BIOLOGICKÉ CENTRUM AV ČR, v. v. i.

Research activities strategy

for 2018 - 2022

of the Biology Centre of the Czech Academy of Sciences

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Content

1 Introduction

This Research Strategy of the Biology Centre of the Czech Academy of Sciences, (hereinafter "the Strategy") follows the "Plan of Research Activities of the Biology Centre of the Czech Academy of Sciences for the years 2012-2017" of 3 January 2012.

The main part of the Strategy is the Medium-term Research Activities Plan (Chapter 5), which sets out the main objectives and research activities of the Biology Centre of the Czech Academy of Sciences (hereinafter referred to as “the BC”) for the period 2018-2022.

The BC consists of five scientific institutes and a research infrastructure. The research activity plan is elaborated to the level of individual research groups at individual scientific institutes.

2 Vision and Mission of the BC

2.1 Establishment of BC

The BC was established by the Academic Assembly of the Czech Academy of Sciences (at its XXVII session on 15 December 2005) in order to carry out basic scientific research in the biological sciences, especially entomology, hydrobiology, plant molecular biology, parasitology and soil biology, with the aim of contributing to the utilization of the results and providing research infrastructure.
The BC also participates in the education and training of scientists in cooperation with universities to implement doctoral study programmes.

2.2 Mission of BC

BC is a non-university research institution that deals with the developmental and evolutionary biology and ecology of various organisms. The primary mission of BC is to advance scientific knowledge. In addition, results of BC research are used in agriculture, forestry, fisheries, human and veterinary medicine, public and state administration, and other social sectors. Educational activities are an integral part of the overall BC's presentation. The main emphasis is placed on the education of doctoral students and postdoctoral fellows; in addition, undergraduate students are trained in research teams. Great attention is paid to cooperation with domestic and foreign partners and communication with the general public, including the popularization of science, research and development. BC's professional expertise is offered and applied in solving practically and socially important issues.

BC focuses on research and development in following fields:

1) Origin, evolution and sustainability of organismal biodiversity.
2) Ecological interactions shaping temperate and tropical ecosystems. Protection of biodiversity in terrestrial ecosystems.

3) Co-evolutionary mechanisms and functions of parasitic organisms in biodiversity. Development of technologies for biomedical use.

4) Genetic, molecular and biochemical mechanisms of invertebrate development and adaptation to environment. Development of strategies for pest management.

5) Genome organization, epigenetics and molecular signalling of model plant species. Principles of plant metabolism and photosynthesis. Diagnosis of pathogens and mechanisms of pathogenesis of diseases caused by them.

6) Interactions between soil animals, microorganisms and abiotic part of soil environment. Principles of soil regeneration and maintenance of soil fertility.

7) Ecological interactions in natural and artificial waterbodies. Water chemistry, microbial ecology, and fish biology. Production processes of freshwater ecosystems.

2.3 Vision of BC

We see the future BC as the institution of the edge-cutting non-university research in the areas of evolutionary and developmental biology and ecology. The BC will be respected in domestic and international context and has the ambition to be one of the leading research institutions in Europe and in the world. The way to achieve this leading position is to strengthen the BCs' international character, to attract gifted young researchers and to open senior positions for foreign experts from abroad. We will also strengthen the international character of the School of Doctoral Studies in Biological Sciences in cooperation with the Faculty of Science of the University of South Bohemia in České Budějovice.

3 Analysis of the Default State

3.1 Analysis of the external environment

3.1.1 Financial resources for the BC's activities

The BC is a public research institution (PRI, under Act No. 361/2005 Coll.) and its activities are funded from multiple sources, whose main structure follows sources from the provider of the Czech Academy of Sciences (institutional) and other sources (extra-budgetary). Within extra-budgetary sources, the BC records the Czech Republic's national resources (Czech Science Foundation, Czech Technology Agency, ministries, etc.), sources from abroad and extra-budgetary resources (in particular revenues and reimbursements).

Institutional resources represent about 35-40% of the BC's total resources. Special sources from other domestic and foreign providers represent about 40-55% of the BC's total resources, depending on its success in grant competitions. The rest of the resources are mainly revenues from economic contracts, the provision of non-residential premises and equipment and the operation of the BC cafeteria.

The largest provider of targeted subsidies from extra-budgetary resources in recent years

has been the Czech Science Foundation. The BC compiles a balanced budget each year, broken down into an investment and non-investment withdrawal plan.

3.1.2 External evaluation of the BC's activities

The Research, Development and Innovation Council has developed an evaluation system for research organizations entitled "Methodology for the evaluation of research organizations and the evaluation of programmes for the purpose of promoting research, development and innovation" (abbreviated as "Methodology 17+" or only "M17+"), which was approved by Government Resolution No. 107 of 8 February 2017. The basic principles of the new rating system are described here: https://www.vyzkum.cz/FrontClanek.aspx?idsekce=695512

Academic Council of the Czech Academy of Sciences - The activities of the BC are mainly evaluated by a direct superior body, namely the Academic Council of the Czech Academy of Sciences, which organizes regular, comprehensive, international evaluation of all scientific work of the Czech Academy of Sciences. Two comprehensive assessments of activities of the individual institutes have been carried out for the periods 2005-2009 and 2010-2014. The next evaluation period will be 2015-2019. Based on the results of these evaluations, the Academic Council of the Czech Academy of Sciences adjusts the amount of funding for BC activities.

Grant agencies - The evaluations of all grant-supported projects that the BC and its staff request funding for are subject to the rules of the relevant grant agencies.

Contracting partners - Evaluation of the results of economic contracts is a matter for the contractual partners.

3.1.3 Expected development of the external situation

In its core business, the BC is constantly striving for excellence in all research directions, based on current life science issues, the emergence and sustainability of biodiversity, the interactions between organisms and the relationship of organisms to the environment. The development of international cooperation on research is an essential feature and a prerequisite for internationally competitive research and results. Looking for ways to transfer research findings into practice will remain an integral part. The BC has the basic prerequisites in terms of the staffing of research activities, including the necessary representation of foreign colleagues, and the prerequisites for the high-quality education of doctoral students and young scientists in the joint school of doctoral studies with the University of South Bohemia, as well as in terms of instrumentation and technical equipment.

In terms of external evaluation, the development of the system of R & D evaluation at the Czech state level (Methodology 17+) and its application by the Czech Academy of Sciences is decisive, being closely related to institutional support for the long-term development of research organizations. Here the BC will seek to achieve excellent results subject to international peer review within the framework of individual modules, as well as in other aspects of BC development, such as the social

relevance of research, its viability and strategies and concepts in such fields as human resources.

The targeted support and external direction of calls for targeted research projects are fixed for the years 2018-2022, both for the current period of the cohesion policy (European Structural and Investment Funds and their implementation through operational programmes within the Czech Republic, especially the Operational Programme Research, Development and Education), and for the future form of the programme period 2021-2027. This also applies to the EU Framework Programme for Research and Innovation (Horizon 2020) and to the forthcoming Horizon Europe (9th Framework Programme) for the years 2021-2027. Increased involvement in both these programmes is a prerequisite for the development of the BC. In terms of the direction of targeted support in the Czech Republic, there are the activities of the Czech Grant Agency, the Czech Technology Agency and departmental targeted support (Ministry of the Environment, Ministry of Agriculture, etc.).

3.2 Analysis of the internal environment

3.2.1 Structure and numbers of BC staff

The BC consists of five scientific institutes which were merged into the structure of the BC on 1 January 2006. The legal form of the BC was changed as of 1 January 2007 from that of a state contributory organization to a public research institution (PRI). Even after the merger, the individual institutes retain a considerable degree of autonomy, whether in decision-making on research strategy, personnel policy or the management of financial subsidies, which are divided among the individual BCs on the basis of the scheme below. The conceptual and financial autonomy of the institutes is based on the Joint Memorandum of the Entomology Institute, the Hydrobiology Institute, the Parasitology Institute, the Institute of the Molecular Biology of Plants, the Institute of Soil Biology, the Technical-Economic Administration of the BC/the THSBP and the Academic Council of the Czech Academy of Sciences, discussed on 21 September 2005. The conceptual and financial autonomy of the institutes is also enshrined in the Organizational Code of the BC.

As of 20 May 2016, an additional organizational component has been added to the BC structure: National Soil and Water Infrastructure for the comprehensive monitoring of soil and aquatic ecosystems (SoWa). Currently the BC consists of five scientific institutes and a single research infrastructure:

- Entomology Institute
- Hydrobiology Institute
- Parasitology Institute
- Institute of the Molecular Biology of Plants
- Institute of Soil Biology
- Soil and Water Research Infrastructure

Research and operations infrastructure in the BC are provided by the Technical-Economic Administration of the BC. At present (as of 31 July 2018), the individual research departments of the BC have the following employee statistics:

Research unit	FTE (full-time equivalent)	Registered number of employees	Researchers (registration status)	Doctoral students (registration status)
Entomology Institute	160.3	219	89	66
Hydrobiology Institute	67.2	79	36	8
Parasitology Institute	132.5	174	86	28
Institute of the Molecular Biology of Plants	51.4	60	33	3
Institute of Soil Biology	42.2	54	25	2
Soil and Water Research Infrastructure	25.9	31	9	3

3.2.2 Division of subsidies for activities from the Academic Council of the Czech Academy of Sciences among components of the BC

Subsidies for activities are considered as institutional subsidies with a specific purpose for their use as part of resource allocation. The Czech Academy of Sciences publishes a "Collective Letter" which summarizes the information on individual types of subsidies for activities and, where appropriate, sets guidelines for their redistribution within the organization. Subsidies for specific employees or scientists – i.e. wage support, support for international cooperation, regional cooperation, scholarships, etc. – are automatically assigned to the organizational component to which the employee or researcher belongs in organizational terms.

The only subsidies for activities that need to be redistributed within the BC are asset reproduction subsidies and rent and routine maintenance allowances. Here it is necessary to follow the rules of the Czech Academy of Sciences every year, as the calculation coefficients for distribution can be changed. Reallocation under the rent allowance is based on an estimate of the cost of renting non-residential premises leased by the BC on the basis of lease agreements, while we distinguish between lease contracts with another PRI and other entities.

Regarding the contributions for routine maintenance and the asset reproduction subsidies, the purchase prices of undepreciated assets of the BC are used here. The Czech Academy of Sciences lists the coefficients for individual asset types (buildings, computers, vehicles, software, etc.). The financial department prepares the documents - quantification of the value of the assets is divided among the organizational components of the BC. The legal department prepares the documents for the quantification of the costs of renting non-residential premises.

3.2.3 Technical condition of the BC's sites and modernization of the BC's infrastructure

In terms of ensuring the BC's research infrastructure according to the current requirements for the performance of professional activities, and with regard to technical, environmental, safety and functional aspects, it is necessary to prepare and implement the strategic plan for the overall revitalization of the BC complex, requiring an investment in the order of 2.5 to 3 billion CZK. This has to be done in a comprehensive manner, but within predefined stages without disturbing the conditions necessary for the professional work of individual institutes. For this purpose, a zoning study has been prepared, and work on architectural analysis and the obtaining of zoning and building permits (particularly for stage 1) is underway. In terms of internal conditions, in addition to technical design and construction planning, funds will be sought both from the European Strategy Forum on Research Infrastructures (ESFRI Road) and from European Structural and Investment Funds, as well as domestic sources.

Great attention will need to be paid to the modernization of laboratories (building infrastructure) in both the BC premises (Branisovska, Na Sádkach), laboratory equipment (molecular biology and structural biology, analytical and preparative biochemistry technology, high resolution imaging, fluorescence and electron microscopy, bioinformatics support, equipment and technology for environmental research in the field) as well as the operational and technological (energy) facilities in both sites. Modern technical facilities (laboratory infrastructure, laboratory equipment, technological facilities) will be a prerequisite for high-quality professional activities as well as the acquisition of talented young students and scholars from home and abroad for excellent research in the BC.

4 Strategic Objectives

4.1 Strategic objectives

The strategic objective of the BC for 2018-2022 is to consolidate and strengthen the position of the BC as an institution which:

- produces top-quality results of basic research;
- produces results applicable in the protection of biodiversity, soil and water, in agriculture, forestry, and medical research;
- develops unique research infrastructure at the BC's sites;
- is an internationally respected centre for the education and training of scientists;
- provides expert services to society;
- is a major contributor to the growth of the nation's education and its prestige abroad.

4.2 Strategic steps

The major concrete steps toward reaching the Strategic objectives are following:

- the General reconstruction and modernization of BC infrastructure will start in 2020;
- in the frame of General reconstruction, the former administration building (THS) will be changed to research building devoted primarily to advanced evolutionary and ecological research;
- the new system will be implemented starting from 2020 for internal evaluation of scientific performance of individual Research groups of BC;
- the goal of the new evaluation system is to unify the criteria for whole BC and, based on their application, to identify the excellent groups for further support and the relatively weak groups destined for reorganization or closure;
- the new internal evaluation system will strengthen the position of Research group as the primary organization unit of BC;
- in accordance with HR Reward principles, we will support BC internationalization at all levels of organization;
- the conditions will be sought for foundation and operation of the BC Strategic fund. The goal of proposed BC Strategic fund is to create conditions for development of BC in desirable research areas (support of excellent Research groups, opening of new groups);
- the *pros* and *cons* will be considered for intended merging of the Institute of Hydrobiology, the Institute of Soil Biology, and the research infrastructure SoWa into single "Institute of Land and Water Resources".

5 Plan of Research activities of the BC for the years 2018 – 2022

5.1 Entomology Institute of the BC

The Institute of Entomology conducts basic research on insects in the fields of molecular biology and genetics, biochemistry, physiology and developmental biology, systematics, biodiversity and ecosystem protection and ecology. The selected research results are directed towards application to the protection of nature and the environment, to the preparation of integrated strategies to control insect pest populations, and to act as the basis for developing knowledge in the biomedical sciences. The ENTU research programme focuses on four main areas, and several research groups cooperate in each. Below are specific research plans to the level of the individual research groups (with the names of research managers).

5.1.1 Molecular and genetic mechanisms of insect development

Molecular genetics (Žurovec) - We deal with the study of cell-autonomous and systemic control of the energetic homeostasis of insect cells. We study insect cell growth regulators, both in tissue cultures in vitro and in the insect body in vivo. Recently, we have been focusing on adenosine signalling.

Developmental genetics (Jindra) - We use reverse genetic approaches (transgenesis, mutagenesis,

RNAi) to study biological processes in model species (Drosophila melanogaster, Tribolium castaneum and Caenorhabditis elegans): (i) hormonal and genetic regulation of insect growth, metamorphosis and oogenesis; (ii) role of nuclear receptors and transcription factors; (iii) the molecular mechanism of the action of juvenile hormones; (iv) developmental genetics of cell differentiation and asymmetric cell division**.**

Regulaction of insect metabolism (Krejčí Bruce) - we study the effect of metabolic stress on cell signalling and tissue development, using Drosohila melanogaster as a model. We investigate how the information about nutrient availability and about the metabolic state of an organism is transmitted amongst the individual tissues and how this affects their development and function. Our aim is to elucidate some of the regulatory mechanisms behind the modulation of cell signalling by cellular and systemic metabolism. We also aim to investigate signalling pathways that regulate metabolism during Drosophila development.

Molecular chronobiology (Doležel, Šauman) – we study circadian and photoperiodic clocks in insects, in particular: (i) evolution of circadian clocks; (ii) molecular and genetic mechanisms of temperature compensation; (iii) photoperiodic clocks on genetic, molecular, and anatomical levels; (iv) light input into the photoperiodic clock.

Molecular cytogenetics (Marec) – we study the structure and function of nuclear genomes of insects and other arthropods with a focus on key questions of biology of sex chromosomes, particularly their evolution, role in ecological adaptation, speciation and sex determination. For chromosome research we use advanced methods of molecular cytogenetics including mapping of genes and repetitive sequences and we also use current methods of genome sequencing and their subsequent analysis by bioinformatics tools.

Insect Telomere (Čapková Frydrychová) - we study the role of telomere and telomerase in regulating the length of insect life, in regulating caste differentiation, and also in resistance to stress. We focus mainly on research into social insects.

5.1.2 Physiology and biochemistry of stress and the seasonal responses of insects

Insect Physiology (Kodrík) – we study insect neurohormones (mostly from the adipokinetic hormone family) and their role in important physiological and developmental processes in insect body. The study involves issues as metabolism, digestive enzymes and anti-stress reactions elicited by various stressors including insecticides, pathogens and natural toxins.

Insect Diapause (Košťál) - we study the physiological principles of the seasonal change of insect phenotype (diapause) and the associated increase in resistance to low temperatures. We focus on the biochemical analysis of the metabolome and on the accumulation of low-molecular substances with cryoprotective effects. We are also concerned with the change in the phase behaviour of body water, the modification of the composition and function of biological membranes, the expression of shock and other protective proteins.

Applied entomology (Doležal, **Skoková Habuštová, Zemek) -** we focus on biology of insect pests and development of biological control methods in forestry and agriculture.

Analytical Biochemistry (Šimek P.) - we focus on research into and development of new bioanalytical approaches and their application in research on insect metabolism and other important model organisms. We develop analytics for a large set of metabolites, from small molecules derived from organic acids, amino acids, amines, nucleosides, nucleotides, lipids, steroids, sugars or their conjugates to peptide sequencing.

5.1.3 Biodiversity of temperate zone insects and their protection

Forest ecology (Čížek) – we study the ecological principles that condition and create biodiversity in forest and grassy ecosystems in a temperate climate. An important part of our programme is the solution of practical issues regarding the protection of selected ecosystems in the Czech Republic.

Temperate biodiversity (Konvička) – we conduct ecological studies of the populations of endangered and common species of insect, primarily butterflies. We study butterfly and moth communities in terms of their functional characteristics. We investigate the causes of endangerment and propose procedures for rescuing endangered species of fauna, not only in the Czech Republic, but also in the Mediterranean. We study the effect of modern methods of ecological management (free-range grazing of large herbivores) on insect populations and communities. We also research the physiology of mountain butterflies and their survival in harsh conditions.

Lepidoptera phylogeny (Faltýnek Fric) – we study evolutionary aspects of butterfly and moth (Lepidoptera) ecology, both on spatial (biogeography) and environmental scale. We focus on predictors for evolution of selected ecological phenomena. We explore genetic diversity of genera and species on local (population genetics) as well as global scale (phylogeography) with respect to present and past climate changes.

Ecology of aquatic insects (Boukal) – we study communities of aquatic insects in standing waters on environmental gradients. We focus on the impacts of anthropogenic changes (especially global warming, eutrophication and industrial pollution) on individual behaviour, life cycles, trophic interactions and community dynamics using a multidisciplinary approach encompassing fieldwork, laboratory experiments and simulation modelling.

Phylogenesis of aquatic insects (Sroka) – we deal with the taxonomies and life-cycles of selected groups of mayflies (Ephemeroptera) and stoneflies (Plecoptera). We map the evolution of these groups using fossil material. We study their distribution, their ecological requirements and the life-cycles of individual species.

Entomopathogenic nematodes (Půža) – we study taxonomy of entomopathogenic and mollusc parasitic nematodes and search for and describe new taxa. We focus on phylogeny of the entomopathogenic nematode-bacteria complexes. We are further interested in ecology of these organisms and explore the possibilities of the use of nematodes in biological control of insect pests.

5.1.4 Ecology and evolution of insect communities

Tropická ekologie (Novotný) – the study of ecological drivers that determine the structure and function of food webs in forest ecosystems from the tropics to the Temperate zone. We focus on biodiversity in many contexts, including evolutionary mechanisms of its origin and ecological mechanisms that determine ecosystem function. Our research is based on detailed species-level description of community composition followed by manipulative experiments and molecular analysis of populations and species, and their interactions.

Ecology of social insects (Klimeš) - we study ecology, phytogeography, evolution and diversity of ants, especially in tropical ecosystems. The aim is to elucidate the factors and mechanisms that shape the diversity and composition of ant communities along ecological gradients (effects of forest succession and stratification, elevation, biogeography). We also study the impact of ants on plants and other insects (herbivores, termites), and their relations (predation, mutualism). Our approaches combine classic community ecology and biodiversity research with the use of advanced statistical models and molecular methods.

Theoretical ecology (Křivan) – our research focuses on mathematical models of behavioral, population and evolutionary ecology and their integration. Using mathematical models we explore interactions between animal behaviors (including but not limiting to adaptive food choice or sexual behavior), population dynamics, and animal trait evolution. We also study effects of infectious diseases on these interactions.

Multitrophic Interactions (Sam K.) – we study ecological factors affecting trophic interactions between predators of insect, insect and plants in forest ecosystems spreading from tropics to temperate. We focus on identification of species and their interactions, manipulative experiments and we test important and flexibility of these interactions. We further focus on direct and indirect communications between different trophic levels.

Integrative ecology (Klečka) – we study the structure and dynamics of complex communities of interacting species. We focus on the interaction of plants and insects as flower visitors.

Community Ecology (Tropek) – we study communities of insects and other arthropods along environmental and geographical gradients. Besides natural gradients (mainly environmental productivity, altitude, latitude), we focus on gradients of ecosystem disturbances, both by industrial activities and natural ones. We study also role of insects in communities, especially plant-polinator relationships. All questions are asked in both tropical and temperate ecosystems.

Experimental ecology (Hrček) – we study the impact of biotic and abiotic factors on the structure and function of food webs. We use field surveys and experiments on different insect taxa, as well as a laboratory model based on interaction networks of Drosophila and their parasitoids. We use morphological and molecular methods for identification and detection of the studied species.

5.2 Hydrobiology Institute of the BC

The Institute of Hydrobiology conducts research on the interrelationships between aquatic organisms and their interactions with abiotic factors in standing water, especially in artificial reservoirs. We conduct surveys from sub-processes to the ecosystem level. The specialization of the Institute staff ranges from hydrochemistry through biochemistry, microbiology, algology, protozoology, and the zoology of zooplankton to ichthyology. This structure enables the study of relationships in food networks using both basic approaches: “bottom-up” (from bottom to top - nutrients to fish – the production of living matter) and "top-down" (from top to bottom - fish to nutrients - feedback control of processes from higher trophic levels). Below is a brief outline of the scientific plans of individual teams to 2022 (with the names of research managers).

5.2.1 Water chemistry and reduction of eutrophication

Hydrochemistry and ecosystem modelling (Kopáček J.) – we study (1) cycling of major nutrients (carbon, nitrogen and phosphorus) and their interactions with cycles of other ecologically important elements (sulphur, aluminium, iron, silicon) in catchment-lake systems, (2) their differences between natural and anthropogenically affected environments (alpine zone, natural and managed forest, farmland), and (3) interactions between abiotic and biotic parts of aquatic ecosystems.

Makrofyta (Čtvrtlíková) - we will study the role of aquatic macrophytes in an improvement of water and sediment quality (nutrient and contaminant contents, water transparency), their competition with other primary producers (phytoplankton, periphyton) as well as their function as a highly structured wildlife habitat in natural lakes, artificial reservoirs and post-mining lakes.

5.2.2 Microbial ecology of water

Protistan bacterivory ecology (Šimek K.) - we investigate major taxa of planktonic heterotrophic flagellates, a taxonomically highly diverse protistan group, representing the core group of bacterivores in freshwaters; ii) we design new phylogenetic FISH-probes that allow targeting the protists in various trophic interactions modulating carbon flow from bacteria to the grazer food chain; iii) we implement a new double FISH approach, facilitating simultaneous detection of the protistan predators and their bacterial prey.

Ecology of phytoplankton and reservoir limnology (Znachor) i) we investigate phytoplankton spatial heterogeneity along both longitudinal and vertical gradients in reservoirs with different trophic status; ii) we conduct time-series analysis to elucidate interactive effects of management practices and the ongoing climate change on community ecology and reservoir limnology; iii) we use various fluorescence techniques for studying microbial interaction; specifically those between phytoplankton and bacteria, fungi and flagellates.

Ecology of complex microbial communities (Sirová) - we study the ecology of complex microbial communities - microbiomes - and the role they play in the ecology and ecophysiology of host organisms, mainly plants. We are primarily interested in the influence of host phylogeny, site, and environmental changes on the diversity, function, and interspecific interactions within microbiomes. Due to the interdisciplinary nature of our topics, we combine a wide range of methods, from microscopy and stable isotope analyses to molecular methods.

Genomic and ecotoxikology of cyanobacteria (Mareš) i) we perform genome mining in cyanobacterial strains to identify new bioactive compounds with biotechnological and ecotoxicological potential and to elucidate their biosynthetic background; ii) we develop techniques for molecular detection of potential cyanotoxin producers in freshwaters; iii) we study the diversity and taxonomy of important representatives of cyanobacteria using the polyphasic approach.

Trophic interactions and nutrient flows in the hypertrophic waters (Vrba) – we study structure, function and seasonal dynamics of plankton, energy flow and nutrient cycling in hypertrophic fishponds. Our particular concerns are (i) microbial diversity of plankton; (ii) the use efficiency of both primary and bacterial production and its transfer into higher trophic levels; (iii) a relevance of resource stoichiometry in trophic interactions and nutrient regeneration.

Metagenomic of microbial and viruses communities (Ghai) – we use metagenomics to study freshwater microbes and their viruses to understand their diversity, ecology, dynamics and interactions under changing conditions. We intend to recover genomes of all important microbial and viral participants across multiple time scales (days to years) in our selected model sites (Římov Reservoir and Jiřická Pond). A long-term goal is to reconstruct the important sequence of events in the complex evolutionary history of aquatic microbial communities, particularly those in freshwater.

Diversity of freshwater bacteria (Kasalický) – i) we use various molecular techniques (CARD-FISH, 16S rRNA gene amplicon sequencing) to understand seasonal and spatial dynamics of aquatic bacterial populations in freshwater reservoirs, lakes, and fishponds; ii) we use targeted isolation of important freshwater bacteria (particularly from *Limnohabitans* genus) to obtain new insights into their genomics, ecophysiology, and evolution; iii) we also focus on the description of new species of freshwater bacteria and their phages.

Plankton picocyanobacteria (Jezberová) - we study diversity, genetic variability and role of freshwater picocyanobacteria, which are not sufficiently explored contrary to the well-studied marine species with global importance. We focus on i) the isolation of a broad variety of picocyanobacterial strains from eutrophic freshwater habitats; ii) their detection in the natural environment using genetic probes; iii) assessment of their importance in the aquatic food webs; iv) comparison of freshwater and marine picocyanobacterial genomes.

5.2.3 Ecology of fish and zooplankton

Early life history of fish (Čech) – we study diurnal vertical and horizontal migrations of juvenile cyprinid and percid fish in reservoirs and lakes and adress the ecological causes as well as the consequences of these migrations. As next, the concern will be focused on the effect of

ecosystem management and nutrient load on the main characteristics of fry communities (species composition, abundance, distribution, growth rate).

Spatio-temporal ecology of fish (Říha) – we focus our research on spatio-temporal distribution of fish in artificial and natural waterbodies. Main emphasis is given to enlightening the diurnal and seasonal changes of fish distribution, the effect of abiotic and biotic factors and individual as wel as intra- and interspecific variability. Our research of spatio-temporal distribution is linked with other aspects of fish ecology (trophic interactions, population genetics and fish physiology) and applied for broader ecological concepts explaining fish ecology and functioning in freshwater ecosystems.

Behavioral ecology of fish (Šmejkal) – we focus our research on protandry behavior in asp and individual fish strategies securing maximization of reproductive success. Further research topics are impact of climate change and predation on the fish spawning and egg survival studied in model system asp/bleak. We give special emphasis to the influence of hydropeaking under water power plants on the fish behavior and egg mortality with potential global threat to riverine biodiversity and productivity.

Trophic ecology of fish (Vašek) – we study relationships between biotic and abiotic components of the aquatic environment at different temporal and spatial scales. We explore food web properties, energy flows and nutrient cycles in freshwater ecosystems. We are interested in ecological and anthropogenic factors that determine the structure and function of food webs in dam reservoirs and postmining lakes. We focus especially on the functional role of fish in food webs of large still-water ecosystems.

Ecology of fish and zooplankton communities (Peterka) – we study changes in the composition of fish communities of long-term monitored reservoirs and newly created postmining lakes. We aim on identification of the abiotic and biotic factors responsible for the changes and particularly focus on the effect of intra- and inter-species interactions and predator-prey relationships on resulting fish community structures. In addition, we are interested in studying the eco-physio-genetic adaptations of zooplankton in the context of colonization of newly created large lakes, the sharing and differentiation of ecological niches with new invasive species and the adaptational responses to the variable and manipulative structure of the trophic pyramid in deep valley reservoirs.

Fish populations dynamics (Kubečka) – we focus our research on studying temporal dynamics of fish populations and its relationship with the environment. We aim at gathering quantitative data for developing ecological models to scrutinize the role played by the biotic (primary and secondary production and competition) and abiotic (water quality parameters and temperature) factors on fish survival rate, growth, reproduction and population dynamics of targeted species. This information will be then applied into mathematical models to simulate the fate of fish according to the different management (stocking regime, fishing pressure and regulations) and climate scenarios (temperature and water level fluctuation).

5.3 Parasitology Institute of the BC

The Institute of Parasitology deals mainly with basic and partially applied research into human and animal parasites. It focuses on the study of life cycles, host relationships, the evolution and molecular aspects of unicellular and multicellular parasites of humans, livestock and fish. Another important part is the study of ticks and their transmitted diseases. The common goal is methodically diverse, internationally successful, comprehensive research on parasitic organisms. Research at the Institute of Parasitology has long been organized according to the thematic areas of individual laboratories (listed below with the names scientific research managers) in the following 4 sections: 1/ Molecular parasitology; 2/ Biology of vectors and transmitted diseases; 3 /Evolutionary parasitology; 4/ Medical and veterinary parasitology.

5.3.1 Molecular parasitology

Molecular biology of protozoa (Lukeš) – we focus on: (i) molecular and cellular biology, life-cycles and strategies of diplonemids; (ii) functional analysis of the protein *Trypanosoma brucei* involved in heme metabolism; synthesis of iron-sulphur clusters; transition from one developmental stage to another and interaction with host; (iii) evolution, diversity and unique molecular aspects of trypanosomatids.

Function biology of protists (Zíková) - we study molecular mechanisms underlying mitochondrial metabolic rewiring during *Trypanosoma brucei* life cycle. We focus on the role of mitochondria in cellular signaling that determines the metabolic status of the cell and its fate. Moreover, we explore the full metabolic potential of the parasite´s mitochondrion to understand parasite´s ability to exploit various niche within its mammalian host.

RNA biology of protists (Paris) - Using methods of molecular biology and biochemistry we study maturation of transfer RNAs (tRNAs) and its role on regulation of gene expression in parasitic protists. We are mostly interested in sub-cellular localization of tRNA modification, editing and splicing events as an additional level to control protein synthesis in cell.

5.3.2 Biology of carriers and transmitted diseases

Molecular Ecology of Vectors and Pathogens (Grubhoffer) - we study (i) diversity of spirochetes species from Lyme disease complex, its biogeography and evolution; mechanisms of borrelia pathogenesis, adaptation and reasons for occurrence of persistent infections; (ii) Lyme disease and relapsing fever surface molecules adhesion mechanisms; interaction of surface molecules with tick internal factors; (iii) molecular factors of innate host cell immunity after tick-borne encephalitis virus infection; interaction of genomic and sub-genomic RNA of flaviviruses with host and viral proteins.

Arbovirology (Růžek) – we study pathogenesis of important arboviral diseases, with special focus on tick-borne encephalitis (interaction of the virus with brain cells, role of the blood-brain barrier in development of the neuroinfection, immune response in the central nervous system); we also work on the development and testing of new antivirals active against medically important flaviviruses.

Laboratory of Electron Microscopy (Nebesářová) – we carry out (i) the latest methods of specimen preparation for 3D applications of high resolution scanning electron microscopy (the improvement of all key steps focused on the 3D visualization of complicated structures); (ii) we develop new biomarkers for correlative and cryo-electron microscopy such as non-toxic markers for a localization of particular molecules in a complex cell environment.

Tick-transmitted diseases (Hajdušek) - we focus on: (i) study of essential biochemical pathways of ticks to develop and test vaccines and drugs against ticks (improvement of the recent vaccine based on the protein called Ferritin2) ; (ii) development of complete transmission models for *Borrelia*, *Babesia*, and *Anaplasma* to test tick candidate proteins involved in the tick-pathogen interaction by using the method of RNA interference.

Genomics and Proteomics of Disease Vectors (Kotsyfakis) - we characterize molecules present in tick saliva, primarily protease inhibitors and non-coding RNAs showing a potential in novel medicine and biotechnology applications. We test their role in tick-host interaction with focus on host homeostasis manipulation and immunomodulation.

Vector immunology (Kopáček P.) – we study the intestine of the *Ixodes ricinus* tick as the organ that is the determiner of its vector competence. We will focus on nutrition factors of the host's blood which are necessary for the development and reproduction of ticks. Furthermore, we will study the regulation of the digestive system and the immune reaction in the gut of a tick, which affect the intestinal microbiome and its interaction with borrelia.

5.3.3 Evolutionary parasitology

Evolutionary protistology (Oborník) – we focus primarily on molecular phylogenetics based on: (i) proteomics of organelles of the chromerid algae *Chromera velia* and *Vitrella brassicaformis*; (ii) their allelopathic interactions; (iii) heterotrophic flagellates from the Bicosoecida (Stramenopila) group.

Environmental Genomics (Horák) – we want to address the factors determining distribution of eupelagonemids, one of the most diverse and abundant lineages of eukaryotes – and their role in the global ocean ecosystem. We also aim to create a predator-prey model to uncover molecular mechanisms of adaptation of heterotrophic flagellates to various types of trophic strategies.

Molecular ecology and evolution of parasites (Štefka) – we explore host specificity and co-evolutionary history of parasites as the determinants of their dispersal abilities, population structure and biodiversity. We study impact of these factors on the maintenance of genomic

diversity and speciation in several host-parasite systems, for example mammal ectoparasites and fish helminths.

Genomics and diversity of protozoa (Kolísko) – we compare genomes of parasitic, commensal and free-living protozoa in order to understand the genomic evolution of parasites and secondary free-living species. We will also study diversity and the interaction of parasites with the human intestinal ecosystem.

5.3.4 Medical and veterinary parasitology

Helmintologie (Scholz) - our research is focussed on (i) integrative taxonomy approaches to trematode and cestode diversity and life-cycles;(ii) systematics and phylogeny of cestodes and fish nematodes; (iii) ecology of trematodes and their role in ecosystem functionning; and (iv) fish-borne parasitic diseases (broad fish tapeworm).

Fish protistology (Holzer) – we study primarily myxozoa, which are parasitic cnidaria, with the aim of understanding: (i) hidden diversity; (ii) the origin of parasitism; (iii) the phylogenesis and (iv) molecular mechanism of the host-parasite relationships of myxoa and fish, including the immunology of the host's response and parasite immune evasion. Everything is based on our unique laboratory model of the proliferative stage of myxozoa.

Veterinary and medical protistology (Kváč) – our efforts are aimed at understanding the diversity and biology of host-parasite relationships and the host-parasite co-evolution of cryptosporidium in rodents and birds. In addition, we study the virulence, transmission by organism and drug resistance of genotypes of the widely-spread human parasite, *Encephalitozoon cuniculi*.

Laboratory of Parasitic Therapy (K. Jirků Pomajbíková) - we study the role of gut eukaryotes in human health and disease. We focus on (i) assessment of the immunomodulatory abilities of these eukaryotes with impact on the host organism, (ii) identification of their compounds with anti-inflammatory properties, and (iii) study of the diversity oft protists in healthy human populations with different degree of modern lifestyle.

5.4 Institute of Plant Molecular Biology of the BC

The Institute of Plant Molecular Biology deals with complex plant research at the molecular level that includes the plant genome, cell structure and function, the understanding of epigenetic mechanisms, the functional genomics of plant metabolites, the molecular principles of photosynthesis, biophysics, the biochemistry and molecular biology of the metabolism of metals and the molecular biology of plant pathogens. The IMBP's research programme is concentrated in six main areas, in some of which several research groups cooperate. Below is a brief outline of a specific scientific plan at the level of individual research groups (with the names of research managers).

Virology (Koloniuk) – we study viruses of plants, fungi, lichen, and bacteria and phytoplasmas, their biological properties and vectors using molecular biology methods and high-throughput sequencing.

Photosynthesis (Litvín, Hronková) - we study: (i) light-harvesting and photoprotective function of pigment-protein complexes from photosynthetic organisms by proteomic and optical spectroscopy methods; (ii) regulation of plant stomata development and function in dependence on environmental conditions by molecular biology methods.

Molecular Genetics (Matoušek) - we characterize functional genomics of hop with regard to production of lupulin and secondary metabolites using bioinformatics and molecular genetic methods. We analyze mechanismis of viroid pathogenesis, propagation and evolution.

Molecular cytogenetics (Macas) - we investigate sequence composition and evolution of repetitive DNA sequences in plant genomes, perform structural and functional analysis of plant centromeres and develop novel bioinformatics tools for genome analysis using next generation sequencing data.

Biophysics and biochemie of plants (**Küpper)** - we are interested in the physiology, biophysics and biochemistry (incl. molecular biology) of photosynthetic organisms (green/brown/red algae, terrestrial and submerged higher plants, bacteria). The main focus is on metal metabolism in terms of uptake, physiological use, sequestration/complexation, detoxification, toxicity and interaction with plant immunity to pathogens."

Plant Epigenetics (Iva Mozgová) – we are interested in the understanding of epigenetic mechanisms that govern photoautotrophic growth in flowering plants, early land plants (bryophytes) and algae and study the evolution of the Polycomb Repressive Complexes in the green lineage.

5.5 Institute of Soil Biology of the BC

The Institute develops the multidisciplinary field of soil biology, i.e. soil zoology, microbiology, chemistry and micromorphology, and deals with basic issues related to the creation, fertility and regeneration of soils. Activity is focused on research into the structure and dynamics of soil organism communities in natural and anthropogenically affected ecosystems, the interaction between soil animals, microorganisms and abiotic components of the soil environment, the study of humus formation and its transformation, and the cycle of biogenic elements in soil. The IPB research programme is concentrated in three main areas, with several research groups cooperating in two of them. Below are specific research plans at the level of individual research groups (with the names of research managers).

5.5.1 Microbial processes in the soil environment

Environmental microbiology (Chroňáková) – we are interested in the diversity of soil actinomycetes and their genetic potential to produce secondary metabolites, their interactions with other

organisms, including humans. We are focused on microbe-mediated processes affecting the fate of pharmaceuticals in soils. Both research directions have potential for biotechnology application. We collect, maintain and use the microbial cultures deposited in BCCO (Biology Centre Collection of Organisms; www.actinomycetes.cz).

Bacterial adaptation (Elhottová) - we study interactions between resident soil microorganism and exogenous microorganisms entering the soil with organic matter and environmental factors that modulate the formation of ecological communities. We are focussed on processes of coalescence, competitive exclusion and selective environmental pressures affecting microbial biodiversity, as well as potential health risks in soils affected by intensive human activities.

Soil microfungi (Ahmed) – we study the biodegradation rate of plastics using soil fungi, with a focus on: (i) biodegradation efficiency of fungi for various types of plastic waste over the short and long term; (ii) mechanisms that plastic-decomposing fungi use in degradation processes. We continue to expand the Collection of Microfungi of the Institute of Soil Biology with fungal strains isolated from various environments.

Soil algae (Lukešová) - we study: (i) diversity and function of soil algae and cyanobacteria in soils, especially their role during ecological succession; (ii) stress response and survival potential of algae and cyanobacteria from extreme habitats. We focus on integrative taxonomy and diversity discovery (polyphasic approach) using strains isolated by us from soils worldwide and kept in BCCO culture collection. We are also interested in production of biological active compounds by isolated strains.

Soil gases (Šimek M.) – we study the production of gaseous metabolites in soils and their emission to the atmosphere. We focus on the role of soil invertebrates in methane production, the formation of methane in the decomposition of xenobiotic compounds, and the possibility of reducing emissions of nitrogen oxides, methane and carbon dioxide from agricultural soils.

5.5.2 Ecology and function of soil fauna

Extreme ecosystems (Devetter) – we study the role of soil microfauna in cycle of soil carbon in various ecosystems and under influence of various factors. We focuss on extreme ecosystems where the relative importance of microfauna is highest. We identify main driving factors for development of soil invertebrates and their interactions**.**

Fauna of anthropogenic ecosystems (Pižl) - we study soil invertebrate communities in natural and human-affected ecosystems. We focus mainly on changes in the structure of communities in agricultural soils during the shift from conventional to nature friendly farming practices. Another research area is the study of taxonomy of soil animals, including the use of molecular approaches.

Fauna of Natural Ecosystems (Tajovský) - we study parameters of soil meso- and macrofauna communities in order to assess and evaluate: (i) the impact of different management and long-term changes in mountain and alpine ecosystems; (ii) the direct and indirect effects of artificial

snow on the soil environment and its recovery; and (iii) long-term changes during secondary soil succession.

Functional diversity (Chen) – we focus on the coexistence of species in the soil and the processes that determine it. We will investigate the role of evolution in the current community structure. We use both the phylogenetic approach and approaches based on the functional properties of species in research into the community structure of soil mesofauna in various ecosystems

Carbon cycle in soil (Jílková) – we study inputs of labile carbon forms into the soil and their impact on organic matter decomposition and soil carbon sequestration. An important part of our research is to tisentagle the roles of plants, soil fauna and microorganisms in these processes and to assess the effect of climatic changes, such as atmospheric CO_2 concentration increase, on these processes.

5.5.3 Nanobiotechnology

Use of magnetic (nano)materials (Šafařík) – we study preparation of new types of magnetically responsive materials and their subsequent application in various areas of biosciences, biotechnology and environmental technology, e.g., for isolation, detection and determination of target biologically active compounds and xenobiotics, or for immobilization of biologically active compounds, affinity ligands, microbial cells or inorganic nano- and microparticles. We develop procedures for conversion of diamagnetic (nano)materials into magnetically responsive composites. Attention will be also focused on the application of nonstandard materials and procedures.

5.6 Soil and Water Research Infrastructure (SoWa)

The SoWa research infrastructure conducts its own research and provides services to other researchers on key issues of the interaction of soil and water. Emphasis is placed on interactions determining the flows of water and major nutrients (especially N and P) in the ecosystem. Emphasis is placed on ecosystems under strong anthropogenic pressure. SoWa's many laboratories work closely with the laboratories at IHB and IPB. Below is a brief overview of the scientific plan of each laboratory to 2022 (with the names of scientific research managers).

Microbial communities on the oxygen gradient (Angel) - we deal with structure and ecological role microbiome of soil fauna. Further we study oxygen gradients in soils, limitation of collections of micro-organisms by selecting the inoculum.

Biotic and abiotic interactions in soil (Frouz) - we investigate interactions between plant roots, soil biota and the abiotic soil environment and the role of these interactions for the development of ecosystems in different spatial environments scale, from aggregates to the entire ecosystem.

Valley reservoir communities (Peterka) - we study changes in the composition of fish communities over the long term monitored reservoirs and newly formed lakes, distribution, energy flow function, abiotic a biotic factors that affect this.

Sediments (Borovec) - we study the main processes governing the transformation of C, P and Fe in sedimentation sister focusing on the importance of stabilizing OM metals, mainly Fe. Furthermore, we find out what the consequences and significance are sediment disturbance or flood events for the aquatic ecosystem.

Utilization of stable isotopes in ecology (Meador) - we study isotopic composition of molecules as biomarkers of turnover nutrients, organic matter and microbial communities in water and soil.

Chemical processes (Porcal) - we study chemical processes in the soil environment that affect transport mineral and organic substances into surface waters. We deal with photochemical transformation dissolved organic matter and its complexation with metals.

5.7 Cooperation between institutions

The common denominator of research on the Biology centre institutes and Research infrastructure SoWa is the theme of evolutionary biology and ecology with an emphasis on the origin and evolution of biodiversity and its sustainability. It creates a common platform for horizontal collaboration between individual scientific institutes and the SoWa through shared grant projects. This fact is a prerequisite not only for strengthening the quality of scientific research of the BC, but also for searching for promising interdisciplinary topics of scientific research.

6 Checking the Fulfilment of Strategic Objectives

6.1 At the BC-wide level

The method for the continuous monitoring of the fulfilment of the Strategic Objectives by the BC Board is set out in the BC Organization Rules and other regulations.

Each year, usually at the spring session of the BC Board, the directors of the BC's scientific institutes and the director of SoWa present their Critical Analysis of the activities of the organizational components in the previous year (see Section III, Organization Rules, Article 5, clause 9, letter k). This is a written analysis that is also presented orally. The BC Director is present at the BC Board's session. The BC Board reviews the Critical Analysis, evaluates the performance of the individual organizational components, their meeting of short-term targets and performance of tasks, and assesses to what extent they are contributing to the fulfilment of the Strategic Objectives.

The BC Board issues a report on the submitted Critical Analysis. The BC Board is entitled to invite the director of a scientific institute or the SoWa to formulate their own plan for remedying possible shortcomings. Subsequently, the plan is discussed and possibly amended at the BC Board's session.

After being negotiated and approved by the BC Board, the plan becomes binding for the director of the scientific institute concerned or the SoWa.

6.2 At the level of individual components of the BC

The directors of scientific institutes and the director of SoWa will review at least once a year the fulfilment of the individual research plans set out in section 5. The main output of the researchers' work are scientific publications in professional magazines registered in the *Web of Science (WoS)* database. For some research staff/teams, the quality of the application of the results is also a monitored parameter. Therefore, the directors of organizational components of the BC primarily monitor whether scientific teams are working (i.e. publishing, patenting) according to the direction that was set, and they also evaluate the number and the quality of the published/patented outputs.

For the purposes of regular inspections, the directors of research divisions of the BC use the tools set out in the Organization Rules of the BC and in other applicable regulations:

- The rules for evaluating research staff of the BC.
- Regular certification of research staff (Certification Committee).
- The BC Performance Table (the annual review of the performance of all research staff, research teams, research institutes and the entire BC (from 2004 on, inclusive).
- Sessions of the Scientific Council.
- Session of the Director's Council.

7 Final Provisions

This Strategy was formulated by the BC Board and the BC Director. The Strategy was approved by the BC Board on 2 November 2018. The re-formulated chapters of Mission (2.2), Vision (2.3), and Strategic Objectives and Steps (4) were approved by the BC Board on 31 December 2020.

21 -05- 2021

prof. Ing. Vladimír Košťál
President of the BC Board

21 -05- 2021

prof. RNDr. Libor Grubhoffer
Director of the BC