Sapienza University, Roma, Italy
Principal investigator from PSBC SAS: Jozef Šibík – member of management committee
Participation in WG 4 Habitat structures: quantity and quality needed for the conservation of forest biodiversity and WG5 Definition of relevant SFM indicators and thresholds.

Mobilising Data, Policies and Experts in Scientific Collections
Grant number: CA17106
Duration: 1.10.2018–1.10.2022
Total funding: 162 035 EUR
Funding for the Centre/Institute: MVTS SAV: 10732 EUR
Coordinator – Partner: Naturalis Biodiversity Center, Leiden, The Netherlands
Principal investigator from PSBC SAS: Karol Marhold, member of the Core Group, Coordinator of the Short Term Scientific Missions

European Information System for Alien Species
Grant number: TD1209
Duration: 2.5.2013–1.5.2017
Funding for the Centre/Institute: MVTS SAV: 5313 EUR
Coordinator – Partner: Centre for Ecology and Hydrology, Oxfordshire, Great Britain
Principal investigator from PSBC SAS: Jana Podroužková Medvecká – member of management committee, deputy head of WG 4 Harmonisation and Integration
In collaboration with partners, the application „VISITOR" was developed - an application for collecting and sharing data on invasive plants and animals with the help of the public (http://visitor.sav.sk/#/). Coupling the DAISIE database with EASIN network which results in the documentation of the process and general principles which can be used for other databases and information sources.

Increasing understanding of alien species through citizen science – Alien CSI
Grant number: CA17122
Duration: 1.6.2018–31.12.2022
Funding for the Centre/Institute: MVTS SAV: 11357 EUR
Coordinator – Partner: United Kingdom Research and Innovation, Swindon, Great Britain
Principal investigator from PSBC SAS: Ladislav Pekárik – member of management committee; Jana Podroužková Medvecká – participation in WG 1 : Engaging people in CS, 2 Approaches to CS, 3 Data management and standards, 4 Analysis and visualisation, and 5 Cross-cutting CS initiative(s) for IAS across Europe.

Developing new genetic tools for bioassessment of aquatic ecosystems in Europe
Grant number: CA15219
Duration: 20.10.2016–30.4.2021
Funding for the Centre/Institute: MVTS SAV: 13984 EUR
Coordinator – Partner: University of Duisburg-Essen, Germany
Principal investigator from PSBC SAS: Fedor Čiampor – member of management committee
Contribution to WG1: DNA Barcode Reference Databases. Organisation of the workshop on DNA barcode gap filling in Bratislava 2020, which also lead to over 100 new and missing barcodes to be created for European freshwater databases. The costs for sequencing were covered by members of COST Action DNAqua-Net through institutional funding and through support of the international barcode of life project (Center for Biodiversity Genomics, Guelph, Canada).
Co-authored Action publications - peer-reviewed:
LEESE, Florian** - BOUCHEZ, Agnès - ABARENKOV, Kessy - ALTERMATT, Florian - BORJA, Ángel - BRUCE, Kat - EKREM, Torbjørn - **ČIAMPOR, Fedor, ml**. - **ČIAMPOROVÁ-ZAŤOVIČOVÁ, Zuzana** - COSTA, Filipe - DUARTE, Sofia - ELBRECHT, Vasco - FONTANETO, Diego - FRANC, Alain - GEIGER, Matthias F. - HERING, Daniel - KAHLERT, Maria - STROIL, Belma Kalamujic - KELLY, Martyn G. - KESKIN, Emre - LISKA, Igor - MERGEN, Patricia - MEISSNER, Kristian - PAWLOWSKI, Jan - PENEV, Lyubomir - REYJOL, Yorick - ROTTER, Ana - STEINKE, Dirk - WAL, Bas van der - VITECEK, Simon - ZIMMERMANN, Jonas - WEIGAND, Alexander M. Why We Need Sustainable Networks Bridging Countries, Disciplines, Cultures and Generations for Aquatic Biomonitoring 2.0: A Perspective Derived From the DNAqua-Net COST Action. In Advances in Ecological Research, 2018, vol. 58, p. 63-99. (2017: 4.912 - IF, Q1 - JCR, 2.524 - SJR, Q1 - SJR). ISSN 0065-2504. https://doi.org/10.1016/bs.aecr.2018.01.001
WEIGAND, Hannah - BEERMANN, Arne - **ČIAMPOR, Fedor, ml.** - COSTA, Filipe - CSABAI, Zoltán - DUARTE, Sofia - GEIGER, Matthias F. - GRABOWSKI, Michael - RIMET, Frédéric - RULIK, Björn - STRAND, Malin - SZUCSICH, Nikolaus - WEIGAND, Alexander M. - WILLASSEN, Endre - WYLER, Sofia A. - BOUCHEZ, Agnès - BORJA, Ángel - **ČIAMPOROVÁ-ZAŤOVIČOVÁ, Zuzana** - FERREIRA, Sónia - DIJKSTRA, Klaas-Douwe B. - EISENDLE, Ursula - FREYHOF, Jörg - GADAWSKI, Piotr - GRAF, Wolfram - HAEGERBAEUMER, Arne - HOORN, Berry B. van der - JAPOSHVILI, Bella -

KERESZTES, Lujza - KESKIN, Emre - LEESE, Florian - MACHER, Jan N. - MAMOS, Tomasz - PAZ, Guy - PEŠIĆ, Vladimír - PFANNKUCHEN, Daniela Maric - PFANNKUCHEN, Martin Andreas - PRICE, Benjamin W. - RINKEVICH, Buki - TEIXEIRA, Marcos A.L. - VÁRBÍRÓ, Gábor - EKREM, Torbjørn**. DNA barcode reference libraries for the monitoring of aquatic biota in Europe: Gap-analysis and recommendations for future work. In Science of the Total Environment, 2019, vol. 678, p. 499-524. (2018: 5.589 - IF, Q1 - JCR, 1.536 - SJR, Q1 - SJR, karentované - CCC). (2019 - Current Contents). ISSN 0048-9697. Dostupné na: https://doi.org/10.1016/j.scitotenv.2019.04.247
RIMET, Frédéric** - AYLAGAS, Eva - BORJA, Ángel - BOUCHEZ, Agnès - CANINO, Alexis - CHAUVIN, Christian - **ČIAMPOR, Fedor, ml.** - COSTA, Filipe - FERRARI, Benoit J.D. - GASTINEAU, Romain - GOULON, Chloé - GUGGER, Muriel - HOLZMANN, Maria - JAHN, Regine - KAHLERT, Maria - KUSBER, Wolf-Henning - LAPLACE-TREYTURE, Christophe - LEESE, Florian - LELIAERT, Frederik - MANN, David G. - MARCHAND, Frédéric - MÉLÉDER, Vona - PAWLOWSKI, Jan - RASCONI, Serena - RIVERA, Sinziana - ROUGERIE, Rodolphe - SCHWEIZER, Magali - TROBAJO, Rosa - VASSELON, Valentin - VIVIEN, Régis - WEIGAND, Alexander M. - WITKOWSKI, Andrzej J. - ZIMMERMANN, Jonas - EKREM, Torbjørn. Metadata standards and practical guidelines for specimen and DNA curation when building barcode reference libraries for aquatic life. In Metabarcoding and Metagenomics, 2021, vol. 5, p. 17-33. ISSN 2534-9708. https://doi.org/10.3897/mbmg.5.58056
FLORIAN LEESE; FLORIAN ALTERMATT; AGNÈS BOUCHEZ; TORBJØRN EKREM; DANIEL HERING; KRISTIAN MEISSNER; PATRICIA MERGEN; JAN PAWLOWSKI; JEREMY PIGGOTT; FRÉDÉRIC RIMET; DIRK STEINKE; PIERRE TABERLET; ALEXANDER WEIGAND; KESSY ABARENKOV; PEDRO BEJA; LIEVEN BERVOETS; SNAEDÍS BJÖRNSDÓTTIR; PIETER BOETS; ANGELA BOGGERO; ATLE BONES; ÁNGEL, BORJA; KAT BRUCE; VOJISLAVA BURSIĆ; JENS CARLSSON; **FEDOR ČIAMPOR; ZUZANA ČIAMPOROVÁ-ZATOVIČOVÁ**; ERIC COISSAC; FILIPE COSTA; MARIETA COSTACHE; SIMON CREER; ZOLTÁN CSABAI; KRISTY DEINER; ÁNGEL DELVALLS; STINA DRAKARE; SOFIA DUARTE; TINA ELERŠEK; STEFANO FAZI; CENE FIŠER; JEAN-FRANÇOIS FLOT; VERA FONSECA; DIEGO FONTANETO; MICHAEL GRABOWSKI; WOLFRAM GRAF; JÓHANNES GUÐBRANDSSON; MICAELA HELLSTRÖM; YARON HERSHKOVITZ; PETER HOLLINGSWORTH; BELLA JAPOSHVILI; JOHN JONES; MARIA KAHLERT; BELMA KALAMUJIC STROIL; PANAGIOTIS KASAPIDIS; MARTYN KELLY; MARY KELLY-QUINN; EMRE KESKIN; URMAS KÕLJALG; ZRINKA LJUBEŠIĆ; IRENA MAČEK; ELVIRA MÄCHLER; ANDREW MAHON; MARKETA MAREČKOVÁ; MAJA MEJDANDZIC; GEORGINA MIRCHEVA; MATTEO MONTAGNA; CHRISTIAN MORITZ; VALLO MULK; ANDREJA NAUMOSKI; ION NAVODARU; JUDIT PADISÁK; SNÆBJÖRN PÁLSSON; KRISTEL PANKSEP; LYUBOMIR PENEV; ADAM PETRUSEK; MARTIN PFANNKUCHEN; CRAIG PRIMMER; BARUCH RINKEVICH; ANA ROTTER; ASTRID SCHMIDT-KLOIBER; PEDRO SEGURADO; ARJEN SPEKSNIJDER; PAVEL STOEV; MALIN STRAND; SIGITAS ŠULČIUS; PER SUNDBERG; MICHAEL TRAUGOTT; COSTAS TSIGENOPOULOS; XAVIER TURON; ALICE VALENTINI; BERRY VAN DER HOORN; GÁBOR VÁRBÍRÓ; MARLEN VASQUEZ HADJILYRA; JAVIER VIGURI; IRMA VITONYTĖ; ALFRIED VOGLER; TRUDE VRÅLSTAD; WOLFGANG WÄGELE; ROMAN WENNE; ANNE WINDING; GUY WOODWARD; BOJANA ZEGURA; JONAS ZIMMERMANN (2016): DNAqua-Net: Developing new genetic tools for bioassessment and monitoring of aquatic ecosystems in Europe. Research Ideas and Outcomes s 2: e11321.

Knowledge conversion for enhancing management of European riparian ecosystems and services
Grant number: CA16208
Duration: 09. 11. 2017–08. 11. 2021
Funding for the Centre/Institute: MVTS SAV: 10348 EUR
Coordinator – Partner: University of Rennes, France
Principal investigator from PSBC SAS: Mária Šibíková – member of management committee

Praparation of the first international conference on riparian ecosystems – scheduled for April 2022 after COVID19 pandemic limitations. More information at https://converges.eu/events/first-international-conference-on-riparian-ecosystems-may-2021-bratislava-slovakia/

Strigolactones: biological roles and applications
Grant number: FA1206
Duration: 12.4.2013–11.4.2017
Funding for the Centre/Institute: MVTS SAV: 4550 EUR
Coordinator – Partner: University of Torino, Italy
Principal investigator from PSBC SAS: Radoslava Matúšová – member of management committee
Elaboration of certified methodology in collaboration with Czech partners: Set of laboratory *in vitro* bioassays for testing of bioactive substances from microalgae.

Non-native tree species for European forests – experiences, risks and opportunities
Grant number: FP1403
Duration: 3.6.2014–13.5.2018
Funding for the Centre/Institute: MVTS SAV: 10757 EUR
Coordinator – Partner: BOKU, Vienna, Austria
Principal investigator from PSBC SAS: Andrej Kormuťák – member of management committee

The quest for tolerant varieties – phenotyping at plant and cellular level
Grant number: FA1306
Duration: 22.5.2014–21.5.2018
Funding for the Centre/Institute: MVTS SAV: 8517 EUR
Coordinator – Partner: KU Leuven, Belgium
Principal investigator from PSBC SAS: Terézia Salaj

Pathogen-informed strategies for sustainable broad-spectrum crop resistance
Grant number: FA1208
Duration: 15.4.2013–15.4.2017
Funding for the Centre/Institute: MVTS SAV: 4550 EUR
Coordinator – Partner: INRAUMR-BGPI, Montpellier, France
Principal investigator from PSBC SAS: Jana Libantová
Outputs – Co-authored Action publications - peer-reviewed:
JOPCIK Martin - MORAVCIKOVA Jana - MATUSIKOVA Ildiko - BAUER Miroslav - **RAJNINEC Miroslav - LIBANTOVA Jana** (2017). Structural and functional characterisation of a class I endochitinase of the carnivorous sundew (Drosera rotundifolia). Planta 245, p. 313-327
RAJNINEC Miroslav - LIBANTOVÁ Jana - JOPČÍK Martin (2016). Optimalisation of expression conditions for production of round-leaf sundew chitinase (Drosera rotundifolia L.) in three E. coli expression strains. Accepted In Journal of Central European Agriculture. ISSN 1332-9049.

- **National projects, incl. international projects with only national funding**

2.4.2. List of ERA-NET projects funded from SAS budget

1. ERA NET – INCOMERA (Innovation and Commercialisation in the NMP Thematic 3rd Transnational Call): A next generation plant biostimulant based on strigolactones included into stimuli responsive nanoformulation
Grant number:
Duration: 01. 01. 2018–31. 12. 2019

Institute: MVTS SAV: 50 000 EUR
Coordinator – Partner: National Institute for Research-Development in Chemistry and Petrochemistry - ICECHIM (Institutul Naţional de Cercetare-Dezvoltare pentru Chimie şi Petrochimie - ICECHIM), Bucharest, Romania
Principal investigator from PSBC SAS: Radoslava Matúšová
The team was responsible for collection and preparation of the samples of plant material for analysis. We then evaluated biological activity (perception) of SL analogs and mimics synthesized by partner organizations involved in the project. We also tested the activity of these humic acid-bound substances. Our first results confirmed the selective activity of the tested SL analogs. Activity of tested substances varied depending on the type of analogues and seeds of parasitic plants tested (*Phelipanche ramosa, Orobanche cumana, Orobanche crenata a Striga hermonthica*). Newly synthesized analogs and strigolactone mimics were tested for biological activity at parasitic plants alone as well as bound to humic acids and other organic components of humus. Humus and its components are used as vegetable biostimulators in agricultural production, their application to the soil is undemanding and therefore "candidates" for strigolactones and their joint application to soil. We quantified biological activity (induction germination of parasitic plants) of selected humus components.

2. **Programme: JRP 475542, TUBITAK: Evolutionary legacy of the Turkish flora and its influence on formation of the European plant diversity: Evidence from genome to ecology**
Grant number: ELTtoEFD
Duration: 1.7.2021–30.6.2024
Total funding: 720.000,00 TL, 120 000 EUR
Funding for the Centre/Institute: MVTS SAV: 12 500 EUR
Coordinator – Partner: Hacettepe University, Faculty of Science, Department of Biology, Turkey
Principal investigator from PSBC SAS: Karol Marhold
The “6th Joint Call for Proposals of TUBITAK- SAS Bilateral Cooperation Projects” intends to improve scientific collaboration between two countries and utilize the experience and infrastructures in both countries. There is no limitation on topics in the call. For our project, we selected the topic of plant diversity, evolution and influence of the Turkish flora on the formation of the current European flora. The aim of the project is to explore and bring novel data on the evolution and diversification of extraordinary plant diversity of Turkey in the light of hypothesis that this area represents one of the cradles of European plant diversity. We will study how and to which extent biota in Turkey influenced and formed recent diversity in the European continent.The specific objectives of this cooperation project are to explore and compare overall diversity, biogeography and evolutionary histories of members of three selected model groups originating from the Turkey with their relatives from adjacent regions including Europe, Caucasus, and the Near East. We will test the hypothesis that species and genetic lineages recently occupying Turkey, represent ancestral gene pool and a major source for colonization, radiation and subsequent diversification of biota in the European continent and other neighbouring regions.

2.4.3. List of projects of the Slovak Research and Development Agency, APVV

1. **Tree and country – influence of trees on diversity of soil microorganisms in agricultural land**
Grant number: APVV-20-0257
Duration: 1.7.2021–30.6.2025
Coordinator: PSBC SAS
Principal investigator: Slavomír Adamčík
Total funding: 210 000 EUR (PSBC SAS budget 100 826 EUR)
Collaboration with the Institute of Molecular Biology SAS and the Institute of Forest Ecology SAS

2. **Chronic ionizing radiation compromises resistance to pests in wild aquatic plants: Discovery and validation of biochemical mechanisms**
   Grant number: APVV-20-0545
   Duration: 1.8.2021–30.6.2025
   Coordinator: PSBC SAS
   Principal investigator: Maksym Danchenko
   Total funding/Funding for PSBC SAS: 160 000 EUR / 120 000 EUR
   Collaboration with the Institute of Chemistry SAS

3. **Functional and taxonomic diversity of wetlands and their relationship to ecosystem processes**
   Grant number: APVV-16-0236
   Duration: 1.7.2017–30.6.2021
   Coordinator: Technical University Zvolen
   Principal investigator for PSBC SAS: Richard Hrivnák
   Total funding/Funding for PSBC SAS: 20 098 EUR/95 000 EUR

4. **Aliens among us: Spatio-temporal dynamics of plant invasions and their adverse impact on ecosystem**
   Grant number: APVV-19-0134
   Duration: 1.7.2020–30.6.2024
   Coordinator: PSBC SAS
   Principal investigator: Richard Hrivnák
   Total funding: 82 872 EUR (2020–2021)
   Funding for the PSBC SAS: 56 150 EUR (2020–2021)
   Collaboration with the Institute of Forest Ecology SAS

5. **Functional analysis of synaptotagmins in responses of plants to environmental stresses**
   Grant number: APVV-16-0398
   Duration: 1.6.2017–31.12.2021
   Coordinator: Comenius University Bratislava
   Principal investigator PSBC SAS: Ján Jásik
   Total funding/Funding for PSBC SAS: 210 000 EUR/ 132 463 EUR

6. **The mechanism of positional signalling in plants – understanding of the DEK1 pathway**
   Grant number: APVV-17-0570
   Duration: 1.8.2018–30.6.2022
   Coordinator: Comenius University Bratislava
   Principal investigator PSBC SAS: Ján Jásik
   Total Funding/Funding for PSBC SAS: 239 739 EUR / 22 269 EUR

7. **The application of myrosinase for sulforaphane activation in development of a novel product exhibiting cancer prevention effects APVV-16-0439**
   Grant number: APVV-16-0439
   Duration: 1.7.2017–30.6.2021
   Coordinator: Slovak Technical University Bratislava
   Principal investigator PSBC SAS: Martin Jopčík
   Total funding/Funding for PSBC SAS: 248 739 EUR /40 000 EUR

8. **Potential of silicon for mitigation of arsenic and antimony toxicity in agricultural crops)**
   Grant number: APVV-17-0164
   Duration: 1.8.2018–30.6.2022
   Coordinator: Comenius University
   Principal investigator PSBC SAS: Miroslava Luxová
   Total funding: 60 000 EUR

Funding for PSBC SAS: 47 952 EUR
Collaboration with the Institute of Chemistry SAS.

9. **The origin of polyploid complexes: the role of polyploidization, geographical and ecological isolation**
Grant number: APVV-17-0616
Duration: 1.8.2018–31.7.2022
Coordinator: PSBC SAS
Principal investigator: Karol Marhold
Total funding/Funding for PSBC SAS: 239 000 EUR

10. **Identification and monitoring Natura 2000 habitats by dynamic segmentation of satellite images**
Grant number: APVV-16-0431
Duration: 1.7.2017 –30.6.2021
Coordinator: PSBC SAS
Principal investigator: Jozef Šibík
Total funding/Funding for PSBC SAS: 96 228 EUR /48 788 EUR

11. **Fungal hybrid heme peroxidases from primeval forest with application in environmental biotechnologies**
Grant number: APVV-20-0284
Duration: 1.7.2021 –30.6.2025
Coordinator: Institute of Molecular Biology SAS
Principal investigator PSBC SAS: Slavomír Adamčík
Total funding/Funding for PSBC SAS: 180 000 EUR /59 227 EUR
Collaboration with the Institute of Molecular Biology SAS

12. **Distribution potential of different fungal trophic groups in Europe**
Grant number: APVV-15-0210
Duration: 1.7.2016–30.6.2020
Coordinator: PSBC SAS
Principal investigator: Slavomír Adamčík
Total funding/Funding for PSBC SAS: 249 666 EUR / 191 716 EUR
Collaboration with the Institute of Forest Ecology SAS

13. **BrassiEvo – Species and genetic diversity in the Brassicaceae family – towards understanding of evolutin in polyploid complexes**
Grant number: APVV-0139-12
Duration: 01. 10. 2013–30.09.2017
Coordinator: PSBC SAS
Principal investigator: Karol Marhold
Total funding/Funging for PSBC SAS: 145 375 EUR / 126 626 EUR

14. **Studying the effect of different nutritional conditions on the accumulation of toxic elements in wheat**
Grant number: APVV-15-0051
Duration: 1.7.2016–30.6.2020
Coordinator: University of Ss. Cyril and Methodius in Trnava
Principal investigator PSBC SAS: Eva Boszorádová
Total funding/Funding for PSBC SAS: 217 198 EUR/22 286 EUR

15. **Danube sturgeons management and protection**
Grant number: APVV-0820-12
Duration: 1.10.2013 – 30.9.2017
Coordinator: PSBC SAS
Principal investigator: Ladislav Pekárik
Total funding/Funging for PSBC SAS: 140 000 EUR/57 230 EUR

APVV mobility projects

16. **Comparative ecology of selected invasive fish species in Slovakia and Serbia in respect with climate change and human disturbance**
Grant number: APVV-SK-SRB-18-0069
Duration: 1.1.2019 –31.12.2021
Coordinator: PSBC SAS
Principal investigator: Ladislav Pekárik
Funding for PSBC SAS: 4075 EUR

17. **Microhabitat use of sexual and clonal forms of loach fishes of the genus Cobitis (Cypriniformes) in Odra and Danube river basins**
Grant number: APVV-SK-PL-2015-0049
Duration: 1.1.2016 –31.12.2017
Coordinator: PSBC SAS
Principal investigator: Ladislav Pekárik
Funding for PSBC SAS: 2000 EUR

18. **Plant-microbial interaction in the light of responses to toxic or potentially toxic metals, metalloids and silicon**
Grant number: APVV SK-PL-18-0078
Duration: 1.1.2019 –31.12.2021
Coordinator: PSBC SAS
Principal investigator: Marek Vaculík
Funding for PSBC SAS: 4 797 EUR

19. **Chitinases and AGPs as proteins diversifying genotypes with high ability to microspore embryogenesis from non-embryogenic in crops**
Grant number: APVV-SK-PL-2015-0044
Duration: 1.1.2016–31.12.2017
Coordinator: PSBC SAS
Principal investigator: Jana Moravčíková
Funding for PSBC SAS: 3 340 EUR

20. **Systematic analysis of the Arabidopsis SYT3 gene**
Grant number: APVV SK-CN-2017-0015
Duration: 1.1.2018 –31.12.2019
Coordinator: PSBC SAS
Principal investigator: Ján Jásik
Funding for PSBC SAS: 7 567 EUR

21. **Disentangling evolutionary relationships across morphologically and ecologically diverse lichen genus Solenopsora**
Grant number: APVV SK-PT-2015-0027
Duration: 1.1.2016 –31.12.2017
Coordinator: PSBC SAS
Principal investigator: Anna Bérešová
Funding for PSBC SAS: 3 562 EUR

22. **Cryptic refugia and diversification patterns of aquatic invertebrates in the Western Carpathians**
Grant number: APVV SK-PL-2015-0042
Duration: 1.1.2016 –31.12.2017
Coordinator: PSBC SAS
Principal investigator: Fedor Čiampor
Funding for PSBC SAS: 3996 EUR

2.4.4. List of projects of the Scientific Grant Agency of the Slovak Academy of Sciences and the Ministry of Education, VEGA (for funding specify only total sum obtained from all VEGA grants in particular year)

	Code	Principal Investigator	Title	total EUR
1	2/0075/14	Adamčík Slavomír	The genus Camarophyllopsis in Europe and North America	**6000**
2	2/0018/18	Adamčík Slavomír	Systematics and phylogeny of the genus Dermoloma in Europe and North America	**40094**
3	2/0051/13	Bacigálová Kamila	(Biosystematics of Taphrina fungi (Ascomycota) in Western Carpathians and Pannonia	**4573**
4	2/0034/13	Bérešová (Guttová) Anna	Analysis of origin and diversification of Western Carpathian elements of the genus Solenopsora (lichens,Catillariaceae)	**7474**
5	2/0032/17	Bérešová (Guttová) Anna	Unraveling processes responsible for the contemporary geographic range of symbiotic organisms with Mediterranean distribution	**22907**
6	2/0054/21	Bérešová Anna	Diversity of fungal and algal communities associated to Mediterranean centered lichens at ecological and spatial levels	**9496**
7	2/0035/17	Boszorádová Eva (Moravčíková Jana)	Studying of the function of dehydrin genes from Arabidopsis thalliana in the tolerance to selected types of abiotic stresses	**18773**
8	2/0102/14	Čejka Tomáš	The assessment of biological value of the drainage ditches	**1466**
9	2/0079/18	Čejka Tomáš	Changes in biodiversity in an urban fragmented landscape	**18809**
10	1/0395/14	Čiampor Fedor	Taxonomy and phylogeny of genera Roraima Kodada & Jäch and Neblinagena Spangler (Coleoptera: Elmidae)	**992**
11	2/0101/16	Čiampor Fedor	DNA Barcoding Elmidae - applicatoin of molecular taxonomy for description of aquatic beetles biodiversity	**18576**
12	2/0042/20	Čiampor Fedor	NGS data in aquatic animal taxonomy: new approaches to researching the diversity of aquatic beetles in a time of massive global insect decline	**9023**
13	1/0515/19	Čiampor Fedor	Taxonomy of families Elmidae, Protelmidae and Dryopidae (Insecta: Coleoptera)	**3895**
14	2/0081/13	Čiamporová-Zaťovičová Zuzana	Alpine ponds – sensitive indicators of environmental changes: macroinvertebrates and determinants of their multilevel diversit	**5904**
15	2/0030/17	Čiamporová-Zaťovičová Zuzana	Diversity and dispersal in metapopulations and metacommunities of small aquatic biotopes	**25699**
16	2/0084/21	Čiamporová-Zaťovičová Zuzana	How environmental DNA (eDNA) reflects life in alpine lakes and their catchments: DNA metabarcoding in the Tatra lakes research	**7277**

17	2/0001/16	Dítě Daniel	Life on the border of exctinction - surviving potential of halophytes in Slovakia	**12991**
18	2/0001/20	Dítě Daniel	Islands of continental slaine vegetation in temperate Europe - what they have in comon and in what they differ?	**10087**
19	2/0103/21	Fialová Ivana	The role of silicon in metabolic and biochemical processes of plants exposed to stress induced by toxic and potentially toxic elements	**8936**
20	2/0140/14	Gajdošová Alena	Regeneration and clonal propagation of Rubus and Prunus spp. under in vitro conditions	**7803**
21	2/0052/17	Gajdošová Alena	Micropropagation and cryopreservation of less known small fruit species	**25261**
22	2/0008/13	Goliašová Kornélia	(Flora of Slovakia – orders Caryophyllales, Polygonales and Ericales: biosystematic study of critical taxa	**9041**
23	2/0016/14	Hajduch Martin	Proteomics mapping of clinically relevant proteins in wheat grain	**7442**
24	2/0099/13	Hegedüšová Vantarová Katarína	(Management, restoration and diversity of grassland vegetation	**7717**
25	2/0132/21	Hegedüšová Vantarová Katarína	Diversity of grassland habitats in Slovakia after two decades in the EU	**5255**
26	2/0060/15	Hindáková Alica	Cyanobacteria and accompanying algae in formation of recent freshwater stromatolites	**8607**
27	2/0131/16	Hodálová Iva	Biosystematic study of Carpatho-Pannonian representatives of the genus Sesleria (Poaceae)	**12712**
28	2/0161/21	Hodálová Iva	Flora of Slovakia - Asteraceaea family (second part): biosystematic study of critical taxa	**6505**
29	2/0041/16	Hricová Andrea	Molecular methods in breeding of naturally gluten free amaranth	**12321**
30	2/0109/19	Hricová Andrea	Morpho-physiological, genetic and biochemical response of amaranth (Amaranthus spp.) to heavy metal stress	**30110**
31	2/0019/14	Hrivnák Richard	Alder forest vegetation – the role of zonal and micro-site gradients in azonal vegetation	**3994**
32	2/0016/19	Hrivnák Richard	Diversity of plant understorey of alder forests in the main bioregions of Central Europe	**11771**
33	2/0027/15	Janišová Monika	Diversity and classification of European grassland vegetation	**13525**
34	2/0095/19	Janišová Monika	Traditional ecological knowledge for grassland conservation and restoration	**17529**
35	2/0051/15	Jarolímek Ivan	Synanthropization of the forest communities: analysis of factors affecting distributin of alien plants in forests	**26455**
36	2/0173/21	Jásik Ján	Molecular and cellular mechanisms of adventitious root differentiation	**18 692**

37	2/0115/17	Jásik Ján	Transcriptional, post-transcriptional and post-translational regulation of IRT1 gene, a key transporter of iron in plant roots	**39 359**
38	2/0056/18	Klubicová Katarína	The study of secretome influence to increasing embryogenetic capacity of selected conifer species	**31226**
39	2/0063/17	Kormuťák Andrej	Hybrid swarms of Scots pine and mountain dwarf pine in Slovakia	**7722**
40	2/0022/20	Kormuťák Andrej	Genetic structure of hybrid swarms of Scots pine and dwarf mountain pine in Slovaia	**9822**
41	2/0000/13	Kučera Viktor	(Biosystematics of the Geoglossum glabrum complex (Fungi, Ascomycota, Geoglossaceae)	**2417**
42	2/0005/15	Kučera Viktor	Screening and transformation of data of model centers of biodiversity for understanding of ecological and phylogenetical relationships of rare and endangered species of fungi	**10103**
43	2/0061/19	Kučera Viktor	Biosystsematics, phylogeny and distribution of ascomycetes of the order Leotiales in the Carpathians	**19426**
44	2/0137/17	Letz Dominik Roman	Taxonomic and nomenclatural revision of diversity of vascularr plants in Slovakia	**24839**
45	2/0090/14	Libantová Jana	Testing of genes for specific hydrolytic enzymes in plant transgenosis in orderr to use them to strengthen defence against pathogens	**16129**
46	2/0075/17	Libantová Jana	Carnivorous plants - perspective source of genes for hydrolitic enzymes with antifungal potential	**26277**
47	2/0041/20	Libantová Jana	Hydrolytic enzymes of carnivorous plants and their potential for application in biotechnology	**26176**
48	2/0022/13	Luxová Miroslava	Zinc and silicon influence on growth, physiological and metabolic symptoms of salt stress in maize (Zea mays L.) plants)	**6243**
49	1/0755/16	Luxová Miroslava	Silicon-mediated inhibition of fungal phytopathogen invasion into the plant roots	**4788**
50	2/0018/17	Luxová Miroslava	Effect of silicon and salicylic acid on physiological and metabolical processes in maize plants stressed by antimony and nickel	**41322**
51	2/0108/21	Májeková Jana	Diversity in urban biota in the Carpathian-Pannonian region	**7532**
52	2/0004/13	Marhold Karol	(Speciation and polyploid evolution in Alyssum (Brassicaceae): elucidating evolutionary processes in diversity hotspots	**8713**
53	2/0138/17	Matúšová Radoslava	Study of selected physiological and molecular factors involved in regeneration and growth of parasitic weeds of Phelipanche spp.	**34422**
54	2/0154/17	Mereďa Pavol	Flora of Slovakia - Asteraceaea family (first part): biosystematic study of critical taxa	**30698**

55	2/0023/13	Pavlovkin Ján	Perception and transduction of stress signals, structural and physiological responses of root cells to high heavy metal concentrations	**2 598**
56	2/0124/14	Pekárik Ladislav	Evolutionary importance of predation rate on life history adaptations of fishes	**3736**
57	2/0005/13	Repka Vladimír	Fungal metabolits of facultative pathogens	**7802**
58	2/0003/17	Repka Vladimír	Activation, regulation and control of cellular mechanisms in suspension culture and intact tobacco plants elicited with mycotoxins of the genus Fusarium	**5354**
59	2/0136/14	Salaj Ján	Optimization of somatic embryogenesis in conifer trees	**6503**
60	2/0024/19	Skokanová Olšavská Katarína	Determination, spreading pattern and impact of invasive plants on native ecosystems: case studies on Centaurea, Fallopia and Solidago	**20445**
61	2/0041/19	Slovák Marek	The impact of hybridisation on diversification and speciation processes in Carpathian members of the genus Soldanella	**16149**
62	2/0088/15	Slovák Marek	Bioecological study of the genus Soldanella section Soldanella (Primulaceae) in the Carpathians, the Hercynian Mts. and Eastern Alps	**23888**
63	1/0012/20	Svitková Ivana	Worlds in a world - from microcosmos to ecosystems	**1763**
64	2/0135/16	Šibík Jozef	The effects of interactions between wild herbivores and vegetation on processes in Alpine ecosystems	**9292**
65	2/0119/19	Šibíková Petrášová Mária	Diversity and distribution of species and communities in changing environment	**45629**
66	2/0096/15	Šingliarová Barbora	Why are some species narrowly endemic while their congeners are geographically widespread? Role of biological traits and genetic variability studies in the three groups of closely related taxa from the family Asteraceae	**16011**
67	2/0040/17	Škodová Iveta	Dynamics of human-altered non-forest habitats in the process of ecological restoration	**19678**
68	2/0022/21	Španiel Stanislav	Evolutionary dynamics of the (Sub)Mediterranean flora: uncovering causes of high species diversity in Alyssum and Odontarrhena (Brassicaceae)	**13140**
69	2/0133/17	Španiel Stanislav	Polyploidy and allopatric differentiation as speciation drivers in the Brassicaceae family	**49632**
70	2/0039/16	Tamás Ladislav	Nitric oxide, phytohormones and reactive oxygen species interactions in barley root responses to heavy metals	**45971**
71	2/0039/20	Tamás Ladislav	Barley root responses to heavy metals: defence or toxicity. Chemical biology approach.	**29462**

72	2/0031/17	Valachovič Milan	Species richness of vascular plants in understorey of beech forests along altitudinal gradiet	**29787**

2.4.5. List of projects supported by EU Structural Funds

Demand-driven research for the sustainable and innovative food Drive4SIFood ITMS 313011V336
Coordinator: Slovak Agriculture University in Nitra
Duration: 1.9.2020–30.6.2023
Principal investigator for PSBC SAS: Alena Gajdošová
Total funding: 9 813 468 EUR
Funding for PSBC SAS: 256 213 EUR

2.4.6. List of other projects funded from national resources

Comprehensive analysis of pathways of unintentional introduction and unintentional spread of invasive alien species of Union concern and invasive alien species of concern to the Slovak Republic and elaboration of draft action plans to address this issue (Work Contract) 2021
Ministry of Environment of Slovak Republic
Principal investigators: Pavol Mereďa jun., Dobromil Galvánek, Tomáš Čejka, Fedor Čiampor, Richard Hrivnák, Jana Májeková, Ladislav Pekárik, Katarína Skokanová, Barbora Šingliarová, Jozef Šibík
Total funding: 145 375 EUR
Funding for the PSBC SAS: 126 626 EUR
Collaboration with Institute of Landscape Ecology SAS
A team prepared two extensive studies for the needs of the Ministry of the Environment of the Slovak Republic and the State Nature Conservancy of the Slovak Republic. As part of a comprehensive analysis, we identified pathways for the introduction and unintentional spread of invasive alien species to the territory of the Slovak Republic and to areas of the European Union through Slovakia. A total of 43 species of plants and 40 species of animals were analyzed (of which 12 species of mammals, five species of birds, 10 species of fish) included in European and national legislation. The second study contained a draft action plan to address the issue of penetration routes of unintentional introduction and unintentional spread of given invasive non-native species to the territory of the Slovak Republic and to the territory of the EU through the territory of the Slovak Republic. In the action plan, o.i. identified range of responsible entities, as well as a draft schedule of activities and a description of the measures that will need to be taken to address the issue. The action plan also included monitoring the effectiveness of the proposed measures and estimating the overall level of financial security for the proposed groups of responsible entities. The Action Plan was the basis for the Legislative Process LP / 2021/788, which was discussed by the Government of the Slovak Republic following an interdepartmental comment procedure.

2.4.7. List of projects funded from private funds

none

2.4.8. List of projects funded from other competitive funds

Identification of pathways of introduction and unintentional spread of invasive non-native species to the territory of the Slovak Republic and to areas of the European Union via Slovakia – 2021
Researchers: Pavol Mereďa jun., Dobromil Galvánek, Tomáš Čejka, Fedor Čiampor, Richard Hrivnák, Jana Májeková, Ladislav Pekárik, Katarína Skokanová, Barbora Šingliarová, Jozef Šibík

Collaboration with Institute of Landscape Ecology SAS
Funding for PSBC SAS: 19 800 EUR
A team of scientists from PSBC SAS and the Institute of Landscape Ecology SAS has prepared two extensive studies for the needs of the Ministry of Environment of the Slovak Republic and the State Nature Conservation of the Slovak Republic. As part of the comprehensive analysis, we have identified pathways of introduction and unintentional spread of invasive non-native species to the territory of the Slovak Republic and to areas of the European Union via Slovakia. A total of 43 plant species and 40 animal species (including 12 mammal species, five bird species, 10 fish species) included in European and national legislation were analysed. The second study included a proposal for an action plan to address the issue of penetration routes of unintentional introduction and unintentional spread of the invasive non-native species in question to the territory of the Slovak Republic and the EU via the territory of the Slovak Republic. The Action Plan identifies, inter alia, the range of responsible entities, as well as a draft timetable of activities and a description of the measures to be taken to address the issue. The action plan also included monitoring of the effectiveness of the proposed measures and an estimate of the overall level of financial security for the proposed groups of responsible entities. The Action Plan was the basis for the Legislative Process LP/2021/788, which will be discussed by the Government of the Slovak Republic after the inter-ministerial comment procedure. (Research supported by extra-budgetary sources).

Monitoring of the aquatic fauna of Slovakia was carried out by applying innovative methods of DNA barcoding and metabarcoding – 2019
Researchers: Fedor Čiampor, Zuzana Čiamporová Zaťovičová
Contract research with the Research Institute of Water Management
Funding for PSBC SAS: 10 000 EUR
Contribution to implementation of Water Framework Directive in Slovakia. The task was to implement DNA barcoding and metabarcoding of water fauna in Slovakia, to better cover and precise the information on water fauna in Slovakia with DNA barcodes.

2.5. PhD studies and educational activities

Researchers of PSBC SAS are involved in the pedagogical process, especially educating students at all levels of higher education including doctoral. PSBC SAS is an external educational institution and, in contractual cooperation with universities, participates in the implementation of several doctoral study programmes. The researchers are consultants of PhD theses of students from universities abroad. We establish cooperation with foreign universities for Cotutelle doctorate.

2.5.1. List of accredited programmes of doctoral studies, period of validity, source of funding

1) Botanika (botany), Faculty of Natural Sciences, Comenius University Bratislava
2) Fyziológia rastlín (plant physiology), Faculty of Natural Sciences, Comenius University Bratislava
3) Genetika (genetics), Faculty of Natural Sciences, Comenius University Bratislava
4) Biotechnológie (biotechnology), Faculty of Natural Sciences, Comenius University Bratislava
5) Agrobiotechnológie (agrobiotechnology), Slovak University of Agriculture in Nitra
6) Molekulárna biológia (molecular biology), Slovak University of Agriculture in Nitra

Framework agreements with both Universities – for an indefinite period of time.
Certificate of competence to carry out research and development issued by the Ministry of education, science, research and sport of the Slovak Republic issued on 21 October 2021, valid six years from 19 October 2021.
Internal quality assessment system of doctoral studies in PSBC SAS approved by the SAS Council for Education and Doctoral Studies (Rada SAV pre vzdelávanie a doktorandské štúdium) in force from 1 January 2020.

Source of funding: central resources of SAS (state budget).

2.5.2. Summary table on doctoral studies (number of internal/external PhD students at the end of the year; number of foreign PhD students, number of students who successfully completed their theses during the year, number of PhD students who quit the programme during the year)

PhD study	2016			2017			2018			2019			2020			2021		
Number of potential PhD supervisors																		
PhD students	number, end of year	defended thesis	students quitted	number, end of year	defended thesis	students quitted	unumber, end of yea	defended thesis	students quitted	number, end of year	defended thesis	students quitted	number, end of year	defended thesis	students quitted	number, end of year	defended thesis	students quitted
Internal total	26	2	1	15	7	1	15	4	0	17	4	1	21	2	1	17	1	2
from which foreign citizens	0	0	0	0	0	0	1	0	0	3	0	0	5	0	0	5	0	0
External	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other supervised by the research employees of the institute	0	0	0	9	0	0	8	0	0	7	0	0	10	0	0	7	0	0

2.5.3. PhD carrier path – Information on the next career steps of the PhD graduates who received their degree from the institute

When educating future graduates, our goal is to recognize the abilities and/or ambitions of a student – how well the student is suited to become a researcher or well-prepared professional for university or application practice. Some graduate students received a contract for further work at the PSBC SAS.

Our PhD graduates in 2020:

Loriana Demecsová: good publication record upon graduation, fixed term contract as junior researcher, member of the team focused on plant root responses to stress, Department of Experimental Plant Biology (Institute of Botany). Currently searching for post-doc position.

Monika Frátriková: after graduation she has completed an internship at the Institute of Science and Technology in Austria in the field of plant biotechnology and molecular biology and currently she works at the Environmental Inspection in Žilina, Slovak Republic.

Our PhD graduates in 2019:

Marek Šlenker: fixed term contract as junior researcher, currently specialized in bioinformatics, member of the team of Department of Evolution and Systematics (Institute of Botany)

Katarína Mikulová: builds on gathered experience and education in the field of applied research in a non-governmental environmental organization, responsible for European projects on issues related to the NATURA 2000 (e.g. scheme LIFE programme) and we cooperate regularly, partnering in project proposals.

Miroslav Rajninec: obtained the position of scientific researcher at the PSBC SAS in the field of plant biotechnology and molecular biology

Miroslava Vaculíková: good publication record upon graduation, currently maternity leave

Our PhD graduates in 2018:

Kateřina Bubíková: builds on gathered experience and education in the applied research as the staff of Water Research Institute (Výskumný ústav vodného hospodárstva, under Ministry of Environment SR), Department of hydrobiology, microbiology and ecotoxicology.

Júlia Hunková: obtained the position of scientific researcher at the PSBC SAS in the field of plant biotechnology

Dagmara Libiaková: works outside the field of study in a private company Dexis Slovakia s.r.o. focused on service in the field of industrial distribution

Our PhD graduates in 2017:

Zuzana Ballová: builds on gathered experience and education in Institute of High Mountain Biology, the University of Žilina, deals with the study of alpine ecosystems and responses to the pressure of human activity and climate change. She is also in charge of pedagogical activities.

Miroslav Caboň: good publication record upon graduation, fixed term contract as junior researcher, member of the team of Laboratory of Molecular Ecology and Mycology (Department of Biodiversity and Ecology, Institute of Botany), active building of research career, more in section 2.8.2

Zuzana Fačkovcová: good publication record upon graduation, fixed term contract as junior researcher, member of the team of Lab Allience (Department of Evolution and Systematics, Institute of Botany), active building of research career, more in section 2.8.2

Eliška Gbúrová Štubňová: builds on gathered experience and education as curator and lab worker in Natural History Museum, Slovak National Museum, part-time, fixed-term contract as junior researcher in PSBC SAS (Department of Evolution and Systematics, Institute of Botany, member of the team of Lab Allience)

Matúš Kempa: part-time, fixed-term contract as junior researcher specialized in e-infrastructure, Department of Evolution and Systematics (Institute of Botany)

Milan Zajac: applies his experience and education as expert of State Nature Conservancy SR (under Ministry of Environment SR), Administration of Protected Landscape Area Kysuce

Michal Záhorský: works abroad outside the field of study, does not apply the education acquired so far.

Our PhD graduates in 2016:

Veronika Lancíková: obtained the position of scientific researcher at the PSBC SAS in the field of plant biotechnology and molecular biology

Marína Maglovski: after PhD. study she worked in GSK company – a science-led global healthcare company (research, development and manufacture of innovative pharmaceutical medicines, vaccines) in the position of Process Engineer. Currently she works in Land Rover company in Nitra outside the field of study.

2.5.4. Summary table on educational activities

Teaching	2016	2017	2018	2019	2020	2021
Lectures (hours/year)*	316	374	236	363	235	332
Practicum courses (hours/year)*	632	357	397	454	226	322
Supervised diploma and bachelor thesis (in total)	25	36	12	24	30	26
Members in PhD committees (in total)	13	12	10	10	9	11
Members in DrSc. committees (in total)	1	1	1	2	3	3
Members in university/faculty councils (in total)	2	2	2	1	1	1
Members in habilitation/inauguration committees (in total)	3	1	3	4	0	0

2.5.5. List of published university textbooks

1) BALÁŽOVÁ, Želmíra - GÁLOVÁ, Zdenka - RAŽNÁ, Katarína - MORAVČÍKOVÁ, Jana - **LIBANTOVÁ, Jana - HRICOVÁ, Andrea** - VIVODÍK, Martin. Biotechnológie v rastlinnej produkcii. J. Žiarovská, J. Salaj (Eds). Nitra : Slovenská poľnohospodárska univerzita v Nitre, 2021. 175 p. ISBN 978-80-552-2308-7
2) **DEMKO, Viktor**. Physcomitrium (Physcomitrella) patens - modelový organizmus v experimentálnej biológii rastlín (elektronický dokument) / Physcomitrium (Physcomitrella) patens - model organism in experimental plant biology (electronic document). Reviewer Ján Jásik. 1. vyd. - Bratislava : Mikula, 2021. - 73 s. ISBN 978-80-99987-02-0.
3) ŠIMONOVIČOVÁ, Alexandra - NOSALJ, Sanja - MACHARIKOVÁ, Miroslava - PELECHOVÁ DRONGOVÁ, Zuzana - TAKÁČOVÁ, Alžbeta - MIŠÍKOVÁ, Katarína - **GUTTOVÁ, Anna**. Pôdne mikroskopické vláknité huby, cyanobaktérie, riasy, machorasty, lichenizované huby a ich biodiverzita. Recenzenti Elena Piecková, Lívia Kijovská, Jana Sedláková. 1. vyd. Bratislava : Univerzita Komenského, 2021. 264 s. Dostupné na internete: https://fns.uniba.sk/pracoviska/environmentalna-sekcia/kpe/diverzita-podnychmikroskopickych-vlaknitych-hub-a-nizsich-rastlin/. ISBN 978-80-223-5206-2
4) GÁLOVÁ, Zdenka - BALÁŽOVÁ, Želmíra - CHRENEK, P. - CHŇAPEK, Milan - **LIBANTOVÁ, Jana** - MATUŠÍKOVÁ, Ildikó - **MORAVČÍKOVÁ, Jana - SALAJ, Ján** - DRÁBEKOVÁ, Janka. Metódy a techniky génových manipulácií. : druhé doplnené vydanie. Nitra : Slovenská poľnohospodárska univerzita, 2018. 199 s. ISBN 978-80-552-1805-2.
5) RAŽNÁ, Katarína - BEŽO, M. - ŽIAROVSKÁ, Jana - ŠTEFÚNOVÁ, Veronika - FILOVÁ, Angela - **GAJDOŠOVÁ, Alena** - OSTROLUCKÁ, Mária-Gabriela - **HRICOVÁ, Andrea - LIBIAKOVÁ, Gabriela**. Explantátové kultúry rastlín. Prvé. Nitra : Slovenská poľnohospodárska univerzita, 2018. 151 s. ISBN 978-80-552-1860-1.
6) **VACULÍK, Marek**. Základné princípy fytoremediácií. Recenzenti Milada Čiamporová, Alexander Lux. 1. vyd. Bratislava : Univerzita Komenského, 2018. 90 s. ISBN 978-80-223-4514-9.
7) GÁLOVÁ, Zdenka - CHŇAPEK, Milan - BALÁŽOVÁ, Želmíra - VIVODÍK, Martin - **MORAVČÍKOVÁ, Jana**. Molekulárna biológia. Nitra : Slovenská poľnohospodárska univerzita, 2016. s. 134. ISBN 978-80-552-1550-1.

2.5.6. Number of published academic course books

none

2.5.7. List of joint research laboratories/facilities with universities

The AgroBioTech Research Centre (ABT RC)
Institute of Plant Genetics and Biotechnology PSBC SAS partners with Slovak University of Agriculture in Nitra and Constantine the Philosopher University in Nitra within the common research centre established within the project AgroBioTech ITMS 26220220180 (supported by Structural Funds, 2013–2015). The centre houses facilities to perform concentrated innovative research in the relevant fields aimed at conducting new methods and procedures in research, especially within applied research, with the express goal of transferring its results into practice, being in line with the priorities of agrobiology, the processing technology of agricultural products and the agri-food industry, biotechnology, genetic technologies, agroecology, bioenergetics, and bioeconomy. Institute of Plant Genetics and Biotechnology PSBC SAS participates with two laboratories – Laboratory of molecular plant breeding and Laboratory of reproduction and developmental biology. The current collaboration continues within the project Drive4SIFood (NFP313010S984, Structural Funds).

Memorandum on cooperation: Stredoslovenské centrum vedy a vzdelávania SAV and Matej Bel University Banská Bystrica of 3. 8. 2018
Joint workplace of the SAS (Institute of Earth Sciences SAS, Plant Science and Biodiversity Centre SAS, Mathematical Institute SAS, Insitute of Informatics SAS) and the Faculty of Natural Sciences of the Matej Bel University (Agreement on Establishment of 24 October 2019). Five staff members of PSBC SAS work in joint workplace, covering the topics of molecular plant systematics, study of plant-environment interactions, ecophysiology, vegetation ecology, population biology, as well as their applications in nature protection and landscape planning. The aim of the cooperation is to build opportunities for quality botanical research in the region of Central Slovakia. Researchers participate in pedagogical activities of the Department of Biology and Ecology, Faculty of Natural Sciences, MBU and supervise or consult bachelor's, master's and dissertation theses of MBU students.

2.5.8. Supplementary information and/or comments on doctoral studies and educational activities – focused on what changes have occurred since the last evaluation in 2016

We implemented a series of steps to
- better promote the PhD positions,
- to enhance the experience of PhD students,
- and development of their carreer.

Besides Universities information systems, the topics (PhD positions) are advertised at https://euraxess.ec.europa.eu/jobs, SAS website (https://www.sav.sk/?lang=sk&doc=educ-phdtopic), during the public SAS event – presentation of topics for PhD studies (https://www.sav.sk/?lang=sk&doc=educ-phdpresentations) and at PSBC SAS website (https://cbrb.sav.sk/en/education-and-career/ph-d/).

To increase the quality and attractivity of PhD studies we search for partners for **„cotutelle de thèse“** type of study. At the moment, one student Adam Kantor performs his PhD study based on the Agreement on dual dissertation between Comenius University Bratislava and Charles University no 2021/181 (Dohoda o dvojím vedení disertační práce mezi Univerzita Komenského v Bratislave a Univerzitou Karlovou č. 2021/181) in accredited programme botany.

Researchers from PSBC SAS formally supervise PhD students from universities abroad:

Slavomír Adamčík:
- co-advisor of Cathrin Manz, Goethe University Frankfurt am Main
- co-advisor of Ruben de Lange, Ghent University

Fedor Čiampor:
- Thiago Tadeu Polizei, Universidade de São Paulo, Brazil

We work towards **optimization of the processes related to the PhD study**. The outputs of the discussions were incorporated into the **Research development strategy for the period 2021–2025** and Action plan. Our priorities to achieve are:
- a well-prepared researcher who understands the concept of excellence of scientific work, recognizes scientific production of world-leading groups in her/his field, has experience with work in international teams and labs, is able to formulate research hypotheses and questions; able to compete internationally for post-doctoral positions in scientific teams mainly abroad;
- well-prepared young professional for application sphere, including nature protection.

We consider investing resources (time and energy) in education, including the quality of PhD studies fundamental for development of the institution and the research. There are several important moments to improve PhD studies: starting from topical themes, where the solution of scientific problems connects with practice, through orienting the PhD student to aims and goals, strategy and plan how to achieve these goals, along with regular mentoring. Effective and clear communication in the research team, obtaining feedback, and support for inventive and personal development are also needed. To keep the management of the PSBC SAS posted with how the students perform, we started individual annual meetings of students, their supervisors, guarantor and director at the end of the school year. The themes are discussed according to a structured questionnaire. The aim is, in accordance with the internal guideline "Quality Assurance of Doctoral Studies at the CBRB SAS", to summarize the finalized school year, positive and negative parts, how all formal criteria to move to the next year are met (e.g. number of credits), the status of prepared publications. The meeting is a space for questions, proposals and clarifications to avoid problems, to ensure the proper continuation of the study, meeting deadlines and quality of outputs.

We outlined several strategic steps to implement in the upcoming period, e.g.:

- to raise the quality of education; implement elements of active learning and improvement of teaching and training by trainers or guarantors so that we meet the goals of Bloom's taxonomy (Bloom et al., 1956); cultivating and developing independent thinking;
- more efficient use of cotutelle-type studies;
- increase the possibilities for formalized cooperation in PhD studies (framework agreements) with other universities, including international;
- increase the number of guarantors, or researchers meeting the criteria of a guarantor;
- systematic guidance of doctoral students to participate in the scientific life of the institution and the Slovak Academy of Sciences, the use of discussion events such as journal club, seminars, and active promotion of their progress; active participation and several representatives in the Young Scientists of the SAS forum;
- increased emphasis on the integration of young researchers into research teams of large national APVV or international projects;
- PhD students actively contribute to the education of bachelors and masters, higher involvement of PhD l students as supervisors of bachelor's theses;
- to encourage the students to participate in the calls of the DoktoGrant program.

Further educational activities – cooperation with schools

Evernia goes to school – Green Norwegian Tilgnerka: Long term cooperation with Spojená škola Tilgnerova, Bratislava

Recently indoor air quality (IAQ) has become a key issue, especially in schools, where children spend most of the day. Only in a few cases IAQ was investigated using lichens as biomonitors. During autumn 2017, lichens (*Evernia prunastri*) were exposed for two months indoors and outdoors in public (schools) and private (dwellings) environments, in both rural and urban areas of Slovakia. The bioaccumulation of selected elements and the physiological status of the samples were considered. The content of heavy metals increased in samples exposed outdoors for 11 out of 12 elements (Al, As, Cd, Cr, Cu, Fe, Pb, S, Sb, V and Zn, but not Ca) in the urban area and for 5 (As, Cd, Cu, Pb and Sb) in the rural area. Indoor concentrations were overall similar, both in rural and urban buildings, independently of the outdoor conditions. An indoor accumulation occurred only for Cd, Cu and Pb. An indoor origin was suggested for Cd, while for Cu and Pb, outdoor penetration (car traffic) is the likely cause of indoor values. Indoor exposed lichens maintained their vitality (as reflected by chlorophyll *a* fluorescence emission). This latter result further supports the use of lichen biomonitoring as a suitable method for assessing IAQ. *Evernia* goes to school" was a citizen science initiative: we sincerely acknowledge managers, teachers, students and volunteers of "Spojená škola Tilgnerova" in Bratislava

and “Základná škola Jána Hollého s materskou školou” in Madunice (Slovakia). The output of common work over the school year was published: Paoli et al. 2019: Plants 8: 125.

More information:
https://cbrb.sav.sk/spolupraca-so-spojenou-skolou-tilgnerova-bratislava-podpora-projektu-zelena-norska-tilgnerka/
https://tilgnerka.edupage.org/text/?eqa=dGV4dD10ZXh0L3RleHQxMzgmc3VicGFnZT0z

2.6. Societal impact

2.6.1. The most important case studies of the research with direct societal impact, max. 4 for institute with up to 50 average FTE researchers per year, 8 for institutes with 50 – 100 average FTE researchers per year and so on. Structure: Summary of the impact; Underpinning research; References to the research; Details of the impact; Sources to corroborate the impact. One page per one case study

1) **2016: Participation in legislative process – Interdepartmental Comments** Procedure: Draft on the act on the prevention and management of the introduction and spread of invasive alien species and on the amendment of certain laws (Ministry of Environment SR). Karol Marhold, Anna Bérešová.
Underpinning research: The activities were supported by outputs of several projects funded from national and EU sources:
European Information System for Alien Species – COST TD 1209
EU-BON - Building the European Biodiversity Observation Network 308454
How do non-native tree species influence the biodiversity and the level of invasion of undergrowth? Visegrad fund
Establishment of European Red List of Habitats Alterra Wageningen

Sources to corroborate the impact: https://www.sopsr.sk/invazne-web/?page_id=42 – national legislation; https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2019/150/

2) **2016: SK-Press 2016: Slovak Presidency of the Council of the European Union – COP13 CBD and COP 2 ABS.** Expert support for preparatory meetings in Slovakia (Karol Marhold, Anna Bérešová), ABS expert group in Brussels (synthetic biology and clearing house mechanism) and for the 13th meeting of the Conference of the Parties to the Convention on Biological Diversity and 2nd meeting of the Conference of the Parties serving as the meeting of the Parties to the Nagoya Protocol (ABS), Cancun, Mexico (Anna Bérešová). Within EU coordination on the issues of synthetic biology and digital sequences she actively participated in the analysis of CBD Secretariat documents and both protocols in relation to EU Council conclusions, in the preparation of negotiations and bilateral meetings, as well as in the preparation of conference documents, which included the views of all parties. Following the COP conferences, she participated in the preparation of an information note from the conference, which was submitted to the EU Member States and summarized the decisions of the Second Conference of the Parties to the Nagoya Protocol.
Underpinning research:
Flora of Slovakia – orders Caryophyllales, Polygonales and Ericales: biosystematic study of critical taxa VEGA 2/0008/13
Disentangling evolutionary relationships across morphologically and ecologically diverse lichen genus Solenopsora SK-PT-20150027
BrassiEvo, Species and genetic diversity in the Brassicaceae family - towards understanding of evolution in polyploid complexes APVV-0139-12
The genus Camarophyllopsis in Europe and North America VEGA 2/0075/14
Analysis of origin and diversification of Western Carpathian elements of the genus Solenopsora (lichens,Catillariaceae) VEGA 2/0034/13
(Biosystematics of Taphrina fungi (Ascomycota) in Western Carpathians and Pannonia VEGA 2/0051/13
Utilisation of RAD sequencing in plant systematics and evolution. A case study of the genus Soldanella 2015-05-15-001, SAIA
Taxonomic revisions in Placynthiaceae Synthesys, AT-TAF-4805
Cryptic refugia and diversification patterns of aquatic invertebrates in the Western Carpathians APVV-SK-PL-2015-0042
DNA Barcoding Elmidae – application of molecular taxonomy for description of aquatic beetles biodiversity VEGA 2/0101/16
Biosystematics of the Geoglossum glabrum complex (Fungi, Ascomycota, Geoglossaceae) VEGA 2/0000/13

3) **2017: Ministry of Environment SR: Strategy of the adaptation of the Slovak Republic to the adverse consequences of climate change.** Expert input in the text of the document relevant to the element "Natural environment and biodiversity – changes in geographic distribution of species, extinction of vulnerable species and expansion of resilient species. Proposals for adaptation measures. Jozef Šibík, Anna Bérešová.
Underpinning research:
Clonal Plant Response to Disturbance in the Tatras UNCO 2016
Developing of the Arctic Vegetation Archive and synthesis of Arctic vegetation SAIA 12629
Distribution potential of different fungal trophic groups in Europe APVV-15-0210
Alpine ponds – sensitive indicators of environmental changes: macroinvertebrates and determinants of their multilevel diversity VEGA 2/0081/13
Unraveling processes responsible for the contemporary geographic range of symbiotic organisms with Mediterranean distribution VEGA 2/0032/17
Sources to corroborate the impact: https://climate-adapt.eea.europa.eu/repository/11273729.pdf

4) **2017: Ministry of Environment SR: Environmental policy strategy of the Slovak Republic until 2030.** Participation in public consultation, input to the elements of forests, especially their management in protected areas taking into consideration the aspects of

evolutionary biology, conservation biology, ecosystem ecology, biogeography, paleoecology and other natural and social sciences. Jozef Šibík, Anna Bérešová.
Underpinning research:
Alder forest vegetation – the role of zonal and micro-site gradients in azonal vegetation VEGA 2/0019/14
Synanthropisation of the forest communities: Analysis of factors affecting distribution of alien plants in forest VEGA 2/0051/15
Management, restoration and diversity of grassland vegetation VEGA 2/0099/13
Sources to corroborate the impact: https://www.minzp.sk/iep/strategicke-materialy/envirostrategia-2030.html

5) **2018: Ministry of Environment SR:** Expert input in the text of the document "Nature and landscape protection concept for the period 2020–2030". Jozef Šibík, Anna Bérešová.
Underpinning research:
Diversity and classification of European grassland vegetation VEGA 2/0027/15
Management, restoration and diversity of grassland vegetation VEGA 2/0099/13
Knowledge conversion for enhancing management of European riparian ecosystems and services COST CA16208
Sources to corroborate the impact: **file**:///C:/Users/user1/Downloads/Koncepcia_ochrany_prirody_a_krajiny_do_roku_2030.pdf

6) **2018: Ministry of education, science, research and sport SR**: Participation in the proposals for the topics of sub-programmes of the State programme for research and development for the period 2018–2023 with an outlook to 2028. Focus on the topics within two sub-programmes: 1) Sustainable land management and the environment, and 2) Biotechnology (State programme "Quality of health and nutrition of the population, development of biotechnology and agriculture, protection and improvement of the environment"). Karol Marhold, Anna Bérešová, Ján Salaj, Jozef Šibík.
Underpinning research:
Identification and monitoring Natura 2000 habitats by dynamic segmentation of satellite images APVV-16-0431
The origin of polyploid complexes: the role of polyploidization, geographical and ecological isolation APVV-17-0616
Functional and taxonomic diversity of wetlands and their relationship to ecosystem processes APVV-16-0236
Diversity and distribution of species and communities in changing environment VEGA 2/0119/19
Polyploidy and allopatric differentiation as speciation drivers in the Brassicaceae family VEGA 2/0133/17
Dynamics of human-altered non-forest habitats in the process of ecological restoration VEGA 2/0040/17
Zinc and silicon influence on growth, physiological and metabolic symptoms of salt stress in maize (Zea mays L.) plants VEGA 2/0022/13
Silicon-mediated inhibition of fungal phytopathogen invasion into the plant roots VEGA 1/0755/16

7) **2020: Ministry of agriculture and rural development SR**: preparation of proposals for new common agriculture policy in EU after 2020 taking into consideration measures helping to halt the loss of biodiversity in agriculture landscape, including conditionalities, agroenvironmental measures, voluntary schemes (eco-schemes). The discussions took place during the seminar – initiative of researchers from iDIV, UFZ, University of Rostock and Thünen Institute. Katarína Vantarová, Monika Janišová, Dobromil Galvánek.
Underpinning research:
Life on the border of extinction – surviving potential of halophytes in Slovakia VEGA 2/0001/16
Diversity and classification of European grassland vegetation VEGA 2/0027/15
Management, restoration and diversity of grassland vegetation VEGA 2/0099/13

Knowledge conversion for enhancing management of European riparian ecosystems and services COST CA16208
Traditional ecological knowledge for grassland conservation and restoration VEGA 2/0095/19
Sources to corroborate the impact:

8) **2020: Ministry of Investments, Regional Development and Informatization: Update of the Research and Innovation Strategy for Smart Specialization of SR (RIS3 SR).** Addition of innovation items within the domain 5-1: Resilient and healthy local food systems – new amaranth varieties "Pribina" and "Zobor"; domain 5–3: Society in the environment; domain 5–4: Sustainable natural resources (soil, water, air, biodiversity, ecosystems) – automatic monitoring and warning system to identify changes in habitats; Assessment of degradation and biological quality of soil ecosystems; Slavomír Adamčík, Alena Gajdošová, Ján Jásik, Karol Marhold, Jozef Šibík, Anna Bérešová.
Update of the Research and Innovation Strategy for Smart Specialization of SR (RIS3 SR 2021-2027). Addition of innovation items for Ministry of Investments, Regional Development and Informatization
Underpinning research: The research is supported by numerous projects funded from national and EU sources:
7th FP: EU-BON - Building the European Biodiversity Observation Network (2012 - 2017)
Horizont 2020: Distributed System of Scientific Collections – Preparatory Phase Project (ESFRI – DiSSCo – Distributed System of Scientific Collections) (2020 – 2023)
ESA:Software tools for monitoring NATURA 2000 habitats by satellite images (2017 -2019)
ESA: NaturaSat- software for exploring Natura 2000 habitats by satellite data (2020 - 2022)
Royal Botanic Gardens, Kew, Richmond: Conserving the endemic flora of the Carpathian region (2019 – 2022)
LIFE: Restoration of sterlet populations in the Austrian Danube (2015 – 2021)
APVV: Distribution potential of different fungal trophic groups in Europe (2016 - 2020)
APVV: Tree and country – influence of trees on diversity of soil microorganisms in agricultural land (2021 – 2025)
APVV: Functional and taxonomic diversity of wetlands and their relationship to ecosystem processes (2021 - 2025)
APVV: Spatio-temporal dynamics of plant invasions and their adverse impact on ecosystem (2020 - 2024)
VEGA: Diversity of fungal and algal communities associated to Mediterranean centered lichens at ecological and spatial levels (2021 – 2024)
VEGA: Molecular methods in breeding of naturally gluten free amaranth (2016 – 2018)
VEGA: Morpho-physiological, genetic and biochemical response of amaranth (*Amaranthus* spp.) to heavy metal stress (2019 – 2021)
References to the research:
PAOLI, Luca - FAČKOVCOVÁ, Zuzana - LACKOVIČOVÁ, Anna - GUTTOVÁ, Anna**. Air pollution in Slovakia (Central Europe): a story told by lichens (1960–2020). In Biologia, 2021, vol. 76, no. 11, p. 3235-3255. https://doi.org/10.1007/s11756-021-00909-4
BUBÍKOVÁ, Kateřina - SVITKOVÁ, Ivana - SVITOK, Marek - HRIVNÁK, Richard**. Invasive elodeas in Slovakia (Central Europe): distribution, ecology and effect on native macrophyte assemblages. In Aquatic Invasions, 2021, vol. 16, no. 4, p. 617-636. DOI: 10.3391/ai.2021.16.4.03
CETLOVÁ, Veronika - ZOZOMOVÁ-LIHOVÁ, Judita - MELICHÁRKOVÁ, Andrea - MÁRTONFIOVÁ, Lenka - ŠPANIEL, Stanislav**. Multiple Drivers of High Species Diversity and Endemism Among Alyssum Annuals in the Mediterranean: The Evolutionary Significance of the Aegean Hotspot. In Frontiers in Plant Science, 2021, vol. 12, art. no. 627909. https://doi.org/10.3389/fpls.2021.627909
MIKULA, Karol - ŠIBÍKOVÁ, Mária - AMBROZ, Martin - KOLLÁR, Michal - OŽVAT, Aneta A. - URBÁN,
JAROLÍMEK, Ivan - ŠIBÍK, Jozef**. NaturaSat - A Software Tool for Identification, Monitoring and Evaluation of Habitats by Remote Sensing Techniques. In Remote Sensing, 2021, vol. 13, no. 17, art. no. 3381. https://doi.org/10.3390/rs13173381

Andrea HRICOVÁ, Jozef FEJÉR, Gabriela LIBIAKOVÁ, Monika SZABOVÁ, Ján GAŽO, Alena GAJDOŠOVÁ, 2016. Characterization of phenotypic and nutritional properties of valuable Amaranthus cruentus L. mutants. Turk J Agric For, 40, (2016), p. 761-771, DOI: 10.3906/tar-1511-31

HRICOVÁ, Andrea* - MISTRÍKOVÁ, Veronika* - GAJDOŠOVÁ, Alena - FEJÉR, Jozef - NÔŽKOVÁ, Jana - KARILUOTO, Susanna - GAŽO, Ján - SZABÓOVÁ, Monika**. Comparative Analysis Reveals Changes in Some Seed Properties in Amaranth Mutant Variety 'Zobor' (A. hypochondriacus x A. hybridus). In Agronomy-Basel, 2021, vol.11, no. 12, article Number 2565. https://doi.org/10.3390/agronomy11122565

Details of impact: Addition of innovation items within the domain 5-1: Resilient and healthy local food systems – new amaranth varieties "Pribina" and "Zobor"; domain 5–3: Society in the environment; domain 5–4: Sustainable natural resources (soil, water, air, biodiversity, ecosystems) – automatic monitoring and warning system to identify changes in habitats; Assessment of degradation and biological quality of soil ecosystems.

Sources to corroborate the impact: https://www.mirri.gov.sk/sekcie/investicie/strategia-vyskumu-a-inovacii-pre-inteligentnu-specializaciu-sr/index.html

9) **2020: Activities resulting from the membership in the Committee of Experts at the Commission for Biosafety of the Ministry of the Environment** consisting in the elaboration of expertise as a basis for the recommendations of the Commission for Biosafety on applications and notifications related to the use of genetic technologies and genetically modified organisms in the Slovak Republic.

Underpinning research: The expertise is supported by the long term research performed in numerous projects (here are mentioned projects within the period 2016 – 2021)

VEGA project 2/0090/14 Testing of genes for specific hydrolytic enzymes in plant transgenesis in order to use them to strengthen defence against pathogens (2014 - 2016)

VEGA project 2/0075/17 Carnivorous plants – the prospective source of genes for hydrolytic enzymes with antifungal potential (2017 – 2019)

VEGA project 2/0041/20 Hydrolytic enzymes of carnivorous plants and their potential for application in biotechnology (2020 – 2023)

COST Action FA 1208 Pathogen-informed strategies for sustainable broad-spectrum crop resistance (2013 – 2017)

APVV project 16-0439 The application of myrosinase for sulforaphane activation in the development of a novel product exhibiting cancer prevention effects (2017 – 2021)

References to the research (selected)

JOPČÍK, Martin - MORAVČÍKOVÁ, Jana - MATUŠÍKOVÁ, Ildikó - BAUER, Miroslav - RAJNINEC, Miroslav - LIBANTOVÁ, Jana. Structural and functional characterisation of a class I endochitinase of the carnivorous sundew (Drosera rotundifolia L.). In Planta, 2017, vol. 245, no. 2, p. 313-327. (2016: 3.361 - IF, Q1 - JCR, 1.490 - SJR, Q1 - SJR, karentované - CCC). (2017 - Current Contents). ISSN 0032-0935. Dostupné na: https://doi.org/10.1007/s00425-016-2608-1 Typ: ADCA

MICHALKO, Jaroslav - RENNER, Tanya - MÉSZÁROS, Patrik - SOCHA, Peter - MORAVČÍKOVÁ, Jana - BLEHOVÁ, Alžbeta - LIBANTOVÁ, Jana - POLÓNIOVÁ, Zuzana - MATUŠÍKOVÁ, Ildikó. Molecular characterization and evolution of carnivorous sundew (Drosera rotundifolia L.) class V beta-1,3-glucanase. In Planta, 2017, vol.245, no.1, p. 77-91. (3.361 - IF2016). (2017 - Current Contents) https://doi.org/10.1007/s00425-016-2592-5

FRÁTRIKOVÁ, Monika - BAUER, Miroslav - JOPČÍK, Martin - LIBANTOVÁ, Jana. Simple veritification of vitro - grown clones of the genus Drosera L. using its molecular markers. In Acta Scientiarum Polonorum. Hortorum Cultus, 2018, vol. 17, no. 1, p. 159-164. (0.448 - IF2017) https://doi.org/10.24326/asphc.2018.1.15

BOSZORÁDOVÁ, Eva - MATUŠÍKOVÁ, Ildikó - LIBANTOVÁ, Jana - ZIMOVÁ, Mária - MORAVČÍKOVÁ, Jana. Cre-mediated marker gene removal for production of biosafe commercial oilseed rape. In Acta Physiologiae Plantarum, 2019, vol. 46, no. 6, art. no. 73. (1.608 - IF2018). ISSN 0137-5881. https://doi.org/10.1007/s11738-019-2865-2

RAJNINEC, Miroslav - JOPČÍK, Martin - DANCHENKO, Maksym - LIBANTOVÁ, Jana**. Biochemical and antifungal characteristics of recombinant class I chitinase from Drosera rotundifolia. In International Journal of Biological Macromolecules, 2020, vol. 161, p. 854-

863. (2019: 5.162 - IF, Q1 - JCR, 0.972 - SJR, Q1 - SJR). ISSN 0141-8130. https://doi.org/10.1016/j.ijbiomac.2020.06.123
RAJNINEC, Miroslav* - FRÁTRIKOVÁ, Monika* - BOSZORÁDOVÁ, Eva - JOPČÍK, Martin - BAUER, Miroslav - LIBANTOVÁ, Jana**. Basic beta-1,3-Glucanase from Drosera binata Exhibits Antifungal Potential in Transgenic Tobacco Plants. In Plants, 2021, vol. 10, no. 8, art. no. 1747. (2020: 3.935 - IF, Q1 - JCR, 0.892 - SJR, Q1 - SJR, karentované - CCC). (2021 - Current Contents). ISSN 2223-7747 https://doi.org/10.3390/plants10081747
Details of impact:
Preparation of expert opinions Assessment of two applications concerning the renewal of the placing on the market of specific GM crops (2016) and preparation of an opinion on the use of GMOs in confined spaces (2019)
Sources to corroborate the impact: https://www.minzp.sk/bezpecnost/geneticky-modifikovane-organizmy/komisia-biologicku-bezpecnost/

2.6.2. List of the most important studies and/or other activities commissioned for the decision-making authorities, the government and NGOs, international and foreign institutes (title, name of institution, contract value, purpose (max 20 words))

2018: State Nature Conservancy SF – regular joint meetings
A professional organization of the Ministry of the Environment SR with nation-wide competence, focused mainly on ensuring tasks in the field of nature and landscape protection according to the provisions of Act no. 543/2002 Coll. on the protection of nature and landscape, as amended, and in the area of protection of species of wild fauna and flora by regulating trade in them in accordance with the provisions of Act no. 15/2005 Coll. on the protection of species of wild fauna and flora by regulating trade in them and on the amendment of certain laws as amended. In order to strengthen information flow and communication between the State Nature conservancy we initiated regular joint meetings starting in 2018. The aim is to keep the staff of national park and protected landscape area administrations posted about the research tasks of scientists, results of the studies and scientific issues they address.

Collaboration with NGOs – LIFE projects
2016–2021: monitoring of habitats linked to the management measures, consequent succession
1. LIFE14 NAT/SK/001306 Restoration and management of Danube floodplain habitats: Bratislavské regionálne ochranárske združenie (BROZ)
2. LIFE10 NAT/SK/083 Restoration of endemic Pannonian salt marshes and sand dunes in Southern Slovakia: Daphne – Institute of Applied Ecology
3. LIFE10 NAT/SK/080 Restoration of NATURA 2000 sites in cross-border Bratislava capital region: Daphne – Institute of Applied Ecology
4. LIFE16 NAT/CZ/000001 Optimalization of NATURA 2000 sites management delivery in the South Bohemia Region and the territory of South Slovakia: Bratislavské regionálne ochranárske združenie (BROZ)
5. LIFE17 NAT/SK/00589 Conservation of subpannonic dry grassland habitats and species: Bratislavské regionálne ochranárske združenie (BROZ)

2021: Comprehensive analysis of pathways of unintentional introduction and unintentional spread of invasive alien species of Union concern and invasive alien species of concern to the Slovak Republic and elaboration of draft action plans to address this issue (Work Contract). Ministry of Environment of Slovak Republic. Contract value: 19 800 EUR.
Pavol Mereďa jun., Dobromil Galvánek, Tomáš Čejka, Fedor Čiampor, Richard Hrivnák, Jana Májeková, Ladislav Pekárik, Katarína Skokanová, Barbora Šingliarová, Jozef Šibík. Collaboration with Institute of Landscape Ecology SAS.
A team prepared two extensive studies for the needs of the Ministry of the Environment of the Slovak Republic and the State Nature Conservancy of the Slovak Republic. Within the first of them, pathways of introduction and unintentional spread of invasive alien species to the

territory of the Slovak Republic and to the areas of the European Union via Slovakia were identified. A total of 43 species of plants and 40 species of animals (of which 12 species of mammals, five species of birds, 10 species of fish) listed in European and national legislation among invasive organisms were analyzed. This analysis made it possible to subsequently prepare a draft of the action plan on the pathways of unintentional introduction and spread of invasive alien species to the territory of the Slovak Republic and the territory of the EU through the territory of the Slovak Republic. According to the Regulation (EU) No. 1143/2014 of the European Parliament and of the Council, such action plan must be adopted in every EU Member State, which Slovakia has not done so far. Within the action plan, among other things, we identified range of responsible entities and the proposed schedule of activities and a description of the measures that will need to be taken to address the issue. The action plan also includes monitoring the effectiveness of the proposed measures and estimating the overall financial expenses. The Action Plan was the basis for the Legislative Process LP / 2021/788, which was discussed by the Government of the Slovak Republic following an interdepartmental comment procedure.The action plan was submitted for an interdepartmental comment procedure in December 2021, so that it can be approved by the Government of the Slovak Republic (https://www.slov-lex.sk/legislativne-procesy/-/SK/dokumenty/LP-2021-788).

2021: Participation in legislative process. In cooperation with the State Nature Conservancy SR we prepared an amended draft of Decree no. 170/2021 Collections of the Act of the Ministry of Environment of the Slovak Republic, which implements Act no. 543/2002 on Nature and Landscape Protection, as amended. We have prepared and commented documents for the following parts of the Decree: Annex no. 1: List of habitats of European importance and habitats of national importance and their social value, and Annex no. 4: List of protected plants (incl. fungi, lichens and bryophytes). A record number was included in the Annex no. 4 – more than 2100 species of different organisms, of which are 89 fungi, 44 lichens, 220 bryophytes, 796 vascular plants, and more than 960 animals.

2.6.3. List of contracts and research projects with industrial and other commercial partners, incl. revenues (study title, name of institution, contract value, country of partner, purpose (max 20 words))

2016 Contract for work and licence agreement with Daphne – Institute of Applied Ecology. Contract value: 80 000 EUR. Vegetation databases – a tool for monitoring of habitats for nature conservation purposes. Data (phytosociological relevés) for identification and monitoring, conversion of relevés to the habitat types, data georeferencing etc.

2019 Contract with Water Research Institute – which implements Water Framework Directive in Slovakia. Our responsibility is to implement DNA barcoding and metabarcoding of water fauna in Slovakia, to better cover and precise the information on water fauna in Slovakia DNA barkódmi v referenčných databázach a údaje z testovania metabarkódingových postupov v monitoringu vodnej fauny. Contract value: 10 000 EUR

2018 Contract with Bratislavské regionálne ochranárske združenie (BROZ). The aim was to improve the status of priority habitats and species of European importance in 21 localities of the NATURA 2000 network in Slovakia and in 7 localities in the territory of Moravia. Due to the abandonment of traditional management, the sites are endangered by overgrowth of overgrowth trees, expansive grasses and the spread of non-native species. Through appropriate measures, the project makes a significant contribution to building the NATURA 2000 network, improving its functionality and preserving the regions' natural heritage. For restored areas, the aim is to ensure sustainable care and restore ecosystem services. Contract value: 4 194 EUR

2.6.4.1 List of intangible fixed assets (internally registered IP (confidential know-how), patent applications, patents granted, trademarks registered) denoting background IPR none

2.6.4.2 List of licences sold abroad and in Slovakia, incl. revenues (background IPR identification, name of institution, contract value, country of partner, purpose (max 20 words))
none

2.6.5. Summary of relevant activities, max. 300 words (describe the pipeline of valorization in terms of Number of disclosure, Number of registered IP internally, number of CCR/LIC contracts and their respective summary values, the support you are receiving in specific points internally at the institute, at SAS, externally – also the limitations and drawbacks.
none

2.7. Popularisation of Science (outreach activities)

2.7.1. List of the most important popularisation activities, max. 20 items

Natioanal outreach:

Telecomunication media

1. Participation in script and realization of documentary film promoting internationally recognized scientists from Slovakia: „Svetoznámi slovenskí vedci: Rande s Belkou. Document on the life and research of the first female botanist in Slovakia Izabela Textorisová
2. RTVS television: Magazín VAT – Flora of Slovakia, Jaromír Kučera; regular science and technology programme; Správy RTVS (evening news): Pavol Mereďa, Milan Valachovič, Mária Šibíková, Jozef Šibík
3. RTVS Radio Slovensko: Nočná pyramída – series of interviews with scientists: 2019, 2020, 2021 (Slavomír Adamčík, Miroslav Caboň, Fedor Čiampor, Ján Jásik, Ladislav Pekárik, Milan Valachovič); Veda SK – Karol Marhold, Pavol Mereďa

Events

4. **European Researchers Night – participations in 2016, 2017, 2018, 2019, 2021:** Science booths in Bratislava and Banská Bystrica; 2021 – online nationwide studio, lectures „Visit your school – get to know your scientist“.
   Anna Bérešová, Beáta Bočová, Katarína Botková, Kateřina Bubíková, Miroslav Caboň, Fedor Čiampor, Zuzana Čiamporová Zaťovičová, Tomáš Čejka, Roderik Fiala, Ivana Fialová, Dobromil Galvánek, Alica Hindáková, Marta Illýová, Lucia Kenderešová, Jaromír Kučera, Alexandra Lešková, Michal Martinka, Pavol Mereďa, Veronika Mikitová, Petra Mikušová, Jana Podroužková Medvecká, Marek Vaculík, Katarína Skokanová, Barbora Šingliarová, Monika Janišová, Ivana Svitková, Marek Vaculík, Veronika Zelinová

5. **Week of Science and Technology – participation in 2016, 2018, 2019, 2021:** Doors open day
   Denisa Bazalová, Katarína Botková, Miroslav Caboň, Michaela Caboňová, Veronika Cetlová, Lucia Čahojová, Milana Čiamporová, Loriana Demecsová, Roderi Fiala, Zuzana Gajdošová, Alica Hindáková, Andrea Hricová, Vidya Chirrapuranthu Sukumaran Nair, Adam Kantor, Simona Klačanová, Juraj Kleman, Miroslav Klobučnik, Gabriela Kozárová, Miroslav Krausko, Michal Martinka, Andrea Melichárková, Pavol Mereďa, Vasilii Shapkin, Marek Šlenker, Jozef Šibík, Mária Šibíková, Miroslava Vaneková, Barbora Zámocká

6. **Weekend with Slovak Academy of Sciences – 2018, 2019:** Science Street Festival – science booths and lectures in Bratislava City Centre
   Denisa Bazalová, Anna Bérešová, Andrea Hricová, Pavol Mereďa, Veronika Lancíková, Ladislav Pekárik, Mária Šibíková, Jozef Šibík, Milan Valachovič, Marek Vaculík

7. **International Danube Day 2018**
   Ladislav Pekárik

8. **Cooperation with Slovak Centre of Scientific and Technical Information (CVTI) – 2019, 2020, 2021**
   Presentations/lectures, podcasts, interviews – Vedecká kaviareň, Veda na dosah. Anna Bérešová, Eva Boszorádová, Miroslav Caboň, Fedor Čiampor, Zuzana Čiamporová Zaťovičová, Tomáš Čejka, Alena Gajdošová, Ján Jásik, Miroslav Krausko, Pavol Mereďa, Jana Moravčíková, Ladislav Pekárik, Jozef Šibík, Ladislav Tamás, Marek Vaculík, Katarína Vantarová

9. **Exhibitions:**

Agrokomplex 2017, 2018, 2019
Andrea Hricová, Monika Frátriková, Veronika Lancíková, Júlia Hunková, Veronika Ihradská, Martin Jopčík, Katarína Klubicová, Jana Libantová, Gabriela Libiaková, Miroslav Perniš, Miroslav Rajninec, Terézia Salaj

10. **Contributions to nation-wide monthly or weekly journals/magazines:**

Čarovné Slovensko (2020): Jaromír Kučera
Čarovné Slovensko (2020): Viktor Kučera
Téma (2020): Viktor Kučera
Téma (2020): Jaromír Kučera
Téma (2021): Jaromír Kučera

11. **Contributions to nation-wide newspapers (daylies – Quark, SME, Denník N, Hospodárske noviny, Týždeň, Pravda):**

Slavomír Adamčík (2020, 2016)
Tomáš Čejka (2017)
Fedor Čiampor (2021, 2020)
Daniel Dítě (2021)
Anna Guttová (2016)
Richard Hrivnák (2017)
Monika Janišová (2020)
Jana Libantová (2020, 2016)
Pavol Mereďa (2020)
Dušan Senko (2021, 2020)
Jozef Šibík (2021, 2020, 2016)

12. **Cooperation with schools: teaching, lessons, excursions**

Anna Bérešová (2021): Spojená škola Tilgnerova – support for project „Green Norwegian Tilgnerka“ (EEA and Norway Grants 2014–2021; Working together for a green, competitive and inclusive Europe); on-line lessons in biology (2020)

13. **Citizen Science support**

Anna Bérešová – expert consultancy for publication „Petržalské lišajníky“, Jonáš Gruska, LOM 2021;
Jana Májeková – series of botanical excursions for public „Sobotňajšie botanické exkurzie“ 2016–2021
Ladislav Pekárik – video for EU-Citizen Science; mobile app VISITOR – upgrade and maintenance

International outreach:

- Overseas study veak 2017: Slavomír Adamčík; Britsh Mycological Society Forey 2017: Slavomír Adamčík; UK Fungus Day, Fungus Bioblitz 2016: Slavomír Adamčík
- Bioblitz, Talamone (Italy) 2018: Zuzana Fačkovcová; Bioblitz Riserva Naturale Statale Belagio (Italy) 2019

2.7.2. Table of outreach activities according to institute annual reports

Outreach activities	2016	2017	2018	2019	2020	2021	total
Articles in press media/internet popularising results of science, in particular those achieved by the Organization	25	25	25	19	50	37	181
Appearances in telecommunication media popularising results of science, in particular those achieved by the Organization	5	12	6	16	18	29	86
Public popularisation lectures	26	47	36	22	13	29	173

2.8. Background and management. Infrastructure and human resources, incl. support and incentives for young researchers

2.8.1. Summary table of personnel

2.8.1.1. Professional qualification structure (as of 31 December 2021)

	Degree/rank				Research position		
	DrSc./DSc	CSc./PhD.	professor	docent/ assoc. prof.	I.	II.a.	II.b.
Male	5	32	1	3	6	21	9
Female	1	43	0	0	1	22	19

I. – director of research with a degree of doctor of science/DrSc.

II.a – Senior researcher

II.b – PhD holder/Postdoc

2.8.1.2. Age and gender structure of researchers (as of 31 December 2021)

Age structure of researchers	< 31		31-35		36-40		41-45		46-50		51-55		56-60		61-65		> 65	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Male	2,0	1,5	5,0	4,2	7,0	5,0	5,0	4,2	4,0	4,0	4,0	3,5	1,0	1,0	3,0	2,5	3,0	2,0
Female	7,0	5,2	5,0	4,2	6,0	5,3	5,0	4,2	5,0	5,0	5,0	4,2	3,0	3,0	1,0	1,0	4,0	2,2

A – number

B – FTE

2.8.2. Postdoctoral fellowships (list of positions with holder name, starting date, duration. Add brief information about each fellow's career path before and after receiving PhD degree, etc.)

Post-doc positions in evaluated period – with PhD acquired in institutions outside PSB SAS or PSBC SAS students:

Miroslav Caboň
PhD. study: 2013–2017, Institute of Botany, Plant Science and Biodiversity Centre SAS
Career building:

1. Taxonomical delimitation of the European members of the genus Russula subsection Urentes and subsection Rubrineae (Basidiomycota), Visegrád Fund, 2015, 5-month stay in Institute of Microbiology, Czech Academy of Sciences

2. New insight into fascinating evolutionary and ecological divergence of Russula rubra lineage: the study supported by collections in the State Museum of Natural History Stuttgart, Synthesys, GE-TAF-6934, State Museum of Natural History Stuttgart Germany – not financed proposal
3. Influence of temperature as a stress factor to gene response and morphological adaptations of the fungus Flammulina velutipes, SAIA – proposal 17612, research grant application, University Fujian, China – not financed proposal

Post-doc starting date: 1.9.2017 – ongoing
Career building – scholarships/stipendia, stays, workshops:

1. Laboratory of Environmental Microbiology, Institute of Microbiology Czech Academy of Sciences; Petr Baldrián (financed by FEMS-GO-2019-585), november– december 2021
2. Laboratoire de Excellence, INRA-Nancy Francúzsko; Francis Martin (financed by Campus France no. 936983K) 2019
3. Workshop on Phylogenomics 2019, Český Krumlov, Czech Republic
4. Molecular analysis of Trophic Interactions, Metabarcoding of Trophic Interactions, Innsbruck 2018
5. PRACE Seasonal school of bioinformatics Slovak Academy of Sciences, Bratislava 2018
6. Laboratory of fungal genetics and metabolism, Institute of Microbiology Czech Academy of Sciences; Miroslav Kolařík (financed by Visegrad Fund) February-July 2015; scholarship during PhD. studies
7. Other important activities:
8. Curator of the lab MEM – Molecular ecology and mycology
9. Head of the Department of Cryptogams (2020-21)
10. Journal Club – Students club of PSBC SAS – organizer: since 2019 (https://cbrb.sav.sk/vzdelavanie-a-kariera/studentsky-klub/)
11. Preparation of project proposal for national fund VEGA in 2021 (2/0050/22 successful and financed since 2022, principal investigator)
12. co-organizer of The meeting of young taxonomists and biosystematics (Czech Republic and Slovakia), 2018; 2021 (contact person for Slovak republic)
13. Consultation of PhD theses – Barbora Zámocká, Vasilii Shapkin
14. Member of International Society for Mushroom Science, Czechoslovak Society for Microbiology
15. Follow up of the platform Young Scientists of SAS, member of the board since 2022
16. 2020: Supervisor for secondary school student´s project – national competition „Stredoškolská odborná činnosť SOČ“ – Tereza Furdíková: Use of microscopic and molecular identifications in the revision of Russula species in Slovakia, 3rd place in regional round
17. 2020: Invited lector of Ecology (Mycology) at University of Prešov (1 semester)

Michaela Caboňová
PhD. studies: Department of Virology and Microbiology, Comenius University in Bratislava
Career building – before post-doc:

1. 2018 ICGEB travel grant for conference Power of Viruses, Poreč, Croatia (during PhD. studies)
2. 2017 FEMS Research Stay, Rijeka, Croatia (3 months, during PhD. studies)
3. 2016 Student grant of Comenius University (during PhD. studies)
4. supervisor of bachelor thesis (during PhD. studies)

Post-doc starting date: 1.9.2018 – ongoing (currently maternity leave)
Career building – post-doc:

1. Curator of molecular laboratory (Dpt. of plant systematics)
2. November 2018 Training in next-gen methods (SeqMe sequencing company)

Veronika Cetlová
PhD. study: 2015–2020, Institute of Botany, Plant Science and Biodiversity Centre SAS
Post-doc starting date: 1.9.2019 – ongoing

Loriana Demecsová
PhD. study: 2016–2020, Institute of Botany, Plant Science and Biodiversity Centre SAS
Post-doc starting date: 1.9.2020 – ongoing
Applications sent for Post-doc stay:

1. Laboratory of Membrane Biogenesis, Bordeaux France
2. Life Science Zurich Graduate School, Zurich Switzerland
3. The French National Research Institute for Agriculture, Food, and the Environment (INRAE), France
4. Postdoc in plant developmental biology, University of Copenhagen, Denmark
5. Postdoctoral Scholar in Plant Molecular Biology, Pennsylvania State University, United States
6. Post-doctoral fellow in plant cell biology, CNRS, France

Zuzana Fačkovcová
PhD. study: 2013–2017, Institute of Botany, Plant Science and Biodiversity Centre SAS
Career-bulding:

1. 2013: Towards the origin of sub-mediterranean element Solenopsora candicans (lichens, Catillariaceae) in Pannonia and the adjacent Western Carpathians; Synthesis HU-TAF-3373, Hungarian Natural History Museum, Budapest – not financed
2. 2014: Effects of forest management on genetic diversity of a sensitive epiphytic lichen Lobaria pulmonaria: a comparison of old-growth forests with managed stands in the Western Carpathians – SLOBMan; SCIEX-NMS Research Fellowship, Prof. Dr. Christoph Scheidegger, Swiss Federal Institute for Forest, Snow and Landscape Research WSL – not financed
3. 2014: Unraveling processes responsible for contemporary geographic distribution of the species Solenopsora candicans (lichens, Catillariaceae) in Germany – a northern periphery of its range in mainland Europe, Synthesis DE-TAF-4496, Senckenberg Gesellschaft für Naturforschung (SGN), Germany – not financed
4. 2015: Unraveling symbiotic processes responsible for the contemporary geographic range of Solenopsora candicans, a lichen with Mediterranean distribution, Synthesis DE-TAF-5752, Senckenberg Gesellschaft für Naturforschung (SGN) Germany – not financed
5. 2015: Cultivation of lichenized fungi of the genus Solenopsora (Leprocaulaceae), SAIA stipendium, Università degli Studi di Trieste, Italy – not financed

Post-doc starting date: 1.9.2017 – ongoing (currently on maternity leave)
Duration: first prolongation until 2025
Career building – Post-doc stays and attendance at courses:

1. Department of Life Sciences, University of Siena, Italy: „Resistenza e adattamento dei licheni allo stress da metalli pesanti“ (project financed by University of Siena; September – December 2019 and February – March 2020)
2. Hungarian Natural History Museum, Budapest, Hungary: „How ecologically plastic are symbiotic associations linked to mediterranean-type biotopes in Pannonia and Western Carpathians?: case study on *Solenopsora candicans*” (SYNTHESYS HU-TAF-6340, 25 June–4 July 2017)
3. Course on work in R software, Science Faculty UK, Prague, 27–31 January 2020
4. Workshop „The Complexity of Lichen Symbiosis: Novel interdisciplinary approaches from genomic to functional perspectives“, Valencia, 3–4 December 2018.
5. PRACE Seasonal School on Bioinformatics, SAS, Bratislava, 23–26 April 2018
6. Lichen Genomics Workshop II, Graz, 2–5 November 2017.
7. Lichenology course „Lichens as a tool for air pollution research“, Zagreb, 26–29 September 2016

Other important activities:

1. Preparation of the project proposals for H2020 Marie Skłodowska-Curie Individual Fellowships submitted with University of Siena in 2018 (proposal id: 842935), 2019 (892051) and 2020 (101030318). Proposal of 2020: „Adaptive capacity of symbiotic system to atmospheric mercury – environmental stress of global concern“ was scored

as a high-quality project proposal and received a „Seal of Excellence“ certificate delivered by the European Commission.
2. Collaboration with University of Siena, Italy within the project „La Discarica del Cassero: Monitoraggio Lichenico“, 2016, 2018
3. Committee member for the evaluation of “Premio Carlo Gaggi” award proposals (for Italian Lichen Society), 2020
4. Co-tutor of Msc. thesis of student Caterina Maccelli, Department of Life Sciences, University of Siena, supervisor Stefano Loppi, 2018
5. Review on Msc. thesis of Mária Poláková, P.J. Šafárik University in Košice, Slovakia, supervisor Michal Goga, 2020
6. Co-organizing of 44th Meeting of the CETAF Governing Board, 14–15 Nov 2018, Bratislava
7. Member of The International Association for Lichenology (from 2016) and Italian Lichen Society (from 2015)
8. Awarded for publication activity by Czech Botanical Society: „*Cena Josefa Holuba*“ award (2018) and by Slovak Botanical Society: „*Cena P. Sillingera*“ award (2021)
9. Participation at Citizen Science events and consultancies for public:
    - Citizen Science experiment; results published in Paoli et al. (2019): Plants 8: 125.
    - Leading of excursions organized by Maremma Natural History Museum, Italy, focused on environmental education of broad public in protected areas, „BioBlitz, Farma-Belagaio 18–19 May 2019“ and „BioBlitz, Talamone 19–20 May 2018“
    - Consultancies for pupils from Elementary School in Dubnica nad Váhom, Slovakia, during preparation on national competition „Biological olympiad“, 2018

Alica Košuthová
PhD. study: 2005–2013, Institute of Botany SAS
Career building:
1. Lectures in foreign institutions: Large-scale and small-scale patterns in lichen assemblages of Central European acidic aeolian sands. Karl-Franzens-Universität, Graz, Austira, 24. 1. 2013.
2. Preparation of project proposals: Morphological study of the Placynthiaceae phylogeny (Lecanorales, lichenized fungi), Synthesis SE-TAF-3508, Herbarium at the Swedish Museum of Natural History in Stockholm (not financed)

Post-doc starting date: 15.3.2013–31.5.2018
Duration: 5 years
Career building – Post-doc stay:
1. Molecular phylogeny of the European members of Cladonia section Coccifereae, Visegrad Fund (Visegrad Scholarship Program-Intra-Visegrad post-master Scholars), 51401150, 2014–2015, Department of Botany, Faculty of Sciences, Charles University Praha
2. Increased higher education student and staff mobility between Beneficiary and EEAEFTA States, EEA/Norway GrantsNF-CZ07-INP-2-009-2014 NTNU University Museum, Schøninghuset, Norway, Mika Bendiksby
3. Swedish Museum of Natural History, Stockholm; Svenska artprojektet: Collemataceae och Placynthiaceae i Sverige (07/2017– 2019)

Miroslav Krausko
PhD. study: 2013–2017, Department of Plant Physiology, Faculty of Natural Sciences, Comenius University
Post-doc starting date: 1.9.2017 – ongoing
Career building:
1. Max Planck Institute for Plant Breeding Research, Cologne, Germany, Dr. Csaba Koncz, scientific stay, 2018
2. EMBL Advanced training center, Heidelberg, Tim Nuernberger, imaging techniques, 2019

Veronika Lancíková
PhD. study: 2013–2016

Post-doc starting date: 28.6.2016 – 30.6.2021
Career building – post-doc stay (stipend):
Department of Biochemistry, University of Missouri-Columbia, Missouri, USA, 01/2016 – 04/2016
Department of Biochemistry, University of Missouri-Columbia, Missouri, USA, 08/2016 – 08/2017

Alexandra Lešková
PhD. study: 2011–2016 Department of Environmental Ecology, Faculty of Natural Sciences, Comenius University Bratislava; building skills in plant physiology, ecotoxicology, cell biology, heavy metals, iron homeostasis, phytotoxicity. Stays abroad: Leibniz Institute of Plant Genetics and Crop Plant Research, Department of Physiology and Cell Biology
Post-doc starting date: 1.1.2016 – 2020
Career building – Post-doc stay:

1. SupAgro/INRA /CNRS Montpellier, France 2019 (SAIA, 2 months 2019)
2. UMR BPMP Research Centre National Institute of Agricultural Research, Montpellier (2020 – ongoing)

Shorter visits:

1. Max Planck Institute for Plant Breeding Research, Cologne, July 2018
2. EMBL Advanced Training Centre, Heidelberg, Advanced Fluorescence Imaging Techniques, workshop June 2018

Darina Peterková
PhD. study: molecular biology, University Ss. Cyril and Methodius in Trnava
Post-doc starting date: 2020 – ongoing
Other activities:

1. Board member Mensa Slovakia
2. Lector for Lifbee academy in public speaking
3. Consultation and moderator NextStep Science Conference
4. Coordinator of the 11th IQ Olympiáda competition

Marek Šlenker
PhD. study: 2015–2019, Institute of Botany, Plant Science and Biodiversity Centre SAS
Post-doc starting date: 1.9.2019 – ongoing
Career building:

1. Course on bioinformatics, Department of Botany, Science Faculty UK Praha, Vojtěch Zeisek, 2019

2.8.2.1. MoRePro and SASPRO fellowships

none

2.8.2.2. Stefan Schwarz fellowships

1. **Miroslav Caboň:** 1.6.2019–31.5.2022
2. **Zuzana Fačkovcová:** 1.6.2020 – pending (ongoing maternity leave)
3. **Veronika Lancíková:** 1.6.2018–31.5.2020
4. **Ľubica Liptáková:** 1.5.2011 – 31.5.2021 (2012–2018 maternity leave)
5. **Monika Majerová:** 1.5.2015 – pending (2016–2022 maternity leave)
6. **Podroužková Medvecká:** 1.5.2013 – 2021 (2014–2016, 2018–2021 maternity leaves)
7. **Eva Boszorádová:** 1.1.2009 – 28.2.2018 (2011–2016 maternity leave)
8. **Martin Jopčík:** 1.1.2016 – 31.12.2020

2.8.2.3. Postdoctoral positions from other resources (specify)

Contributions to salary resources of the PSBC SAS from the SAS – compensation contribution (rules of the competition https://www.sav.sk/?lang=sk&doc=educ-kompenzacnyprispevok):
1. Miroslav Caboň
2. Michaela Caboňová

3. Loriana Demecsová
4. Zuzana Fačkovcová
5. Eliška Gbúrová Štubňová
6. Júlia Hunková
7. Miroslav Krausko
8. Marek Šlenker

2.8.3. Important research infrastructure introduced during the evaluation period with the information about the sources of funding *(max. 2 pages)*

During the evaluation period we developed already existing labs, updated necessary instruments and established new labs as well.

Remote Vegetation Survey working group
Institute of Botany PSBC SAS is the official training center on the devices for research purposes:
- CI 202 PORTABLE LASER LEAF AREA METER
- Dron Phantom 4 Pro V2.0

We have trained staff who provide consultations and, upon request, demonstrate the use of the device in practice.

Molecular Ecology and Mycology lab
We undergo complete re-build of our laboratories (supported by national projects). All labs became fully air-conditioned following standards for air-flow in molecular laboratories. Laboratory was equipped with new fully ventilated chemical cabinet and several new equipments were purchased: spectrophotometer, cooling centrifuge, lyophilizer.

Laboratory of Molecular Systematics
We generate data on DNA polymorphisms within and between species that are used to address questions of systematics, phylogeny, phylogeography, and population-level microevolutionary processes in various groups of vascular and non-vascular plants. The laboratory was established in 2005. We are constantly striving to renew and expand the existing equipment. In the last few years, we have shifted our main interest from conventional PCR- and Sanger sequencing-based approaches (AFLPs, microsatellites, single-locus sequencing) to a broader application of NGS (next generation sequencing or high-throughput DNA sequencing) techniques, in particular Hyb-Seq and RADseq. The laboratory is equipped with all necessary instruments for both standard DNA methods (DNA extraction, PCR amplification, cloning of PCR products) and preparation of DNA libraries for NGS techniques. Within the last few years, we have acquired a vacuum concentrator, a deep freezer, an autoclave, a PCR cycler, a reverse osmosis-based water purification system, several electronic multichannel pipettes for high-throughput RADseq library construction, and an electrophoresis-based system for accurate DNA fragment size selection, Pippin Prep. The Institute owns or hires licenses for relevant programs needed for molecular data analyses (e.g. Geneious Prime, DAx), but most of the software we use for data processing and phylogenetic analyses is free (e.g., scripts and tools in the R software environment, specialized tools, software, and software pipelines).

Department of Plant Experimental Biology:
Well-established laboratories for routine use methods for recombinant DNA preparation, plant transformation, mutant and transgenic plant analysis, gene expression investigation on different levels, including 2D-PAGE and an electrophoretic assay of enzyme isoforms, further enzyme kinetics analysis, spectrophotometric analysis of different compounds and fluorescence detection of reactive forms of oxygen and nitric oxide. We have laboratories for transmission electron microscopy and confocal microscopy. We carry out immunogold and advanced histochemistry and histoimmunology localization assays by different approaches. We are the pioneers in using photoconvertible fluorescence protein technology to study protein dynamics and turnover. During the evaluation period, we introduced some new instruments:

Abiotic Stress Laboratory

- Horizontal electrophoresis apparatus for DNA gel electrophoresis;
- Semi-dry Western blotting apparatus for Western blots, where target proteins are transferred to a hydrophobic membrane after SDS-PAGE and detected by specific antibodies using a specialized apparatus, a semi-dry or a tank system;
- Microplate reader - detection of levels of plant metabolites and the activities of enzymes in the small volume of the sample;
- Digital heated shaker

Laboratory of Molecular and Cell Biology

- NanoDrop™ One/OneC Microvolume UV-Vis spectrophotometer for measurement of concentration and purity of nucleic acids and proteins.
- Orbital shaker for cultivation of *E. coli* and *Agrobacterium tumefaciens* for GMO
- Refrigerated centrifuge

Laboratory of Plant Root Responses to Stress

- In the evaluated period, we have implemented the method of Western blot using the existing infrastructure.

Laboratory for Parasitic Plant Research

Re-equipped during 2018-2019 equipped with several smaller Instruments funded by the project ERA NET – INCOMERA „A next generation plant biostimulant based on strigolactones included into stimuli responsive nanoformulation“. We list selection of them: Electronic balance, EX 125D, Centrifuge Multi 230 V, Laminar box Alpina - K1000, Incubator with cooling Memmert IPP 30plus, Incubator with cooling Memmert IPP 55plus, Laboratory shaker with accessories, Termoblock BIO TS-100C, Vacum Manifold Visiprep SPE.

Molecular plant breeding laboratory

Established and equipped in framework of EU SF project „AgroBioTech“ and later during the evaluation period was supplemented with several small instruments, like vacuum evaporator, DNA electrophoresis, pH meter, etc., funded from national projects.

Herbarium SAV

Until recently, a substantial part of the SAS herbarium of vascular plants was stored outside the main campus of the Slovak Academy of Sciences and the seat of PSBC SAS. In 2019, we moved these specimens to newly reconstructed premises, which are approximately 1.5 times larger than the original ones and are located within the SAS campus.

2.9. Supplementary information and/or comments on all items 2.1 – 2.8 (max. 2 pages in total for the whole section)

Additional research topics during the evaluated period:

Biodiversity and ecology of aquatic ecosystems

The findings of the **vegetation-ecology studies** demonstrated that **local environmental characteristics**, mainly hydrological connectivity and presence of water habitats in surroundings of studied lentic habitats **were the most important variables for nature conservation** management and all water bodies play an important role in the preservation of aquatic plants in the Pannonian-Carpathian region.

Valuable research output is the results of **long-term (23-yrs) biological monitoring of structural changes in land snail communities in the area affected by the operation of the Gabčíkovo waterworks**. The results demonstrate that the **Gabčíkovo waterworks had a direct and long-lasting effect on the direction of the succession of terrestrial molluscan assemblages**, especially in the area of the by-pass section. The changes in the soil moisture caused by the waterworks' operation led to significant changes in the species

and functional composition of these assemblages. More specifically, however, the **proportion of the generalists who prefer dry biotopes increased, while the number of moisture-demanding species decreased**. Our results indicate that the **current artificial flooding system cannot fully replace previous natural floods in the Danube inland delta**, and it is also insufficient for restoration and preservation of the humidity conditions in the softwood floodplain forests which would be similar to the pre-operation period of the Gabčíkovo waterworks. The results of long-term monitoring can be **a solid database for predicting the trends of changes in the hydropedological regime on other large European rivers**.

Assessing the status of the biological component of freshwater ecosystems is an important part of the implementation of the European Water Framework Directive.
Classical methods of determination are based on the analysis of morphological features of aquatic organisms, which is, however, a time and cost consuming procedure. A modern alternative is the use of molecular traits (DNA barcoding, metabarcoding). This approach is considerably more efficient, accurate and objective, and its application is made possible mainly by the development of next-generation sequencing (NGS). The basic condition for a successful application is the existence of a high quality reference database of DNA barcodes. Monitoring of the aquatic fauna of Slovakia was carried out by applying innovative methods of DNA barcoding and metabarcoding within the framework of an economic contract with the Research Institute of Water Management. This should result in better and more complete coverage of Slovakia's aquatic fauna in reference databases.

Population genetics and reproduction processes of woody species and the multidisciplinary research of new genetic resources for food and environmental use
The challenge to meet the requirements and ensure the welfare of 21st-century consumers is to produce and develop high nutritional quality, safe and value-added products. Besides traditional sources we also **exploit new genetic resources with high content of nutritional components and health-promoting substances**. **Amaranth** is an underutilized crop gaining popularity in the recent past due to its numerous agronomic and nutritional properties. The multidisciplinary research was primarily focused on the identification of advanced mutant lines with an emphasis on their food and environmental utilisation, and search for their potential commercial application. The application of gamma-ray mutagenesis resulted in breeding of the second Slovak variety of this important gluten-free pseudocereal, **preferentially used for food purposes.** After the variety **„Pribina“** a new variety **„Zobor“** was registered (property rights at national level). Bot of them are suitable for Central European cultivation. They exhibit consistently superior performance of principal seed traits over the original and several commercial varieties. The nutritive value is stable, well balanced and comparable to existing varieties. The findings indicate that some of the lines and both varieties are nutritionally valuable, showing long-term high content of oil, squalene and some essential amino acids. Therefore we expect good quality of final food products and improvement of their overall quality. We also **tested the potential of new varieties for environmental use in decontamination of heavy metal polluted soils**, which is associated with use of amaranth as food. Varieties were classified as Cd-hypertolerant and can be used in the phytomanagement of Cd-loaded soils. Limited root-to-shoot translocation of this contaminant is important for safe consumption of product made from grain of tested varieties that are preferentially used for food production. Evaluation and selection of mutagenesis-obtained amaranth lines were carried out in **long-time cooperation with the Prešov University in Prešov** and the **Slovak University of Agriculture in Nitra**. The facilities of the **AgroBioTech**, as the **regional competent center of applied research and development** in the field of agro-bio-technologies, were extensively used.

Hybrid swarms are considered **evolutionarily important elements** of world dendroflora. This is primarily due to unique gene pool and, therefore, the ability to respond differently under almost the same selection pressures as those applying in parental habitats. Genetic diversity, adaptive potential and evolutionary prospects of such hybrids are of considerable theoretical and ecological importance. In Europe, this is specifically related to an extremely problematic species or aggregate of microspecies, e. g. *P. mugo* agg. Spontaneous hybridization occurs also with *P. sylvestris*, forming intermediate populations that are phenotypically unstable and

hard to delimit. Of the four putative hybrid swarms of *P. sylvestris* and *P. mugo* occurring in northern Slovakia, the three swarms grow on peat-bogs and one on calcareous towers with relic pines. Our **artificial pollination experiments proved partial compatibility of the reciprocal crosses** between *P. sylvestris* and *P. mugo*. In spite of the low efficiency of crossings, it justifies using it for a reasonable basis for emerging the hybrid swarms of the parental species in the nature. The reciprocal crosses were found to exhibit **bimodal inheritance of their chloroplast DNAs**. In the cross *P. sylvestris* × *P. mugo*, cpDNA is inherited paternally, whereas in *P. mugo* × *P. sylvestris* cross, the maternal inheritance was found to operate. As to the crossability between putative hybrid swarm individuals and the parental species, a higher efficiency of crossing of hybrid swarm individuals was exhibited towards *P. mugo* species than to *P. sylvestris*. **Pollen fertility** of the four putative hybrid swarms was found to be lowered considerably with respect to the pollen tube length as compared with an average pollen tube length in the parental species *P. sylvestris* and *P. mugo.* The same is true of seed germination from open pollination. It is believed **that lowered viability of hybrid swarms** is due to **increased frequencies of both meiotic irregularities and abortive embryogenesis** which is a phenomenon of common occurrence in the interspecific hybrids of plants. Inter-Primer Binding Site amplification approach was used in **study of genetic structure and diversity** of 13 populations including parental species and their hybrid swarms. The hybrid nature of putative hybrid swarms was confirmed also on the basis of Simple Sequence Repeats.

3. ***Implementation of the recommendations from the previous evaluation period***

For the previous evaluation period **the two institutes forming PSBC SAS were evaluated separately** because they worked as independent institutions. **The merge took place in January 2017**, in the second year of current evaluation period. During the evaluation period we focused on essential day-to-day operation of the new Centre, creating the culture of the Centre, establishment of personal contacts within departments of the two organisational units, while working on the recommendation and comments listed below. Some of them are specific for one organisational unit (institute), several of them were common for both units to certain extent.

Institute of Botany (IB)
Scientific quality and productivity

- publications in top tier journals are missing
- number of citations per year – good although not excellent in international comparison
- the best cited scientist – a good number in international comparison
- no infrastructure development grants from EU structural funds

Overall assessment – comments on the past performance

- high number of citations does not fully come from hypothesis-based research work

Institute of Plant Genetics and Biotechnology (IPGB)
Scientific quality and productivity

- decreasing trend in number of positions (scientists, PhD students)
- modest publication output in international scientific journals, publication productivity in 3rd quartile
- number of citations is low in international comparison
- no outcome of COST projects – networking, short experimental works of young scientists in foreign labs, lack of added value

Social, cultural, or economic impact

- low impact
- potential of biotechnological methods does not seem to be optimally utilized (amaranth breeding)
- contract research did not result in any revenue

Future prospects

- research topics are not in the main international trend
- lack of clear strategy for scientific activities, which are unfocused

- there are study areas which do not belong to the cutting edge of plant genetics and biotechnology (e.g. micropropagation, in vitro regeneration)

Overall assessment – comments on the past performance

- research activities are far from the forefront of the international activities
- publication productivity falls within 3rd quartile, citations within 2nd quartile
- COST projects do not substitute for real research projects

Common comments and recommendations

- better focus on research topics, decrease them, many small projects are not effective; lack of scientific focus
- careful strategic planning of joint activities to utilize the potential of the new Centre
- increase the number of DrSc. title holders
- to establish international advisory board
- mobility to international labs should be improved
- salary decrease of young scientists after obtaining the PhD degree – a serious negative motivation, hampering future prospects of science in the institute
- merge of the institutes from January 2017 – just one month before the start of the new Centre there are no concrete plans on place how the new Centre will work, there is a danger that both institutes will continue their research on the basis „business as usual" without utilizing the possibility of synergistic interactions

Creation of the PSBC SAS was preceded by **communication of the reasons and visions** of both institutes to merge. This was formulated in the internal documents setting common rules:

1) Basic theses of the merge which govern the process of creation and future operation of the Centre, signed by the two directors in October 2016,
2) Statutes of the PSBC SAS stipulating basic characteristics of the centre, organisational structure, organs, statutory representative and deputy, academia, managing board, scientific board, financial competencies, etc and
3) the set of obligatory internal regulations in force since January 2017.

Structure of PSBC SAS

In 2017 the structure of research departments of PSBC SAS copied the former Institutes. Institute of Botany PSBC SAS included four research departments: Department of Plant Physiology, Department of Cryptogams, Department of Taxonomy of Vascular Plants, and Department of Geobotany. Institute of Plant Genetics and Biotechnology PSBC SAS included three research departments: Department of Molecular Biology and Biotechnology, Department of Population Genetics and Breeding, and Department of Reproduction and Developmental Biology. Based on recommendations of International Advisory Board but also our own understanding, we revised and re-organized the internal structure so as it reflects current research lines appropriately. For currrent organisation chart see chapter 1.5.2.

Research quality standards

We elaborated common standards related to the **quality of research performance**, **strategy and research development** supervised by common Scientific board. We formulated the Strategy of research and development of PSBC SAS for the period 2016–2020 together with action plan (and subsequent adjustments for the period 2021–2025), we adopted common criteria for annual evaluation of scientific performance of researchers in PSBC SAS so as they correspond to priority outputs within SAS (focus on quality publications), we thoroughly revised and updated our internal evaluation criteria of scientific performance of researchers for 3-year period by Attestation committee of PSBC SAS (compulsory until 31 December 2021). The members of the managing board, scientific board and academia (mainly heads of the working groups) participated in drafting of the documents. Our common vision is that PSBC SAS:

- represents a space for the implementation of new ideas that clarify the phenomenon of biodiversity, especially its formation, development and impact on society, through modern, interdisciplinary convergent methodological approaches and delivers **excellent research results**;

- belongs to **recognized organizations in the international research area**, which deal with evolutionary systematics, phylogeography, phytocoenology, ecology, and physiology of components of flora and fauna;
- the scientific production belongs to the international top in the European context, it is significant within the Slovak Academy of Sciences and is gaining international recognition.

We established **International Advisory Board** (for composition see 1.4.1) and we have had one meeting so far in 2021. We appreciated their careful and detailed approach to understanding the conditions and environment where we work (mainly budget, available project schemes) and useful comments and suggestions for improval. We already implemented some of them (update of website, organization of departments and their names; see organisational chart above). We find it very useful to hear that some of results would have been suitable for even higher-impact journals. These journals should be attempted and targeted, because this will increase the visibility and international renown of the PSBC SAS.

Quality standards for PhD study, building a research career

We encourage and actively support young researchers (including PhD students) to plan their career, to get experience with getting external resources (e.g. external grants, scholarships, stipendia, internal SAS financial contributions – e.g. DoktoGrant, contributions to successful post-docs, Štefan Schwarz Fund) for visits in foreign labs and research groups, for development of skills, good research and publication practice. We encourage them to participate in workshops and trainings organized by Slovak Academy of Sciences to build soft skills and other important skills. Feedback from them is important to us. Researchers on all stages of their career are encouraged to participate in SAS competitions or competitions promoted by SAS focused on quality research publications, or most cited publications. We would like to identify researchers able to generate strong ideas, bringing shift in knowledge who would like to increase their competencies in writing proposals through participation in seminars and workshops on European financial schemes (e.g. Starting Grants ERC).

Building of a research career is closely connected with the number of researchers with DrSc. title. This is also important to secure PhD school as guarantors. We focused on periodical turnover of DrSc researchers and critical number of them. Since PSBC SAS is external educational institution for PhD studies in the programmes botany, plant physiology, genetics, biotechnology, agrobiotechnology and molecular biology, it is important to cover these programmes by DrSc guarantors. **We increased the number of DrSc. researchers by four:** Milan Valachovič, Ján Jásik, Karol Marhold and Richard Hrivnák (the process initiated in 2020 and finished in May 2022). We identified and encouraged suitable candidates for the programmes botany (Monika Janišová, Slavomír Adamčík, Jozef Šibík, Judita Zozomová), plant physiology (Viktor Demko), genetics (Radoslava Matúšová) and we expect they will initiate the processes of preparation of documentation in 2022 and subsequent defences in future.

In line with our vision we aim to deliver **adequate research outputs**. We put stress on **quality hypothesis-based research**, which ensures appropriate response quantified in number of citations. We prioritize the research of active teams (optimum one per scientific department within the Centre, see the Organisation Chart above), e.g. in number of PhD positions assigned to these teams. During the evaluation period, the following teams strengthened their position and started research directions with high potential for quality outputs:

- **Laboratory of Molecular Ecology and Mycology** – leader Slavomír Adamčík
- **Remote vegetation survey** – leader Jozef Šibík
- **LabAlliance** – leader Marek Slovák
- **Laboratory of Molecular and Cell Biology** – leader Ján Jásik, who came to work in PSBC SAS after his career in Germany (Max-Planck Institute for Plant Breeding Research, UNI Bonn, IPK Gatersleben) in 2016 and formed a research group focusing on synaptotagmins

Laboratory of Molecular Systematics (formed by Karol Marhold prior to evaluation period) continued its standard quality research.

We organize **regular seminars at the PSBC SAS level** (organized by Stanislav Španiel and Jana Májeková), which induce interactions and collaborations, especially among young scientists. Specifically, important collaboration of both organisational units represents a wider platform to guarantee several PhD programmes. Young researchers meet at Journal Club, now Students club (organized by Miroslav Caboň) where they share knowledge on research themes and publications of individual laboratories and groups. The Club similarly to Seminars hosts also foreign colleagues (https://cbrb.sav.sk/en/education-and-career/seminars/, https://cbrb.sav.sk/en/education-and-career/student-club/).

Internationalization, Interdisciplinarity, Impact and Partnership
Plant proteomics was mentioned in last accreditation report as a promising area to be supported in the future. As a form of support, we are establishing cooperation with Dr. Jozef Mravec (University of Copenhagen), an expert in cell wall glycomics, who succeeded in the **the SAS programme Impulz** (to recruit internationally recognized scientists and highly talented young researchers who come from abroad or do not leave for abroad). He shall start to develop his new working group in the IPGB from September 2022. The group will use the infrastructure available at the IPGB and AgroBioTech Centre. Collaboration with other institutes of SAS is envisaged (Institute of Chemistry SAS, Biomedical Centre SAS). Combining existing proteomic and new glycomics expertise may increase complexity and impact of scientific outputs. In addition, we expect that establishing the new working group and topic will positively impact the number of researchers and PhD students. **As a result, scientific quality and productivity of IPGB may increase**.

To address the comments on the lack of clear strategy for scientific activities and focus, lack of cutting-edge research in some spheres (e.g. micropropagation, in vitro regeneration), low impact, no result in revenues from contract research, we explored the potential of these topics and **re-prioritized them favouring high impact topics.** The high impact topics include:

- **plant responses to biotic and abiotic stress – case of parasitic plants with negative impact on crop production** (study of molecular basis of the host-parasitic plant interactions and strigolactones as key signaling molecules involved in these interactions;
- **case of plant interactions and extreme environmental factors such as environmental pollutants** (heavy metals, radiation) or **salinity** (fundamental but also applied research);
- **unexplored plant genetic resources –** carnivorous plants *(Drosera*) as source of **genes with potential biotechnological applications;**

***In vitro* regeneration system** is currently employed only as a tool for theoretical studies e.g. investigation of cell wall proteins potentially important during the induction of embryogenic tissue of selected conifers by a proteomic approach.

We work on building international collaborations which include stays abroad (both of young and more senior researchers) with strong research groups and we have some good examples (e.g. members of the Laboratory of Molecular Ecology and Mycology or Lab Alliance). We encourage and support the establishment of international collaborations. Also senior scientists perform short-term visits in international labs abroad to build networking and search for collaboration (e.g. Ján Jásik, 3 month stay in Max Planck Institute for Plant Breeding Research, Cologne in 2018 supported by Alexander von Humboldt programme „Sponsorship of Renewed Research Stays in Germany“).

The PSBC SAS integrates distinct disciplines and collaborations within PSBC SAS that would increase interdisciplinarity are encouraged. We find spontaneously developing collaborations based on common interest the best way to initiate and steer integrative research. Good examples are:
Demand-driven research for the sustainable and innovative food Drive4SIFood ITMS 313011V336. Principal investigator for PSBC SAS: Alena Gajdošová
Both organisational units collaborate in Activity 13 „Amaranth as an innovative genetic resource“. IB input – occurrence of mycotoxin-producing fungi in plants and seeds of amaranth (Slavomír Adamčík, Miroslav Caboň). Both units also collaborate in proteomic analysis of mutants and plants under biotic stress (Maksym Danchenko, Ivana Fialová, Ján Jásik).

COST projects – active participation in international networks, added value
We monitor added value of membership in networking COST projects, activity of researchers in the network as leaders of working groups, outputs – position papers, regular papers, organisation of events, conferences (see also 2.4.1):

	researcher	number of COST networks
1	Fedor Čiampor	2
2	Andrea Hricová	2
3	Martin Jopčík	1
4	Andrej Kormuťák	1
5	Veronika Lancíková	2
6	Jana Libantová	1
7	Karol Marhold	1
8	Radoslava Matúšová	1
9	Jana Medvecká	1
10	Ladislav Pekárik	2
11	Marek Vaculík	1
12	Terézia Salaj	2
13	Jozef Šibík	1
14	Mária Šibíková	2

Outputs of participation in COST networks:

position/opinion paper		monograph	standard paper		certified method	projects	app, database	conference organiser
total	IF		total	IF				
4	1	1	8	4	1	5	2	2

Contribution to internationalization

Memorandum of understanding 2019
After a successful five years of collaboration, **Colorado State University, Fort Collins, USA** renewed the partnership with the PSBC SAS. Representatives of Warner College of Natural Resources - Dean John Hayes, Vice Dean for International Relations Kathleen Fairfax, Head of the Forest, Rangeland and Watershed Departments Stewardship Linda Nagle, Chad Hoseth International Program Office Director, Statutory representative of the PSBC SAS Anna Bérešová and heads of the research teams on both sides – David J. Cooper and Jozef Šibík signed the **International Memorandum of Understanding** for the next five years. The scientific teams will continue in successful transcontinental collaboration in research on sensitive biomes of the Alpine regions. The cooperation will include exchanges, internships, as well as the preparation and implementation of benchmarking studies of various aspects of the Alpine tundra in Europe and the North American continent. Alpine regions are extremely sensitive to disturbances and global change, not least those intense. It is important to understand the relationship between environmental factors, grazing, functional groups of plants, as well as the characteristics and responses of individual ecosystems to current changes. The long-term goal is to determine the differences between the grazing and the unfettered alpine meadows of areas with a drier continental climate in the United States in the United States and in the wetter areas of the European mountains. An important part of cooperation is creation and effective use of vegetation databases for identification and vegetation monitoring and solutions to current topics in the field of ecology, environmental protection environment and restoration of disturbed habitats.

To raise awareness about the PSBC SAS and research themes and to find new potential partnerships we participated in a **seminar organized by the Slovak Academy of Sciences with representatives from the University of Bergen, Norway** on January 21-22, 2019. We presented selected research topics using remote sensing data and information from vegetation databases.

We focused on **increased awareness in the international research community** about our workplace, its research and publications of individual laboratories and groups and we focus **on hosting a larger number of foreign trainees** in domestic work teams, their participation in the seminars, journal or students clubs.

Visits or stays of foreign researchers in PSBC SAS and common activities with international colleagues:

	Name	Institution	Financial resource	Host	Output
2021	Seyedeh Fatemeh Fallah	Golestan University, Gorgan, Iran	SAIA fellowship	Maksym Danchenko	experimental training started on December 1, 2021
	Cathrin Manz	Goethe University Frankfurt, Germany	DAAD project	Slavomír Adamčík	consultancy of PhD thesis: Diversity and ecology of the genus Russula in the tropics, supervisor: Meike Piepenbring
	Felix Hampe	Goethe University Frankfurt, Germany	DAAD project	Slavomír Adamčík	Diversity and ecology of the genus Russula
	Dmytro Ganzha	Institute of Hydrobiology, National Academy of Sciences of Ukraine	SAIA fellowship	Maksym Danchenko	experimental training
	Olena Nesterneko	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine	SAIA fellowship	Maksym Danchenko	drafting manuscript
	Natalia Kutsokon	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine	SAIA fellowship	Maksym Danchenko	consulting results for preparation of manuscript
	Valerii Darmostuk	University of Kherson, Ukraine	SAIA fellowship	Anna Bérešová	Darmostuk et al. 2022: Herzogia 35: 115–130
	Ruben de Lange	Ghent University, Belgium		Slavomír Adamčík	consultancy of PhD thesis: Diversity and phylogeny of Russula subgenus Compactae, supervisor: Annemieke Verbeken
	Beloslava Ganeva	University of Plovdiv, Bulgaria	Erasmus	Jozef Šibík	

	Namik Rashydov	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine	SAIA fellowship	Maksym Danchenko	seminar: Nascent prion-like proteins in plants under influence of abiotic stress factors
2020	Munazza Kiran	Fungal Biology and Systematics Laboratory, Departnent of Botany University of Punjab, Pakistan	SAIA fellowship	Slavomír Adamčík	Sánchez-García M., Adamčíková K., Moreau P.-A., Vizzini A., Jančovičová S., Kiran M., Caboň M., Matheny B., Adamčík S. Mycological Progress, 2021, 20: 11-25.
	Benjamin Avis	Indiana University Northwest Indiana, USA	Indiana University Northwest Indiana Stipendium	Slavomír Adamčík	Diversity and ecology of the genus Russula
	Tereza Michalová	Institute of Microbiology, Czech Academy of Sciences	APVV project	Slavomír Adamčík	consultation of sampling method
2019	Heping Zhao, Qi Zhang, Rongroung Lin, Shengcheng Han, Yingian Wang, Zu Huang	China	mobility APVV-SK-CN-2017-0015 project collaboration	Ján Jásik	Systematic analysis of the Arabidopsis SYT3 gene
	Michelle Vera Castellanos	Universidad del Rosario, Bogota, Columbia	IAPT research grant	Slavomír Adamčík	consultancy of bachelor thesis: Phylogenetic analyses and discovery of new species of the genus Russula (Fungi) associated with Quercus humboltii in Colombia, supervisor: Adriana Corrales
	Cathrin Manz	Goethe University Frankfurt, Germany	DAAD project	Slavomír Adamčík	consultancy of PhD thesis: Diversity and ecology of the genus Russula in the tropics, supervisor: Meike Piepenbring
	Felix Hampe	Goethe University Frankfurt, Germany	DAAD project	Slavomír Adamčík	Diversity and ecology of the genus Russula

	Munazza Kiran	Fungal Biology and Systematics Laboratory, Department of Botany University of Punjab, Pakistan	SAIA fellowship	Slavomír Adamčík	Adamčík et al. 2019: Fungal Diversity Journal 99: 369-449.
2018	Nicolas Ernesto Blanco	Argentina	ICGEB project	Ján Jásik	Study of the dynamic behaviour of SnRK1.1 by advanced fluorescence microscopy techniques in planta
	Ksenia Ermokhina	Russia	SAIA fellowship	Jozef Šibík	analyses of data from the Arctic Vegetation Archive; methods for vegetation analysis and synthesis of Arctic vegetation in the context of changing climate; exchange of skills from mapping arctic and alpine vegetation in arctic zone of Russia
	Irena Asparuhova Golubinova	Bulgaria	Erasmus+	Radoslava Matúšová	stay for teaching staff employed in a higher education institution - training visits
	Plamen Atanasov Marinov-Serafimov	Bulgaria	Erasmus+	Radoslava Matúšová	stay for teaching staff employed in a higher education institution - training visits
	Roman Kish	Ukraine	SAIA fellowship	Iveta Škodová	field work, data collection
2017	Laura Concostrina Zubiri	Centre for Ecology, Evolution and Environmental Change (cE3c), Facultade de Ciencias da Universidade de Lisboa, Portugal	mobility APVV project SK-PT-2015-0027	Anna Bérešová	Guttová et al. 2017: Lichenologist 51: 75-88
	Silvana Munzi	Centre for Ecology, Evolution and Environmental Change (cE3c), Facultade de Ciencias da Universidade de Lisboa, Portugal	mobility APVV project SK-PT-2015-0027	Anna Bérešová	Guttová et al. 2017: Lichenologist 51: 75-88

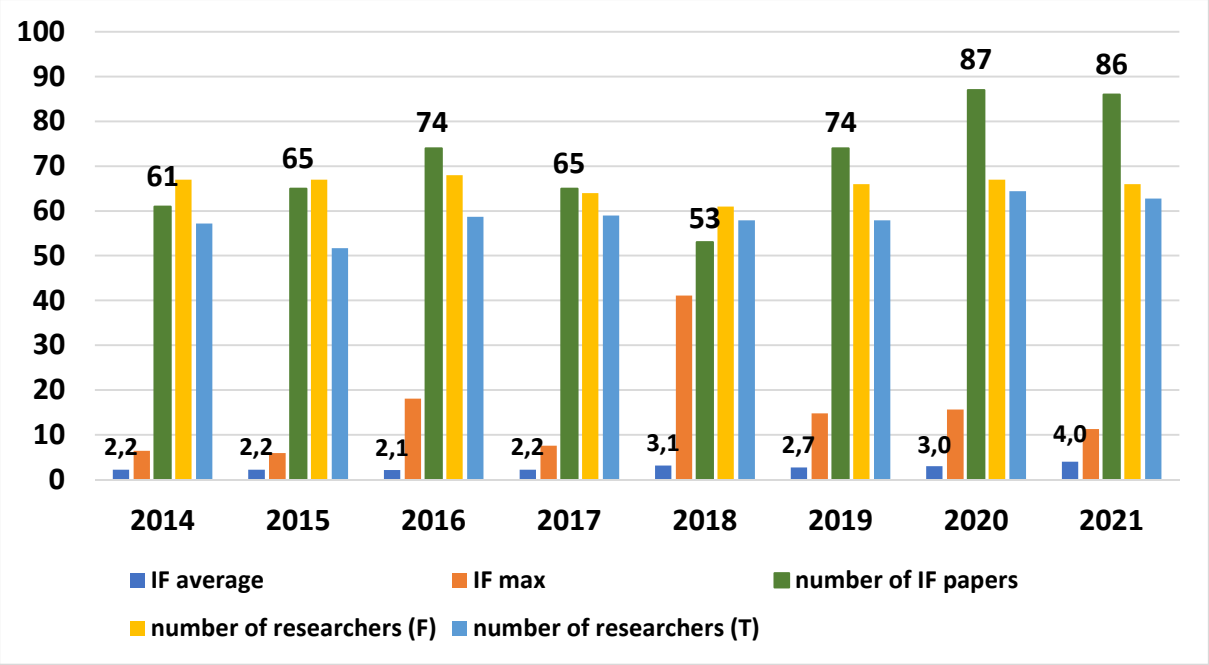
	Ivana Rešetnik	Croatia	Inter-academy mobility exchange	Stanislav Španiel	Rešetnik & Španiel 2018: Glas. Hrvat. bot. druš. 6: 4-16; Španiel et al. 2018: Phytotaxa 379: 57–65
	Kamil Zielinski	Poland	Inter-academy agreement	Jana Moravčíková	Zielenski et al. 2021 Plant Science 302:110700 ; Moravčíková J. et al. (2018) 13th International Scientific Conference Biotechnology and Quality of Raw Materials and Foodstuffs: Smolenice Castle, 17. - 19. 09. 2018;
	Maryna Kryvohyzha	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine	SAIA fellowship	Jana Libantová	Kryvokhyzha, M. et al. 2019: Influence of Biotechnologia acta 12:57-66.
	Valentina Encheva, Julia Encheva	Bulgaria	Erasmus+	Radoslava Matúšová	Stay for teaching staff employed in a higher education institution – training visits
	Namyk Rashydov	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine	Supported by FP7 PEOPLE-2013-IRSES-612587	Katarina Klubicova	Perniš M. et al. 2020 Journal of Plant Physiology 251:153219
	Olena Nesterenko	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine	Supported by FP7 PEOPLE-2013-IRSES-612587	Katarina Klubicova	experimental training
	Olya Yaroshko	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine	SAIA fellowship	Alena Gajdošová	Yaroshko et al. (2018) In Biologija, 64: 321-330; Yaroshko et al. 2020. Plant Physiology and Genetics 52: 128-139
	Alexander Paukov	Uralskii federalnyi universitet, Jekaterinburg, Russia	mobility visit	Anna Bérešová	seminar: Species delimitation within Aspicilia desertorum group (Megasporaceae, lichenized Ascomycota)

	Roswitha Elisabeth Schmickl	Department of Botany, Faculty of Science, Charles University, Czech Republic	mobility visit	Marek Slovák	seminar: Hyb-seq and Sondovač (phylogenetic marker development for target enrichment from transcriptome and genome skim data)
	Skip Walker	University of Alaska, Fairbansk, USA	Alaska Geobotany Center, Institute of Arctic Biology project	Jozef Šibík	seminar: Vegetation along the Eurasia Arctic Transect; Walker et al. 2018: Phytocoenologia 48: 181-201; Raynolds et al. 2019: Remote Sensing of Environment 232: 111297.
	Jana Steinová	Department of Botany, Faculty of Science, Charles University, Czech Republic	mobility visit	Anna Bérešová	seminar: Study of diversity via NGS sequencing
	Anzhelika Teptina	Uralskii federalnyi universitet, Jekaterinburg, Russia	mobility visit	Stanislav Španiel	project preparation: taxonomy and phylogeography of Odontarrhena hyperaccumulating heavy metals
	Helena Štorchová	Institute of Experimental Botany, Czech Academy of Sciences	mobility visit		seminar: Short-day and long-day genotypes of Chenopodium album aggr. - molecular background of adaptive evolution
	Viktor Nachynko	Botanical garden of Ivan Franko National University of Lviv, Ukraine	mobility visit		Revision of the genus Thymus in herbarium SAV
	Petr Tarkowski	Centre of the Region Haná for Biotechnological and Agriculture Research, Czech Republic	mobility visit		seminar: Mass spectrometry of plant secondary metabolites and phytohormones
2016	Silvana Munzi	Centre for Ecology, Evolution and Environmental Change (cE3c), Facultade de Ciencias da Universidade de Lisboa, Portugal	mobility APVV project SK-PT-2015-0027	Anna Bérešová	Guttová et al. 2017: Lichenologist 51: 75-88

	Marianna Georgieva	Institute of Plant Physiology and Genetics, Bulgaria	SAIA fellowship	Martin Hajduch Katarina Klubicova	Georgieva et al., 2017 DNA Repair 50: 14-21
	Natalia Kutsokon	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine, Ukraine	Supported by FP7 PEOPLE-2013-IRSES-612587	Martin Hajduch Katarina Klubicova	Kutsokon et al. 2020: Acta Physiologiae Plantarum 42: 86
	Namik M. Rashydov	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine, Ukraine	Supported by FP7 PEOPLE-2013-IRSES-612587	Martin Hajduch Katarina Klubicova	Kutsokon et al. 2020: Acta Physiologiae Plantarum 42: 86
	Olena Klimenko	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine, Ukraine	Supported by FP7 PEOPLE-2013-IRSES-612587	Martin Hajduch Katarina Klubicova	Klimenko et al: 2019: Ecotoxicology and environmental safety 173: 86-95.
	Valentina Berezhna	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine, Ukraine	Supported by FP7 PEOPLE-2013-IRSES-612587	Martin Hajduch Katarina Klubicova	experimental training
	Olena Nesterenko	Institute of Cell Biology and Genetic Engineering, National Academy of Sciences of Ukraine, Ukraine	Supported by FP7 PEOPLE-2013-IRSES-612587	Martin Hajduch Katarina Klubicova	experimental training
	Joanna Korzeniak	Poland	International academic agreement (MAD)	Ktarína Vantarová	Vantarová et. al. 2021: Plant Biosystems 155: 16-41.

Scientific quality and productivity

Positive trend in number and quality of key publications (types AAA, ABA, AAB, ABB, ADCA, ADCB, ADDA, ADDB, ADEA, ADMA, ADMB, ADNA, ADNB; Q – Scimago):



Positive trend in number of papers in Q1 and Q2:
2021: 93 (Q1: 61, Q2: 14), % papers in Q1: 66
2020: 97 (Q1: 57, Q2: 27); % papers in Q1: 52
2019: 82 (Q1: 40, Q2: 22); % papers in Q1: 48
2018: 59 (Q1: 26, Q2: 17); % papers in Q1: 44
2017: 74 (Q1: 32, Q2: 16); % papers in Q1: 43

Positive trend in number of WOS citations:
2021: 3029
2020: 2363
2019: 2222
2018: 1983
2017: 2095

Our aim is to strengthen our publication record in „top-tier" journals (mainly Nature and Science; then e.g. Molecular Biology and Evolution, PNAS, Proceedings of the Royal Society : B - Biological Sciences, Systematic Biology, Journal of Biogeography, Annals of Botany, ISME Journal, Journal of Hazardous Material, Fungal Diversity Journal) and other highly ranked journals. We implemented this element among measurable indicators of quality research in the Action plan for the period 2021–2025. So far PSBC SAS researchers act mostly as collaborators in the studies. Our aim is to act also as research leaders – first or senior authors of these papers. Quality publications come hand in hand with higher number of citations.

Salary of young post-doc scientists. Active young scientists with quality background have a chance to compete for extra funding from resources of SAS – Stefan Schwarz fellowship (see 2.8.2.2.), and compensation contribution (see 2.8.2.3.). Our post-docs were successful in competition. Scientists, including post-docs in IB PSBC SAS are motivated for good publication record by financial award (internal resources of IB PSBC SAS).

4. ***Research strategy and future development of the institute for the nextfive years*** (Recommended 3 pages, max. 5 pages)

Research strategy of the institute in the national and international contexts, objectives, and methods (including the information on when the strategy was adopted)

Current Research Strategy of PSBC SAS covers the period 2021–2025 (adopted in autumn 2021, amendments in spring 2022). Our goal is to improve or change aspects of our work that are necessary to secure internationally recognized scientific outputs. The Strategy is congruent with our **mission** to contribute or solve complex societal and environmental challenges, while providing knowledge about different aspects of biodiversity and its components, and **challenging the boundaries of knowledge**. The Strategy follows also **our vision**, that the Centre:

- represents a space for the implementation of new ideas that clarify the phenomena of biodiversity, especially its formation, development and impact on society, using modern, interdisciplinary convergent methodological approaches that deliver **excellent research results**;
- belongs to **recognized scientific organizations in the international research area**, which deal with evolutionary systematics, phylogeography, phytocoenology, ecology, and physiology of biodiversity components;
- the scientific production belongs to the international top in the European context, it is significant within the Slovak Academy of Sciences, and is gaining international recognition.

The **Centre adheres to the principles** of the **European Charter for Researchers, the Code of Conduct for the Recruitment of Researchers, the Code of Ethics of the Slovak Academy of Sciences** and the **SAS 2030 Strategy**. Selection of specific goals:

Human resources

- improved career development of a larger number of researchers;
- hosting a larger number of foreign researchers;
- an adequate number of scientific assistance with expanded skills;
- sufficient number of PhD guarantors (DrSc., Prof.) and researchers in productive age who meet the criteria for PhD guarantor

Project preparation

- identification of researchers able to generate strong ideas, bringing shift in knowledge, eager to increase their competencies in writing proposals through participation in seminars and workshops on EU schemes (e.g. Starting Grants ERC); more intensive involvement in Horizon Europe calls;
- improved scientific focus of projects, consolidation of research intentions in response to the comments and recommendations of the international evaluation panel in accreditation;
- use of the synergistic potential and interdisciplinarity of the Centre in a joint project plan;
- diversification of funding resources, focus on foreign schemes, agencies, or private sector.

Intellectual property management

- improving the transfer of knowledge/technology into practice and intensifying cooperation with the private sector based on "SAS Principles for the Application, Protection and Utilization of Industrial Property Rights Established by the SAS" adopted by PSBC SAS; close cooperation with the SAS Technology Transfer Office in the field of protection of intellectual property rights and technology transfer.

Research topics, objectives and methods in both national and international context

- **Evolutionary processes and relationships, taxonomy, diversity and distribution of biota**

The evolution of sexual polymorphism (particularly gynodioecy) in **polyploid species complexes**, the associations between whole-genome duplication and sex shifts, and the consequences for fitness and survival, as well as the adaptability of given entities in the context of climatic changes, comparative biogeography of selected species groups with a special emphasis on temperate mountain biota (Carpathian region), but also on species from the Mediterranean region. We will put **evolutionary hypotheses** to the test in the following areas of interest:

a) biological and ecological aspects influence the evolution of endemics, as well as mechanisms underlying the emergence of endemic taxa (studies of endemics' sexual and asexual

reproduction strategies, including clonality, fruit production, seed viability, and germination experiments);

b) the role of hybridization and introgression in diploid and polyploid model systems for diversification and speciation in mountain plants

We will challenge the topic of **reticulate versus divergent evolution** with focus on processes behind the high species richness and endemism in Brassicaceae genera. **We will test** whether the high endemism rate reflects multiple independent polyploidization events or increased diversification of polyploid lineages. We will also focus on speciation mechanisms and evolutionary triggers in biodiversity hotspots and mountainous areas, and on how historical and recent range shifts have stimulated introgression and allopolyploid speciation. We will apply integrative approach combining phylogenomics (RADseq and HybSeq techniques of next-gen sequencing, complemented by microsatellites), cytogenomics, flow cytometry, morphometrics and ecological niche modelling. We recently optimized a ddRAD protocol for Brassicaceae genera, generated and analyzed initial RADseq libraries. Phylogenomics of natural polyploid plant systems is still lagging behind but new approaches are emerging constantly and this field evolves rapidly nowadays. We expect significant progress in NGS data processing in the near future, especially regarding polyploids, where we will also contribute with the development of our own tools. We plan to continue also in Hyb-Seq data generation, which has proven to be a very efficient method for resolving phylogenomics both at deep and shallow scales.

- **Invasive alien species and the level of invasion of individual habitats**

Ecosystem changes caused by invasive alien plants are detrimental to native species and promote undesired changes in habitats worldwide. Various invasive plant species are known to change plant, microbial and invertebrate diversity, alter the rate of nutrient cycling and biogeochemistry of ecosystems, and **influence plant-plant and plant-soil biota interactions**. It is already well documented that invasive plants influence ecosystems in a non-uniform manner, however differences among closely related invasive taxa have been still overlooked. Therefore we aim to compare the impact on biodiversity and ecosystem processes among closely related members of *Fallopia japonica* agg. or *Solidago canadensis* agg. Due to the team of vegetation ecologists, pedologists, mycologists, bryologist, and malacologist from PSBC SAS and Technical University Zvolen, our research is based on an integrative approach to analyze multiple-taxa diversity, soil properties, seed bank, microbial activity, and fungal trophic structure (by analyses of environmental DNA). We expect that our results could serve as a baseline for further biotope conservation and management decisions.

- **Molecular ecology and mycology**

The fungal diversity in any ecosystem type depends on their ecological interactions and trophic preferences. We will combine phylogeny, morphology and ecology of fungi **to explain their evolutionary processes and adaptations**. Our goal is to understand functional traits of individual fungal species and use this knowledge to study responses of fungal communities to various ecological factors. We will implement taxonomic knowledge to explain results of metabarcoding studies. We will combine metabarcoding of fungi with their enzymatic activities, soil abiotic properties and other data to trace functional changes in soil fungal communities. We will focus on the best way how to specify ecological role of individual species and to use it to assess changes in ecosystems triggered in response to ecological factors or management practices. We emphasize our effort to improve links in a scientific pipeline of (a) taxonomic circumscription of species, (b) identification of their ecological role, (c) assessing their functional traits (d) answering ecological questions important for sustainable environmental management. We have ambition to learn advanced analyses of soil properties and omics analyses of environmental DNA. Our scientific aims are (a) to assess ecological and agricultural value of trees and their impact and its range to the surrounding non-forest vegetation, (b) to identify functional changes in soil fungal communities along the altitudinal forest gradient as the model of the future climate change, (c) to understand succession processes of soil fungal communities in temperate forest dominated by ectomycorrhizal trees and (d) to trace biological interaction of invasive plants with soil fungal communities in order to identify role of fungi for inhibiting or facilitating of the plant invasion.

- **Freshwater biodiversity**

We want to maximize the application of innovative molecular techniques (environmental DNA, high throughput sequencing) and to significantly improve the understanding of the structure and composition of biota of the European FW ecosystems at the level of their genetic diversity. In addition to standard methods (DNA barcoding, metabarcoding), we are also involved in the initiative focusing on the study of whole genomes (ERGA), where we want to contribute in a collaborative way to the development of this promising field, allowing a better understanding of the processes of biodiversity evolution and the response of organisms to changing environmental conditions.

- **Remote vegetation survey**

Remote sensing (RS) provides global coverage and continuous measurements across vast areas at a relatively high spatial and temporal resolution. It helps to provide data from areas where the human survey is next to impossible. **Our core interest is biota** represented by biomes, habitats, communities or single target species population. Since direct human impact, together with climate warming, has profound consequences on biodiversity at local to global scales, there is an urgent need to identify spatio-temporal distribution and condition of habitats and important species populations continuously. According to EU Biodiversity Strategy for 2030 there should be a **specific focus on areas of very high biodiversity value or potential**. We will integrate methods of botany fieldwork scientists, mathematicians, and software developers focusing on habitat use and nature conservancy, with the **Natura 2000** network. RS techniques and methods for automatic identification of new areas seem like the only practical solution. The detailed scale of a single habitat defined by plant species composition was never reached before when using satellite data, and our aim is to fulfil this challenge. Another challenge is assessing the biodiversity using RS. The status of habitats is evaluated by species diversity, which is possible to monitor only by visiting the habitat in the field. Recent technological advances in RS can provide detailed spectral and structural information to characterize diversity. We focus on the above-mentioned problems to build up on our previous success with **developing multifunctional software called NaturaSat** to create a complex and unique tool for identifying and monitoring biodiversity on various organisational levels.

- **Vegetation ecology**

Forest ecosystems: biodiversity, ecology, synanthropization. We focus on ecology-vegetation relationships of specific types of forest ecosystems, especially on the most endangered types, floodplain forests and alder carrs. We will explore the negative influence of fragmentation (e.g. the effects of greater desiccation through increased wind and light, causing higher temperatures, lower humidity in soils); and the role of individual trees for surrounding vegetation and microbiological processes in soils. We continue by studies of methods comparing the natural or semi-natural woodlands and near-situated inappropriate monocultures on plant and animal diversity as well as the influence of alien plants on both plant diversity and composition of native forest types. We will continue in successful research of ecosystem synanthropization, continuously accelerated globally and its impacts on biodiversity are mostly negative including influence on human health and economic interests. We will concentrate on **i) risk of gene pool disruption by alien species**; ii) **behavioural biology of alien invasive species**, iii) finding **the extent of damage to indigenous ecosystems** (size of “black biodiversity”), iv) the **consequences of fragmentation and homogenisation** of vegetation on its biodiversity, v) use of multispectral remote sensing data to understand the distribution, directions and rate of propagation of alien species and their communities.

Grassland research and conservation. Carpathian grasslands will be in an interdisciplinary manner including geography, remote sensing, ethnology, environmental anthropology, history in international collaboration. We will address mainly i) species-rich grassland areas and proposal of optimal management for their conservation; ii) areas with high environmental and social potential for successful grassland restoration. Promising approaches of diversified traditional management (combinations of farming practices) we plan to test in a manipulative field experiment. The land-use changes dynamically in time and these changes reflect in the grassland vegetation composition and its structure. The changes in the agricultural landscape are significantly influenced by the agricultural subsidies received in Slovakia since 2004 when the country joined the European Union. We, therefore, want to focus on the evaluation of changes in species composition and functional traits of the grassland habitats of European and national importance and assess the effectiveness and impact of agricultural subsidies on the recent state of the studied habitats.

- **Biodiversity e-infrastructures (databases)**

We will continue to publish our research results by electronic. Of the sources that we continuously build and improve, we will focus on the following:

1. Work on the database Pladias-SK, a clone of the well-established Czech database Pladias (https://pladias.cz/). It will not only store the distribution data, but will use numerous other datasets for sophisticated biogeographic analyses. The distribution records in Pladias-SK will be linked to the Global Biodiversity Information Facility (GBIF).

2. Based on the further development of the existing software for the database of the Nábělek's herbarium (www.nabelek.sav.sk), we will build the extensive database of herbarium specimens (with images) deposited in herbarium SAV. In the long-term perspective we will also cover other Slovak herbaria. We expect links of this database to the Virtual Herbaria JACQ (https://www.jacq.org/), to GBIF and DiSSCo ESFRI infrastructure (https://www.dissco.eu/) for which our institute represents a national node for the Slovak Republic. We expect in near future intensive digitisation of herbarium specimens from our collections. The DiSSCo project is already included in the European ESFRI Roadmap as well as in the Slovak Roadmap of research infrastructures. We participate in the Horizon 2020 project DiSSCo Prepare, which is building European infrastructure for DiSSCo.

3. Existing chromosome number and ploidy level resources will be updated and connected with similar databases from other countries with the aim to provide a single access web portal for revised chromosome and ploidy level data.

- **Cell wall biology**

Starting in autumn 2022, we plan to complement the cell wall proteomics study with **complex cell wall carbohydrates analysis**. The research group will focus on **developing a new generation of probing and analytical platforms** (aptamer-based) which would enable various types of analyses of plant complex carbohydrates. This will, for instance, include: in situ localisation of complex carbohydrates using confocal microscopy, visualization of associations of cell wall components in native cell walls, and dynamic range quantification and high-throughput compositional profiling of plant carbohydrates in various samples. Dr. Jozef Mravec, who has received **SAS funding to establish a new research group,** will focus on cell wall biology under the **IMPULZ call for top scientists with international experience**, will support cell wall biology research. Close collaboration with the international research partners, mainly from Denmark, is envisaged. Part of the research will also target **cell wall dynamics during somatic embryogenesis** and **cellular elongation** and the role of cell walls in somatic embryogenesis.

- **Plant root research**

In line with the direction of **root research**, we aim to focus on crucial genes involved in the induction and differentiation of adventitious root. Creating an appropriate adventitious root system is essential for successfully multiplying plants via stem cuttings. Adventitious roots are usually created de novo from differentiated cells. Reprogramming of competent cells is characterized by their significant molecular, physiological, and morphological changes, which we wish to understand using grapevine and *Arabidopsis* thin stem discs as models. Auxin-induced and non-induced stem discs will be subjected to RNA sequencing using the Illumina platform to identify essential genes participating in cell reprogramming and root development.

We will continue in efforts to uncover the molecular function of plant **calpain protease in regulating plant growth and development**. Within international collaborations, including EMBL and INSTRUCT, we aim to resolve the DEK1 protein 3D structure. Based on our recent discoveries, we aim to unravel the functional interaction between DEK1 and epigenetic control mechanisms (in particular, the m6A RNA methylation). We will use an interdisciplinary approach involving structural biology, targeted mutagenesis (incl. CRISPR/Cas), cell biology, epigenomics and proteomics.

- **Plant stress biology**

There is growing evidence that **strigolactones (SLs) modulate plant response to biotic and abiotic stresses**. In nutrient-poor soils SLs synthesis is increased, decreased shoot branching and increased root branching. This is how plant survival is enhanced under unfavorable conditions. We developed an *in vitro* culture system to grow parasitic *Phelipanche ramosa* on the host plant and grow and develop *P. ramosa* shoots and flowers *in vitro* in the absence of a host plant. We **plan to develop a system to study the effects of abiotic stress** (e.g. drought, temperature, salinity) on

the interaction of parasitic plants and their hosts. We will explore the **influence of chronic abiotic stress on plant tolerance** toward **biotic stress**. Our experimental model will be based on aquatic plants grown in an environment contaminated with radionuclides. Preliminary data showed increased infestation by mites of *Phragmites australis* naturally grown in contaminated lakes of the Chernobyl exclusion zone. Firstly, we will verify these field data in controlled laboratory conditions. Secondly, we will explore biochemical mechanisms by front-end proteomics, particularly detecting oxidative stress-related protein carbonylations. We will validate and complement the findings by targeted gene expression, enzyme activity, and protein localisation assays. Our ambition is to push the knowledge frontier in fundamental radiobiology and contribute to drafting practical recommendations on monitoring and managing contaminated lakes.

Metal toxicity contributes to the decline in crop yields, and metals in the food chain affect human health. We aim to study plant responses to metal pollutants (e.g. Cd, Ni, Pb, Sb) at different levels and suggest ways to support plants to better cope with toxic metal doses. We demonstrated that heavy metals cause rapid generation of reactive oxygen and nitrogen species and alter auxin levels in barley root tips. We intend to examine the interaction among these three signaling pathways in root responses to heavy metal excess. There are contradictory interpretations of elevated reactive oxygen and nitrogen species levels and auxin redistribution in the root apex. Therefore, we **intend to differentiate between defense- and toxicity-related mechanisms and their signalling pathways**. We wish to inhibit or activate specific steps in the signal transduction pathways and the metabolism of signal molecules and modify specific cellular functions using chemical biology. Manipulating reactive oxygen and nitrogen species levels and phytohormone signaling pathways by small bioactive molecules may help us understand how complex signaling networks regulate root growth and development.

We will investigate protecting effect of Si on plants. We are still far from understanding the complex mechanisms of Si action. We aim to include other soil amendments such as biochar, silicates, and microbiota in our research and **test the effectiveness of these additives** in regulating the mobility of metal contaminants in the soil, their absorption, accumulation and redistribution in the plant body in the context of the Si protective effect. Results of studies can aid in phytoremediation and phytomanagement of contaminated areas.

We will continue delineating the roles of the hitherto poorly understood AtSYT3, AtSYT4, and AtSYT5 **synaptotagmins** by analyzing insertional mutants. We plan to introduce a new model organism, *Physcomitrium patens*. There are eight synaptotagmin homologs in this moss. We intend to use targeted mutagenesis to employ the CRISPR/Cas9 approach that allows simultaneous disruption of several close homologs in a single transfection. In this way, we expect to identify the function of nearby homologs with possible redundant functions.

- **Genetic resources for biotechnology – carnivorous plants**

We will focus on **developing methods for isolation of chitinase cleavage products** and characterization of individual fractions, and their **ability to suppress the growth of selected tumor lines** in collaboration with other academic departments. In addition to genes for chitinases and β-1,3-glucanases, we plan to isolate and characterize other genes for hydrolytic enzymes, such as proteases, with **potential applications in biotechnology**. The research will also include optimizing plant growth conditions under *in vitro* conditions to optimize the production of secondary metabolites (naphthoquinones) useful in the pharmaceutical industry.

- **Multidisciplinary research of new genetic resources – their utilization**

The research will target mainly the **ecophysiological changes due to uptake and accumulation of different metal ions** in amaranth varieties, to show its adaptive characteristics for cultivation in contaminated soil and their capability to accumulate metals. This will include study of growth, morpho-physiology and anatomical responses of plant tissues (microscopy techniques), ionomic profile and ionome analyses (inductively coupled plasma – optical emission spectometry). The research will also integrate the molecular study of possible mechanisms regulating metal accumulation and homeostasis. The investigation of stress-related defense components and mechanisms modulating plant adaptation to environmental stressors driven by climate change will be performed. This will include genome-wide expression analysis, expression and enzymatic profiles of selected genes, known to be responders to different abiotic stresses (quantitative PCR, methylation sensitive AFLP, miRNA analyses) and metagenomic investigations of the endophytic bacterial communities known in endophyte-assisted phytoremediation (Next-Gen Sequencing).