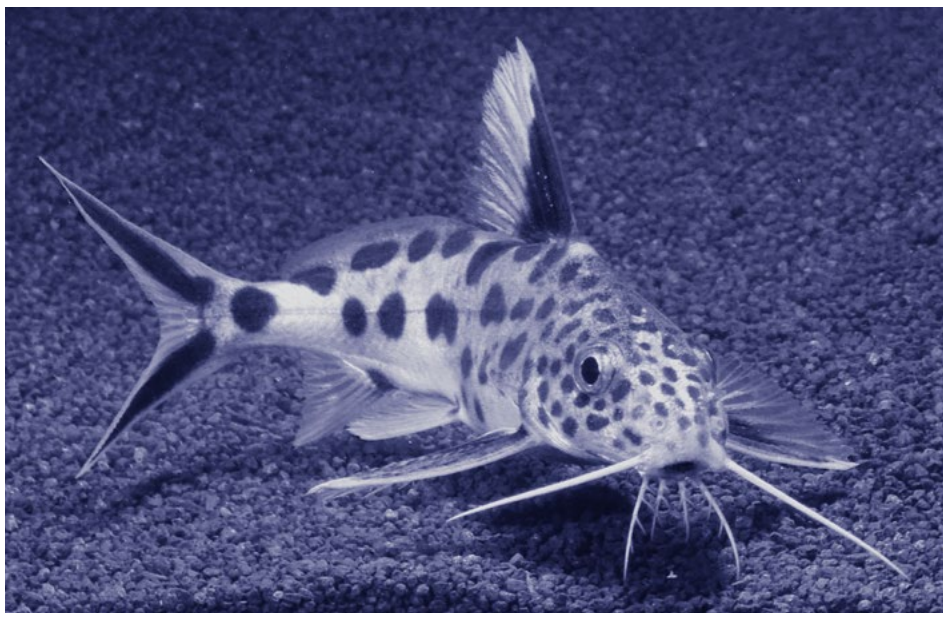
THE CZECH ACADEMY OF SCIENCES

INSTITUTE OF VERTEBRATE BIOLOGY



BIENNIAL REPORT

2017–2018

BRNO 2019

INSTITUTE OF VERTEBRATE BIOLOGY
CZECH ACADEMY OF SCIENCES

BIENNIAL REPORT

INSTITUTE OF VERTEBRATE BIOLOGY

THE CZECH ACADEMY OF SCIENCES

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INSTITUTE OF
VERTEBRATE
BIOLOGY
CZECH ACADEMY OF SCIENCES

BIENNIAL REPORT 2017–2018

A periodical continuation of the Institute's previous bulletins: Vertebratologické zprávy (1969–1987), Zprávy ÚSEB (1988–1991) and the ILE Biennial Report (1993–1994).

Edited by Alena Fornůsková, Josef Bryja, Hana Slabáková and Marcel Honza
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English editing by Kevin Roche
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Front cover: The cuckoo catfish (*Synodontis multipunctatus*), the only obligatory brood parasite species among fishes. (*Photo by R. Blažek*)
Back cover: The Institute's new cuckoo catfish breeding facility, with 24 breeding and 32 experimental tanks housing hundreds of cuckoo catfish and their cichlid hosts. (*Photo by M. Vrtílek*)

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PREFACE

Dear reader,
It is my great pleasure to introduce what has already become a traditional publication of the Institute of Vertebrate Biology (IVB), the Biennial report. The major goal of this report is to provide both a representative overview of the extensive range of research activities undertaken at the IVB and to inform the reader about the most important news and events occurring at the IVB over 2017–2018, all in a style that is fully accessible to the interested layperson.

Each chapter in this report provides a detailed summary of the results of work completed over the previous two years. The majority of scientific papers were published in high ranking journals covered by the Web of Science. Of particular note is the impressive range of international cooperation and wide distribution of study sites throughout the world that is now characteristic of our research activities. Despite the majority of studies addressed by our fellows being primarily focused toward basic science, I must stress that the results of our work have also significantly contributed to applied problems in the areas of nature conservation, fisheries, forestry, agriculture and epidemiological surveillance.

The solid number of foreign students involved in our research is a clear indication that the Institute has a good reputation abroad. In addition, our huge participation in education at Czech Universities and the amazing number of graduate and post-graduate students (more than 100) studying with us is strong evidence of our Institute´s important position in the Czech educational system, particularly in the fields of zoology, ecology, evolutionary biology and biodiversity.

Our staff are extremely competitive and have had great success, both in obtaining research grants and in fund-raising from both national and foreign sources. These research grants and other contract funds contributed significantly to the IVB budget, representing an additional 48 and 47 million CZK in 2017 and 2018, respectively. At this point, I would like to express my deepest appreciation to all fellows who successfully applied for research grants and to express a vote of heartfelt thanks for the truly excellent results achieved over the past two years.

It also gives me great pleasure to announce that, over the past two years, we have completed the construction of a new modern breeding facility at Studenec, at a cost of cca 40 million CZK.

Dear reader,

I will finish my 10 year period as Director of the Institute in mid-June 2019 and I believe that the new Director will bring new ideas and challenges for the future progress of the IVB. I sincerely hope that our work will continue to be guided by a spirit of mutual understanding and collaboration.

Finally, I wish to extend my sincere thanks to all the colleagues that supported and helped me over my tenure as Director.

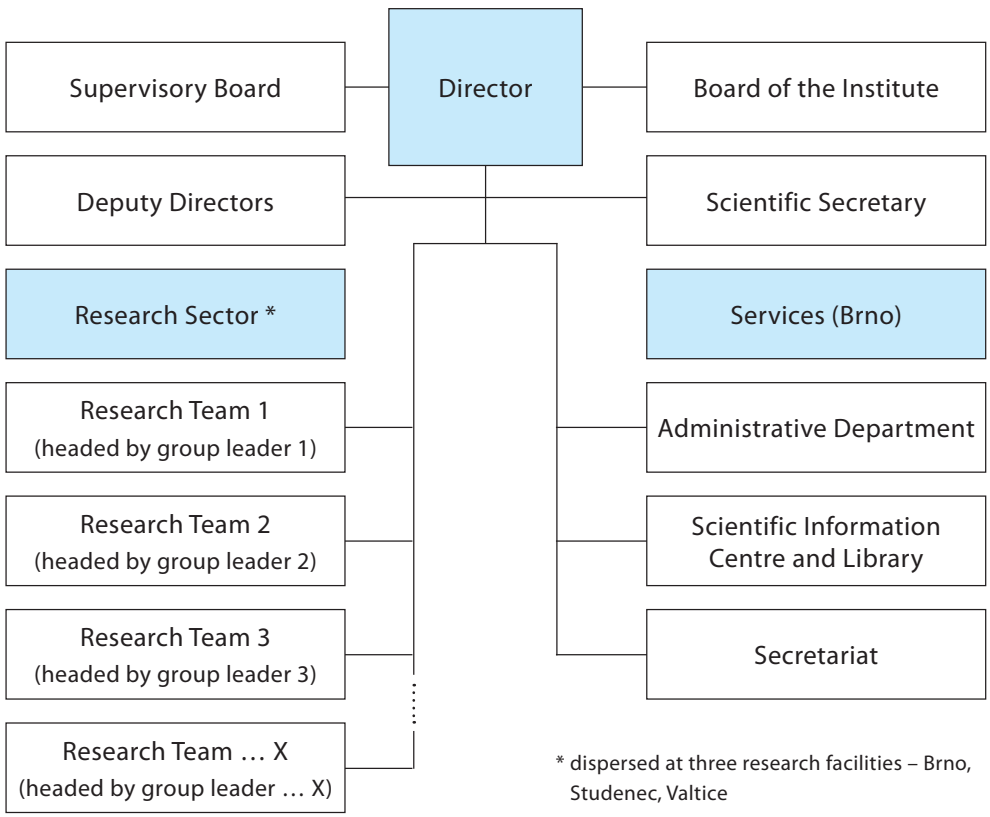
With my very best wishes,

Marcel Honza
Director of the IVB

March, 2019

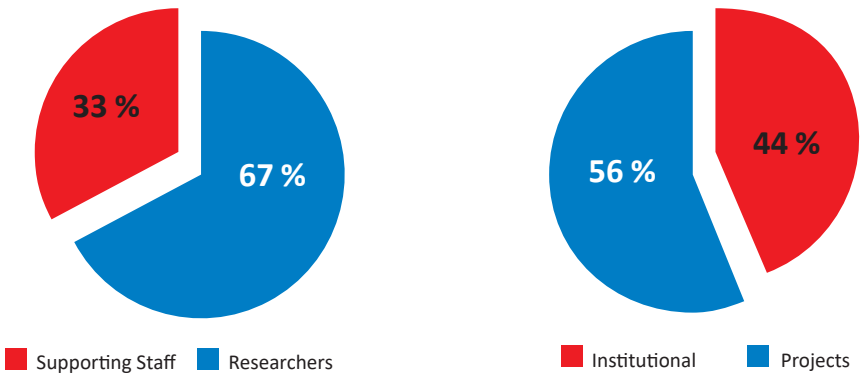
1. BACKGROUND

| STRUCTURE OF THE INSTITUTE OF VERTEBRATE BIOLOGY

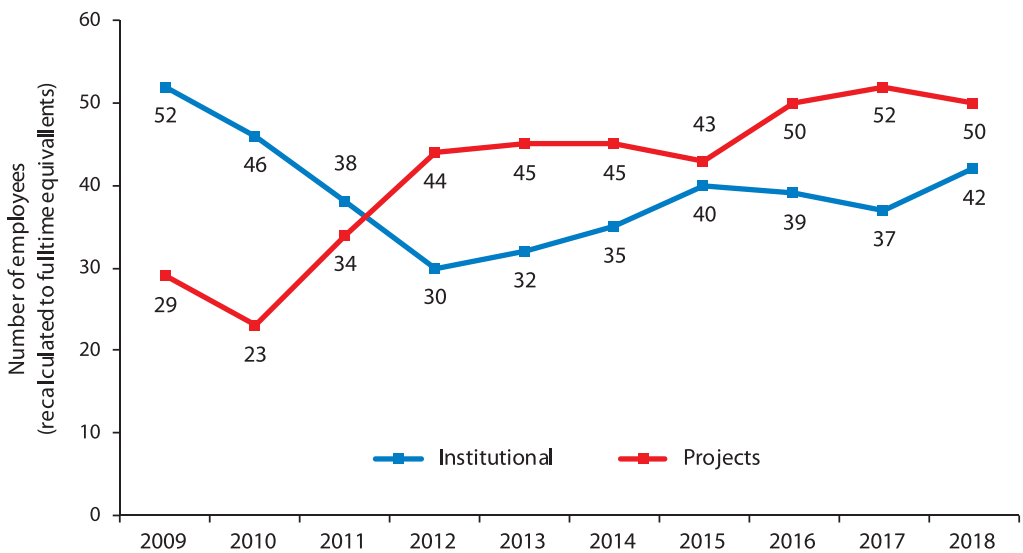


The Institute of Vertebrate Biology (IVB) is a relatively small institute of the Czech Academy of Sciences and, as such, is not structured into separate research departments. Senior researchers are usually the Principle Investigators of national and international projects and are responsible for creating and maintaining their teams, predominantly from external funds. Principle Investigators (group leaders) of projects are directly subordinated to the Director. Research teams are highly flexible and are composed of junior researchers, post-doctorates, research assistants, technicians and pre- and post-graduate students (mostly paid from project grants). Research subjects can be divided into three main domains: evolutionary ecology, biodiversity and pathogens and diseases (see below). However, individual projects can cover more topics and researchers often use interdisciplinary approaches.

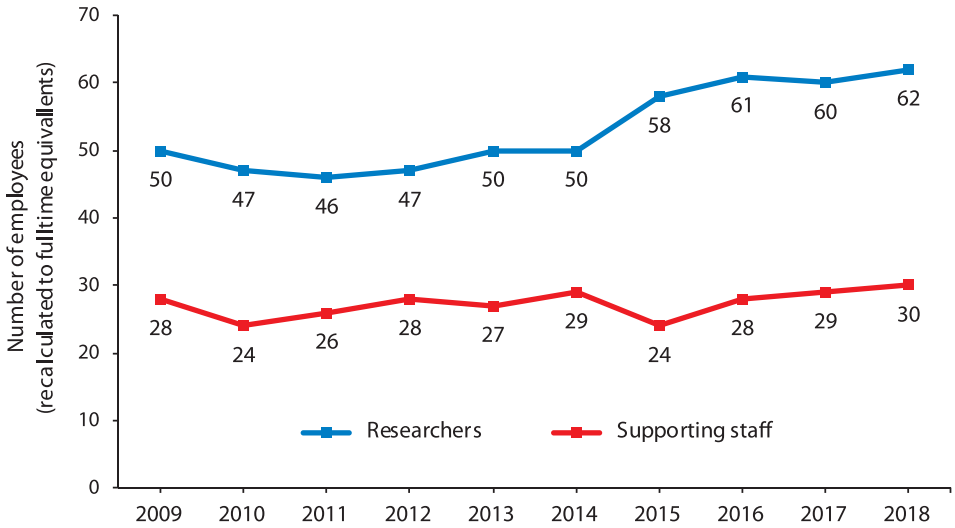
| STAFF AND BUDGET



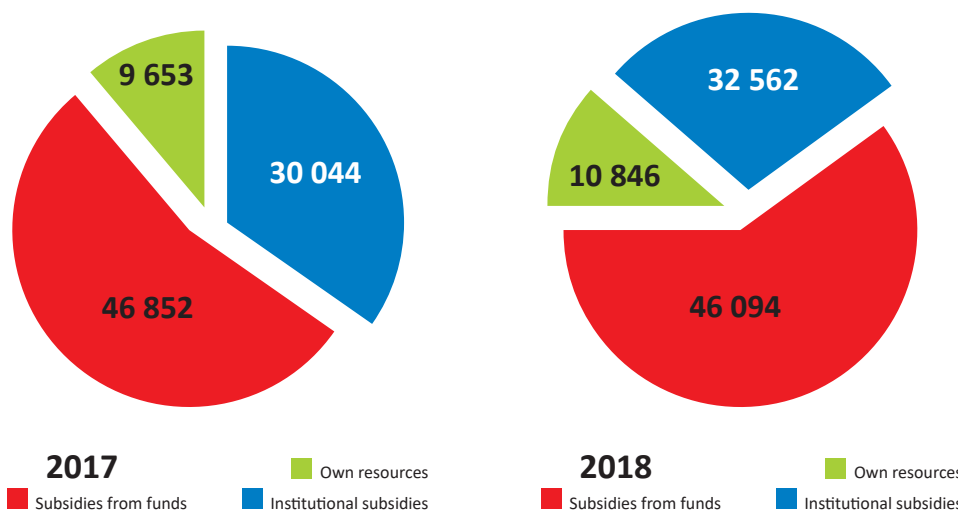
Staff structure over the period 2017–2018.



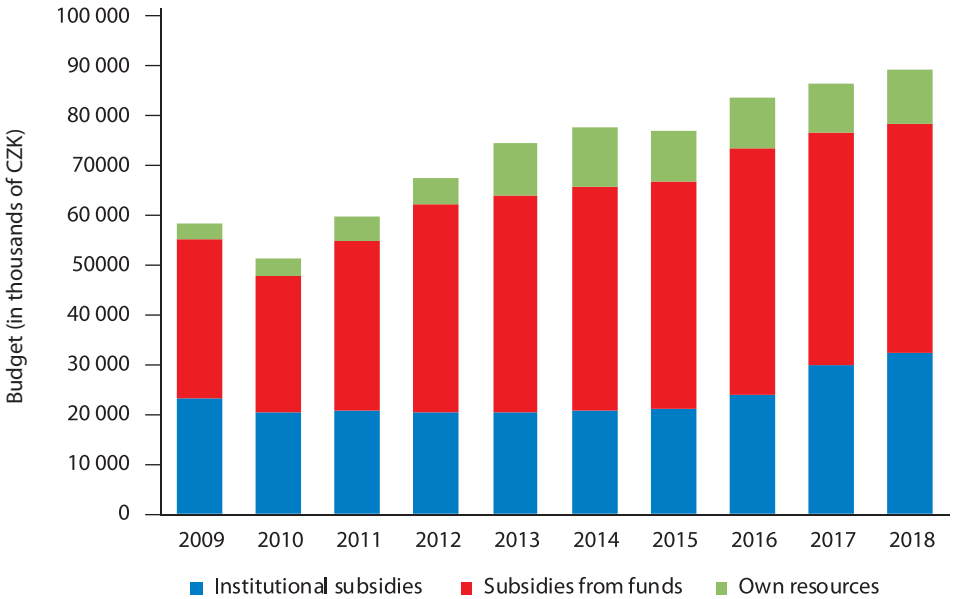
The number of employees paid from different sources has remained relatively stable in recent years, but the proportion of employees dependent on short-term projects is still very high.



Increased subsidies from institutional funds have allowed us to employ more full time paid staff.



Budget structure of (numbers are in thousands of CZK).



The total budget of the Institute has increased slightly, partly due to an increase in institutional subsidies over 2017 and 2018.

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Prof. RNDr. Miloš Macholán, PhD
(*Institute of Animal Physiology and Genetics, Czech Academy of Sciences, Brno*)

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Prof. PhDr. Ludvík Kunz, CSc, dr. h. c. *(since 1. 5. 2017)* (*Institute of Physics of Materials, Czech Academy of Sciences*)
Ing. Jan Osuský *(since 1. 5. 2017)*

| RESEARCH STAFF

Only people with an employment contract are shown, i.e. not all PhD students are listed (for a complete list of PhD students see below). Numerous fellows contracted on the basis of external grant funding have only part-time jobs (extent not shown here), often limited to short periods.

BRNO RESEARCH FACILITY

The research facilities in Brno include zoological collections, a breeding facility for experimental fish (including facilities for semi-natural experiments), a basic laboratory for molecular genetics studies, a parasitological and ichthyological laboratory and high-quality equipment for field research. Research teams at Brno use model vertebrate groups to study basic questions in the fields of ecology and evolutionary biology, ethology, applied zoology, the roles of parasites and invasive species and protection and management of freshwater and terrestrial ecosystems. The main topics studied include:

- reproductive strategies in fishes and birds;
- adaptation and coevolution between parasites and hosts (e.g. cuckoo vs. passerine birds; bitterling vs. bivalves);
- population biology, ecology and biogeography of annual fishes (e.g. *Nothobranchius*, *Cynolebias*);
- relationships between metazoan parasites and their hosts (fish, birds);
- fish communities and populations of key species in various aquatic habitats;
- invasive species in the aquatic environment;
- migration connectivity and seasonal interaction of long-distance migrants;
- ecology and behaviour of bats, especially during hibernation;
- population genetics and interspecies hybridisation in deer;
- ecology and conservation of carnivores in fragmented landscapes;
- food ecology of herbivorous mammals and their impact on the environment;
- diet and parasites of primates.

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Mgr. Jan Mendel, PhD
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Mgr. Jakub Kreisinger, PhD
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Mgr. Radka Poláková, PhD
Mgr. Michal Šulc, PhD
Mgr. Radomil Řežucha, PhD
Mgr. Milan Vrtílek, PhD
Ing. Lucie Všetičková, PhD

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Mgr. Kevin Roche, BSc, PhD
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Mgr. Veronika Nezhybová
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Mgr. Markéta Pravdová
Mgr. Tereza Prokopová

Doreen Schulz, MSc
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Mgr. Andrea Slaninová
Mgr. Luděk Šlapanský
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Mgr. Alena Zikmundová
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Mgr. Erik Bachorec

VALTICE RESEARCH FACILITY

The Valtice research facility is well equipped with both state-of-the-art molecular equipment and a modern animal rearing facility that fulfils all safety requirements needed for the handling of laboratory animals. Research is mainly focused on ecology and eco-epidemiology of zoonotic microorganisms, with a main emphasis on emerging and re-emerging pathogens. In particular, research focusses on the role of endotherm vertebrates (hosts to pathogenic agents) and haematophagous arthropods (biological vectors) in the circulation of zoonotic pathogens, along with the natural and socio-economic factors driving emergence of particular infections. The main issues addressed include:

- isolation and identification of novel microorganisms, including human pathogens (microbe hunting);
- ecology of arthropod-borne microorganisms (e.g. West Nile and tick-borne encephalitis flaviviruses, spirochaete *Borrelia burgdorferi*, rickettsiae *Anaplasma phagocytophilum*, the spotted fever group rickettsiae and *Babesia* spp. protozoa);
- implementing the 'one health' concept for studying emerging zoonoses;
- risk of introduction and establishment of new mosquito invasive vectors and mosquito-borne diseases into Central Europe;
- providing expert advice regarding prevention and control of zoonoses (contribution to preventive human and veterinary medicine);
- providing expert opinion on emerging infectious diseases.

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Ladislava Ševčíková

STUDENEC RESEARCH FACILITY

The Studenec research facility is a very dynamic part of the Institute that has evolved significantly over recent years. It houses modern, well equipped molecular-genetic, physiological and microscopic laboratories, a breeding facility for small mammals, birds and amphibians and facilities allowing experimentation under semi-natural conditions. Empirical data from observations, laboratory analysis and experiments (supplemented by simulation modelling) are used to investigate important evolutionary questions, mainly at the population level. Research activities are mostly fundamental but may have applications in biomedicine, species conservation and epidemiology. Examples of research topics (model organisms given in parentheses) include:

- hybrid zones as barriers against gene flow and their role in speciation (rodents, amphibians, reptiles);
- phylogeography, reconstruction of historical colonisation and mechanisms of biodiversity evolution (mainly African rodents and amphibians);

- study of factors affecting population structure, conservation genetics (fish, birds, rodents, carnivores);
- mating systems, analysis of reproductive success and factors affecting fitness (passerine birds);
- immunogenetics, links between adaptive genetic variation and fitness (rodents, passerine birds);
- host-parasite co-evolution, genetic variation in pathogens and their hosts (rodents, bats, pathogenic fungi, helminths, RNA-viruses);
- mechanisms and evolution of thermal physiology traits in ectotherms (newts);
- functional approaches in the study of morphological adaptation (amphibians and reptiles).

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Projects supported by the Czech Science Foundation (GA ČR)

GAP505/12/G112ECIP European Centre of Ichthyoparasitology. ***Recipient:*** Masaryk University in Brno. ***Principle Investigator:*** Milan Gelnar. ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Co-Investigator:*** Pavel Jurajda. ***Research years:*** 2012–2018.

GAP505/13/05872S The effects of non-native species on host-parasite relationships. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Martin Reichard. ***Research years:*** 2013–2017.

GAP505/13/06451S Linking events through the annual cycle: the importance of carry-over effects for the ecology of migratory birds. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Petr Procházka. ***Research years:*** 2013–2017.

GAP506/13/12580S Which mechanisms affect the diversity of clones and their coexistence with sexual species? European loaches of the genus Cobitis as a model. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Karel Halačka. ***Research years:*** 2013–2017.

GA15-05180S Genetic diversity and cross-transmissions of strongylid nematodes between African great apes and man. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Klára Petrželková. ***Research years:*** 2015–2017.

GA15-07140S Thermal niche: evaluation of current concepts in ectothermic vertebrates. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Lumír Gvoždík. ***Research years:*** 2015–2017.

GA15-11782S Biology of ageing: mechanisms and patterns of senescence in free-living birds. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Tomáš Albrecht. ***Research years:*** 2015–2017.

GA15-13265S High resolution genomic analysis of introgression across a species barrier. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Stuart J. E. Baird. ***Research years:*** 2015–2017.

GJ15-13415Y Amphibian species diversification across sky-island and lowland rainforests in a spatial and ecological context: genome-wide and continental transect. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Václav Gvoždík. ***Research years:*** 2015–2017.

GA15-20229S Evolution of rodents and their parasites in open habitats of East Africa. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Josef Bryja. ***Research years:*** 2015–2017.

GA16-00291S Ageing in the wild: from demography to gene expression. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Martin Reichard. ***Research years:*** 2016–2018.

GA16-20049S Hybrid zones: natural laboratories for the study of pathogen emergence. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Joëlle Goüy de Bellocq. ***Research years:*** 2016–2018.

GA16-20054S Advanced studies on West Nile virus infection pathogenesis towards novel therapeutic strategies. ***Recipient:*** Institute of Organic Chemistry and Biochemistry, Czech Academy

of Sciences. ***Principle Investigator:*** Radim Nencka. ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Co-Investigator:*** Zdeněk Hubálek. ***Research years:*** 2016–2018.

GA16-23773S Phylogeography, selection and mutation rate at the genomic level: Inference from mtDNA sequences of the house mouse. ***Recipient:*** Institute of Animal Physiology and Genetics, Czech Academy of Sciences, Brno. ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Miloš Macholán. ***Principle Co-Investigator:*** Jaroslav Piálek. ***Research years:*** 2016–2018.

GA16-26714S Genomic dissection of barriers to gene flow in hybridising fire-bellied toads. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Beate Nürnberger. ***Research years:*** 2016–2018.

GA17-15480S Freshwater ectotherms under climate change: the role of phenotypic plasticity in life histories and trophic interactions. ***Recipient:*** University of South Bohemia in České Budějovice. ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** David Boukal. ***Principle Co-Investigator:*** Lumír Gvoždík. ***Research years:*** 2017–2019.

GA17-09807S Why and how animals abandon sex? On the causal role of hrybridization in triggering asexual reproduction. ***Recipient:*** Institute of Animal Physiology and Genetics, Czech Academy of Sciences, Brno. ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Karel Janko. ***Principle Co-Investigator:*** Karel Halačka. ***Research years:*** 2017–2019.

GA17-04364S The role of Prdm9 allelic variations and activity in hybrid sterility in mice. ***Recipient:*** Institute of Molecular Genetics, Czech Academy of Sciences. ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Emil Parvanov. ***Principle Co-Investigator:*** Jaroslav Piálek. ***Research years:*** 2017–2019.

GA17-20284S Physiology of bat hibernation with respect to multistressor impacts. ***Recipient:*** University of Veterinary and Pharmaceutical Sciences, Brno. ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Jiří Pikula ***Principle Co-Investigator:*** Natália Martínková. ***Research years:*** 2017–2019.

GA17-12262S Reproductive strategies of an obligate brood parasite: host selection, offspring sex allocation and individual success. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Marcel Honza. ***Research years:*** 2017–2019.

GA17-24782S Latitudinal and altitudinal patterns in avian pace-of-life syndromes: a study of Afrotropical and European songbirds. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Tomáš Albrecht. ***Research years:*** 2017–2019.

GA17-25320S Genotypes and phenotypes associated with Y chromosome introgression in the European house mouse hybrid zone: comparison among transects. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Stuart J. E. Baird. ***Research years:*** 2017–2019.

GA18-14325S The genetic basis of species origin: What can we learn from organisms with female heterogamety? ***Recipient:*** Charles University in Prague. ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Radka Reifová. ***Principle Co-Investigator:*** Tomáš Albrecht. ***Research years:*** 2018–2020.

GA18-17398S Evolution at steep elevational gradients: assessing the role of genetic and ecological factors in speciation processes. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Josef Bryja. ***Research years:*** 2017–2019.

GA 18-19629S Comparative parasite hybridisation genomics controlling for host divergence. ***Recipient:*** Institute of Vertebrate Biology, Czech

Academy of Sciences, Brno. ***Principle Investigator:*** Joëlle Goüy de Bellocq. ***Research years:*** 2017–2019.

GA18-24544S Genomic insights into the evolutionary history and contact zones of slow-worm lizards (Anguis). ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Vašk Gvoždík. ***Research years:*** 2017–2019.

GA18-17796Y Consequences of vertebrate microbiota changes due to symbiotic associations with humans. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Jakub Kreisinger. ***Research years:*** 2017–2019.

GA18-24345S Epidemiology and pathological effects of gastrointestinal helminthiases in critically endangered mountain gorillas. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Klára Petrželková. ***Research years:*** 2017–2019.

GA18-26284S Embryo and environment – annual fish as a unique model to study embryo ecology. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Matej Polačik. ***Research years:*** 2017–2019.

GA18-00682S A novel system to understand brood parasitism: the cuckoo catfish parasiting African cichlids. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Martin Reichard. ***Research years:*** 2017–2019.

Projects supported by the Technology Agency of the Czech Republic (TA ČR)

TG03010048 Commercialization of results of zoological research – applications for nature conservation. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Jan Zukal. ***Research years:*** 2016–2019.

Projects supported by the Ministry of Agriculture of the Czech Republic

QJ1510077 Increasing and more efficient production of salmonids in the Czech Republic using their genetic identification. ***Recipient:*** Mendel University in Brno, ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Jan Mareš. ***Principle Co-Investigator:*** Karel Halačka. ***Research years:*** 2015–2018.

QJ1620240 Application of "top-down" biomanipulation to reduce eutrophication caused by agriculture in reservoirs. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Karel Halačka. ***Research years:*** 2016–2018.

Projects supported by the Ministry of Education, Youth and Sport of the Czech Republic

OP VVV MEZEK International collaboration in ecological and evolutionary biology of Vertebrates. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Josef Bryja. ***Research years:*** 2018–2020.

International projects

KONTAKT II LH15175 Functional interaction between host gene regulation and the microbiome in the primate gut. ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Klára Petrželková. ***Research years:*** 2015–2017. ***Managed by:*** The Ministry of Education, Youth and Sport of the Czech Republic.

VectorNet European network for sharing data on the geographic distribution of arthropod vectors transmitting human and animal disease agents. ***Principle Investigator for the Czech Republic:*** Zdeněk Hubálek. ***Research years:*** 2015–2017.

African and Central European Vertebrates: Discoverability of Genomic Samples Located at the Institute of Vertebrate Biology. Provider: GGBN/GGI Award Programme (Global Genome Biodiversity Network/Global Genome Initiative). ***Recipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator:*** Petra Hájková. ***Research years:*** 2017–2018.

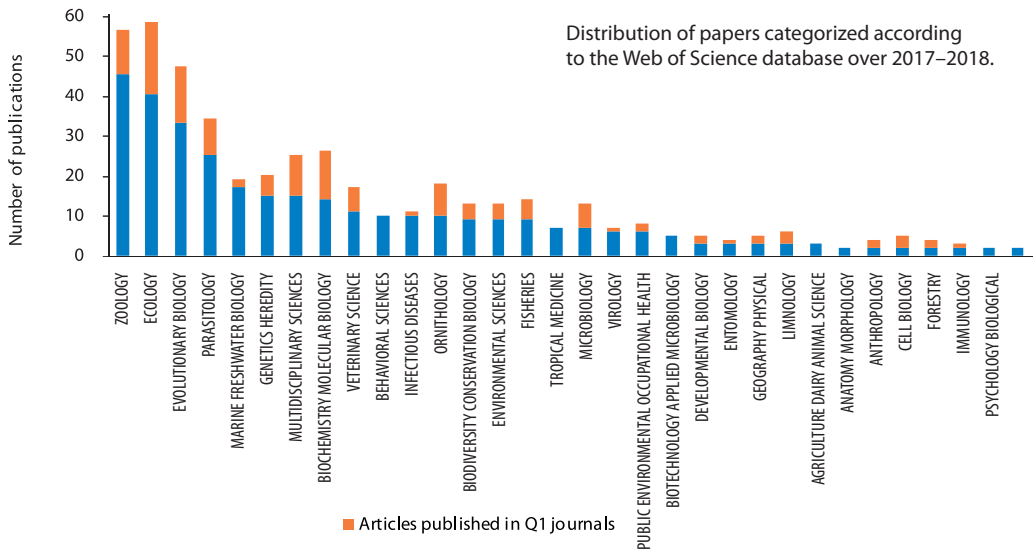
Interreg V-A SK-CZ Coordination of the management of Eurasian lynx and grey wolf populations in the Western Carpathians. ***Recipient:*** State Nature Conservancy of the Slovak Republic. ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator for the Czech Republic:*** Jarmila Krojerová-Prokešová. ***Research years:*** 2017–2019.

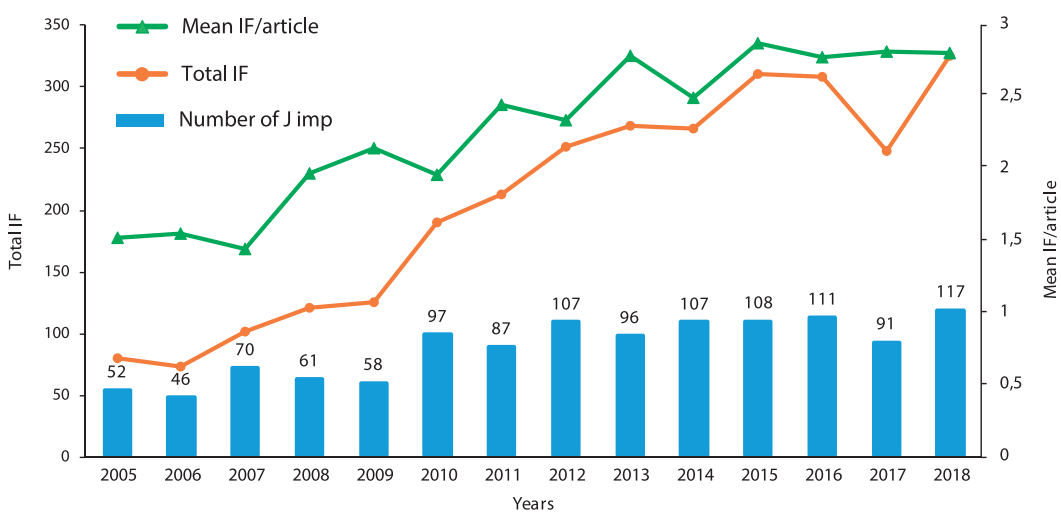
ATHENE – Care for the largest residual populations of the European Owl. ***Recipient:*** Czech Society for Ornithology. ***Subrecipient:*** Institute of Vertebrate Biology, Czech Academy of Sciences, Brno. ***Principle Investigator at IVB:*** Martin Šálek. ***Research years:*** 2014–2020. The ATHENE project is part of the Czech Republic – Free State of Saxony 2014–2020 cross-border Cooperation Program. This project is supported by the European Union under the European Regional Development Fund.

3. SCIENTIFIC RESULTS

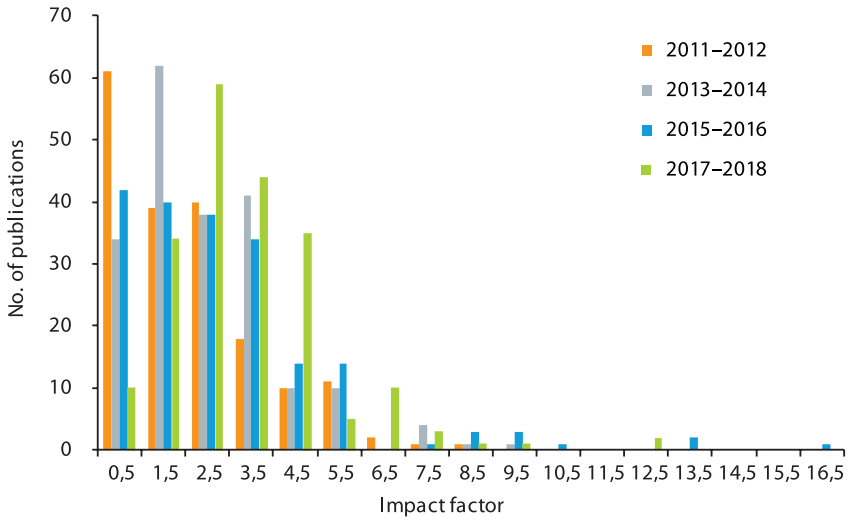
| SUMMARY OF PUBLICATION OUTPUT

Researchers at the IVB produced numerous scientific publications over 2017–2018, mainly in the form of research articles in international peer-reviewed journals. The publication profile and main scientometric criteria are shown below.

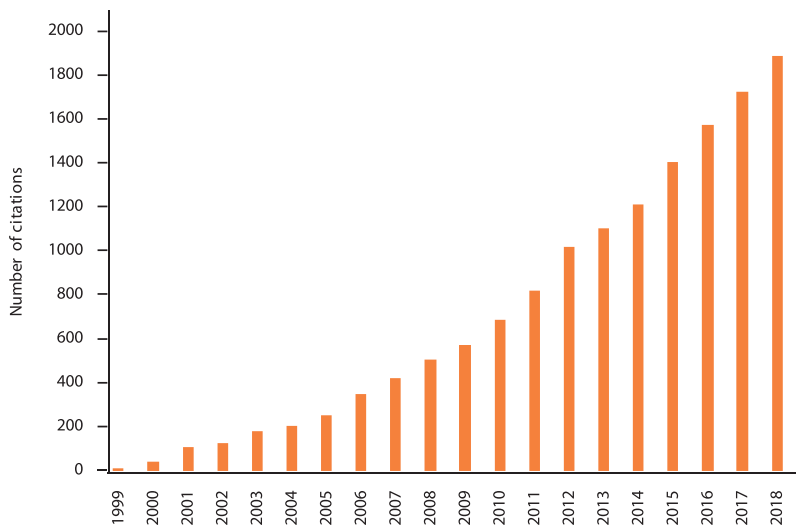




The IF values of papers published over the last two years confirm the increasingly high quality of IVB publications (source: ASEP Database, Czech Academy of Sciences).



The distribution of article impact factors once again shifted toward higher values over 2017–2018.



Citations of IVB papers over the last two years again confirm the increasing trend seen in previous years (note that the Institute of Vertebrate Biology was founded in 1998).

RESEARCH HIGHLIGHTS

Many significant results and findings were published over 2017–2018. Although we provide a complete list of publication produced over that period, we believe that some of the results are so significant that they deserve special attention or emphasis and we have highlighted some of these below.

Species thermal requirements are key to our understanding of both species distribution and the

impact of climate change on population dynamics. In the review "Just what is the thermal niche?", Lumír Gvoždík (*Oikos* 127 (2018): 1701–1710) shows that understanding of this term in the current scientific literature is highly variable, which complicates interdisciplinary communication. Accordingly, Gvoždík proposed a new conceptual framework that should unify our understanding of this ecological term.

The team led by Martin Reichard studies the Annual killifish (genus *Nothobranchius*), which have developed adaptions allowing them to complete their life cycle in temporary pools of the African savanna. In a series of publications (Vrtílek et al. *Current Biology* 28 (2018): R822-R824, *Scientific Reports* 8 (2018): 4774, *Science of Nature* 105 (2018): 68), it was shown that wild killifish reach sexual maturity in just two weeks, and often have complete life cycles representing a condensed version of typical vertebrate ontogeny and lasting just two months.

Brood parasitism in birds (a reproductive strategy in which obligate brood parasites relinquish parental care to host species) has been a traditional research theme at the IVB since 1992. Recently, Radim Blažek published results on a unique fish brood parasite, the Cuckoo catfish, which parasitises African cichlids (Blažek et al. *Science Advances* 4 (2018): eaar4380). In this seminal paper, Blažek demonstrated that the host's ability to resist catfish parasitism depends on both its evolutionary history of coexistence with the parasite and individual experience.

Research in Tanzania. Joëlle Goüy de Bellocq is taking samples of blood from *Mastomys natalensis*.

(*Photo by S. Gryseels*)

Joëlle Goüy de Beloque and colleagues (Gryseels et al. *Plos Pathogen* 13 (2017): e100673) studied the role of host genetic background on distribution of particular arenaviruses (they include e.g. Lassa virus, highly pathogenic for human). Genetic analyses of multimammate mice *Mastomys natalensis* showed that each region has its own mice and that the regional borders appear sharp. They studied one such contact zone in Tanzania and showed that the mice on either side carry different members of the viral family, which appear unable to cross the boundary. This pattern would explain why Lassa is limited to western Africa.

The so-called reticulate evolution combines divergence and hybridisation. For example, if a species wants to colonise a higher elevation, it may be advantageous to receive mitochondrial DNA already adapted to environments with low oxygen concentrations. Josef Bryja and colleagues (Bryja et al. *Molecular Phylogenetics and Evolution* 118 (2018): 75–87), working on endemic rodents in the Ethiopian mountains, recently discovered that Afroalpine ecosystems spread down to lower elevations in the colder Pleistocene period, allowing specialised taxa to cross the Rift valley. Once on the opposite side, they hybridised with local species, facilitating their colonisation of mountains at higher elevations.

In a series of papers (Forstmeier et al. *Journal of Evolutionary Biology* 30 (2017): 968–976, Knief et al. *Nature Ecology & Evolution* 1 (2017): 1177–1184, Tomášek et al. *Proc. R. Soc. B Biological Sciences* 284 (2017): 20162444), our researchers detected a unique mechanism (Z chromosome inversion) responsible for the maintenance of sub-optimal sperm phenotypes in zebra finch populations, small passerines displaying lifelong social monogamy. They further showed that only heterozygous males (carrying just one copy of the inversion) produce "super sperm" and these have the highest fertilisation success. Furthermore, they identified factors that reduce (inbreeding, oxidative stress) and enhance (carotenoid supplementation) sperm quality in zebra finches. More information regarding these interesting findings (and many others) can be found below in Section 6 SELECTED SCIENTIFIC ACHIEVEMENTS.

Geographical distribution of selected research activities

BULGARIA (*Photo by I. Rudolf*)

SLOVAKIA (*Photo by J. Ksiažek*)

RUSSIA (*Photo by N. Martínková*)

BRAZIL (*Photo by M. Reichard*)

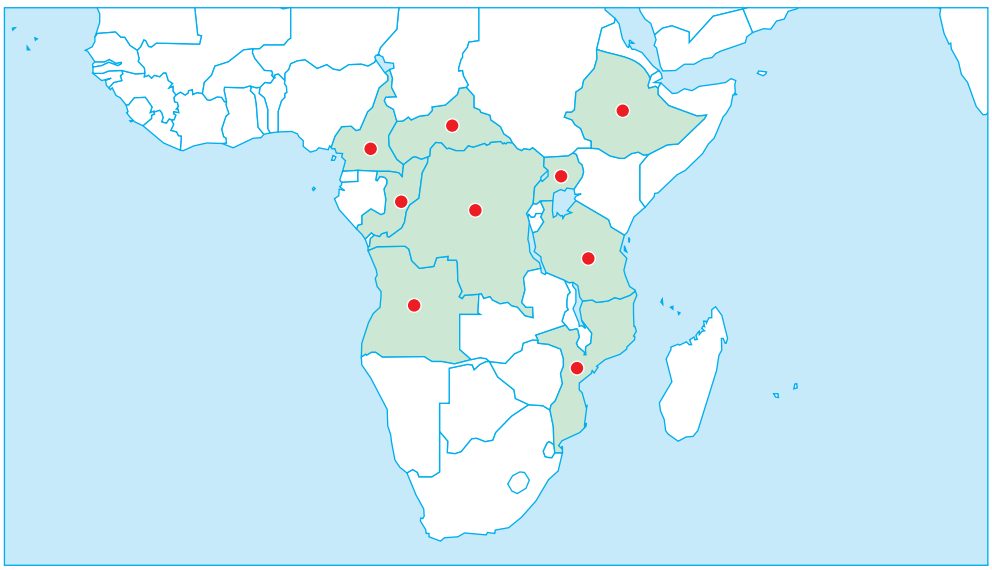
URUGUAY (*Photo by M. Reichard*)

CHINA (*Photo by M. Reichard*)

CAMEROON
(*Photo by V. Gvoždík*)

REPUBLIC OF THE CONGO
(*Photo by V. Gvoždík*)

CENTRAL AFRICAN REPUBLIC
(*Photo by D. Modrý*)

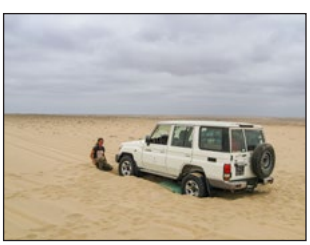


DR OF THE CONGO
(*Photo by V. Gvoždík*)

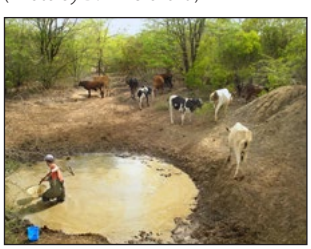
UGANDA
(*Photo by M. McLennan*)

ETHIOPIA
(*Photo by D. Mizerovská*)

TANZANIA (*Photo by S. Gryseels*)



ANGOLA (*Photo by J. Krásová*)



MOZAMBIQUE (*Photo by M. Polačik*)

Geographic distribution of the most important international cooperation activities

Complete list of publications

Books, textbooks, edited proceedings

BRYJA J, HORSÁK M, HORSÁKOVÁ V, ŘEHÁK Z, ZUKAL J (eds), 2017. *Zoologické dny Brno 2017*. ÚBO AV ČR, Brno, 254 pp. ISBN 978-80-87189-21-4.

BRYJA J, SOLSKÝ M (eds), 2018. *Zoologické dny Praha 2018*. ÚBO AV ČR, Brno, 283 pp. ISBN 978-80-87189-24-5.

BALLA M, ČAPEK M, DANKO Š, FULÍN M, CHRAŠČ P, KLOUBEC B, LITERÁK I, MOŠANSKÝ L, PAČENOVSKÝ S, PEŠKE L, REPEL M, ŠIMKOVÁ A, VYHNAL S, 2017. *Vtáctvo slovenskej časti Medzibodrožia*. Slovenská ornitologická spoločnosť/ BirdLife Slovensko, Bratislava, 505 pp. ISBN 978-80-89526-17-8.

MODRÝ D, PAFČO B, PETRŽELKOVÁ KJ, HASEGAWA H (eds), 2018. *Parasites of apes: an atlas of coproscopic diagnostics*. Chimaira, Frankfurt am Main, 198 pp. Frankfurter Beiträge zur Naturkunde 78. ISBN 978-3-89973-116-3.

Book chapters

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ALBRECHT T, 2017. Sperm competition – Evidence in nonhumans. In Shackelford TK, Weekes-Shackelford VA (eds). *Encyclopedia of Evolutionary Psychological Science*. Springer, Cham: 1-4. ISBN 978-3-319-16999-6.

HONZA M, CHERRY MI, 2017. Egg characteristics affecting egg rejection. In Soler M (ed.). *Avian brood parasitism*. Springer, Cham: 401-419. Fascinating life sciences. ISBN 978-3-319-73137-7.

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ZUKAL J, BERKOVÁ H, BANĎOUCHOVÁ H, KOVÁČOVÁ V, PIKULA J, 2017. Bats and caves: activity and ecology of bats wintering in caves. In Karabulut S, Cinku MC (eds). *Cave investigation*. InTech, Rijeka: 51-75. ISBN 978-953-51-3331-5.

Papers in journals included in the Web of Science Database

AGHOVÁ T, KIMURA Y, BRYJA J, DOBIGNY G, GRANJON L, KERGOAT GJ, 2018. Fossils know it best: Using a new set of fossil calibrations to improve the temporal phylogenetic framework of murid rodents (Rodentia: Muridae). *Molecular Phylogenetics and Evolution* 128: 98-111.

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BLAŽEJOVÁ H, ŠEBESTA O, RETTICH F, MENDEL J, ČABANOVÁ V, MITERPÁKOVÁ M, BETÁŠOVÁ L, PEŠKO J, HUBÁLEK Z, KAMPEN H, RUDOLF I, 2018. Cryptic species *Anopheles daciae* (Diptera: Culicidae) found in the Czech Republic and Slovakia. *Parasitology Research* 117: 315-321.

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| SELECTED SCIENTIFIC ACHIEVEMENTS

Evolutionary Ecology

Biodiversity

Parasites and diseases

Evolutionary Ecology

Photo by R. Blažek

EVOLUTIONARY ECOLOGY

Extremely rapid life history of African annual killifish

From the moment they leave the egg, annual killifish live their lives at incredible speed. African annual killifish are found in freshly inundated pools that form across the African savannah at the peak of the rainy season, most of which will dry out again in three to four weeks, killing all the fish. During our research on demography and ageing of wild killifish populations, we found that killifish hatch, grow, reach sexual maturity and reproduce in just two weeks.

In other pools, rainwater may remain for much longer, with some pools containing water for over four months. Indeed, pools in wetter coastal areas of Mozambique predictably have water for much longer than those in the dry interior regions. We examined four annual killifish species, whose natural distribution includes both wet and dry regions, to assess whether different populations of the same species have evolved different life history optima.

We discovered that killifish from dry regions live shorter lives, and that this is also observed under laboratory conditions without the risk of habitat desiccation. Shorter-lived populations also aged more sharply, experiencing more rapid and steeper physiological deterioration than longer lived populations. Unexpectedly, this rapid ageing was not mirrored by faster growth and sexual maturation, or in a stronger investment into reproduction. Further, long- and short-lived populations did not differ in their so-called "pace-of-life" as neither metabolic activity nor behaviour differed, perhaps being optimised at some other level than between populations. Overall, we demonstrated that inter-population variability in African annual killifish lifespan and ageing is genetically correlated and strongly affected by natural selection.

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17-18-day-old African annual killifish.
(*Photo by M. Vrtílek*)

A temporary pool in Mozambique, typical habitat of African annual killifish.
(*Photo by M. Vrtílek*)

Embryo adaptations to seasonal and unpredictable habitat in the African annual killifish

A peculiar group of annual fish has adapted to life in small savannah pools that dry out annually. The fish produce drought-resistant eggs that persist in the desiccated pool substrate over the dry season, and hatch as soon as the pool fills with rainwater. However, it sometimes happens that the first rains of the season are not heavy enough to keep the pools full long enough for fish to grow, mature and reproduce.

We studied adaptations and strategies displayed by the eggs during their embryonic development to cope with such situations. In the wild, the egg hatch coincides with peak rainfall during the rainy season, with temporal and spatial synchronisation apparently following the geographic rainfall pattern. The fish typically hatch synchronously, but occasionally both protracted hatching and multiple age cohorts may also occur. Under laboratory conditions, we documented a strong bet-hedging strategy in the egg bank, with some eggs developing to the pre-hatching stage in just three weeks, while others took many months to reach the pre-hatching stage. Weak rainfall (which may be followed by rapid desiccation) prompts hatching in a fraction of the eggs while others remain in diapause (a resting stage). Duration of embryonic development appears to be under maternal control as, during her life, a female initially produces fast-developing eggs and switches to production of slow-developing eggs later. This is an adaptive process as pools occasionally become desiccated but may be re-inundated during the rainy season. When this happens, the fast-developing eggs can give rise to the next generation of fish within the same rainy season. In contrast, slow-developing eggs are intended to enter diapause and remain like this throughout the dry season. Since energy consumption is kept to a minimum during diapause, duration of development is de-coupled from the amount of energetic reserve provided to the egg by the mother. Despite huge variation in the duration of embryonic development, larger eggs always produce larger juveniles. Over the killifish range, duration and predictability of pool inundation varies along a gradient; nevertheless, we found a similar degree of developmental asynchrony across all areas examined. Further, fish from more arid regions (where pools often desiccate during the rainy season) produced more eggs with short embryo developmental times, thereby enhancing the chances of hatching a second generation within a single season. Our results suggest that evolution of African annual fish embryonic development has been remarkably fine-tuned to the hostile and unpredictable environment of temporary pools.

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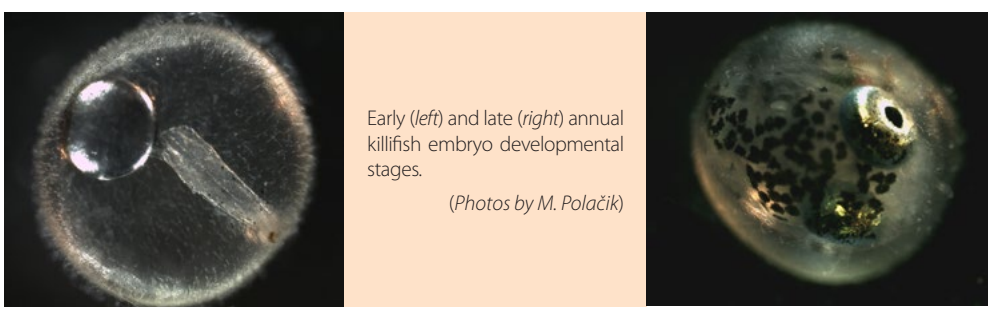

Early (*left*) and late (*right*) annual killifish embryo developmental stages.

(*Photos by M. Polačik*)

Coevolution between a brood parasite and its hosts: parasite growth, begging behaviour and rearing costs imposed on hosts

Growth is a key life history trait related to individual fitness. We studied sex differences in the growth of common cuckoo (*Cuculus canorus*) nestlings reared by two warbler hosts (genus *Acrocephalus)* and found that both sexes exhibited similar mass after hatching and grew at a similar rate. Nevertheless, males achieved ~10% higher asymptotic mass than females, while fledging at a similar age as females. These findings imply that male nestlings may have higher needs than female nestlings. Moreover, parasite chicks can fool their foster parents into increased provisioning using various begging strategies. Apart from the normal begging vocalisation produced during host feeding visits, common cuckoo nestlings use a different type of vocalisation in the absence of their foster parents. Our study confirmed experimentally, for the first time, that host-absent vocalisation of a parasitic chick may be interpreted by foster parents as a signal of hunger, thereby increasing host feeding frequency.

Great Reed Warblers (*Acrocephalus arundinaceus*) feeding a young parasitic chick.

(*Photo by M. Honza*)

The fundamental brood parasite-host coevolutionary paradigm assumes that host care for the parasite is dramatically more costly than care for host's own progeny. We quantified parasite-rearing costs in common redstarts (*Phoenicurus phoenicurus)* raising either common cuckoo or their own chicks throughout the complete breeding cycle using multiple cost parameters, including incubation, brooding and feeding effort; length of parental/host care; parent/host body condition and heterophil/lymphocyte ratio as a stress-level indicator. Contrary to traditional assumptions, rearing the much larger parasite was not associated with an overall increase in physiological or physical costs to the host but was similarly demanding as rearing its own brood.

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Brood parasitism in fishes: African cuckoo catfish parasitizing mouthbrooding cichlids

Brood parasitism is a reproductive strategy whereby parents pass all their care for the offspring onto other hosts, i.e. individuals that act as foster parents for the parasitic offspring. This represents a special case of host-parasite relationship and is not uncommon between parents of the same species, occurring under a variety of possible scenarios. In contrast, brood parasitism between parents of different species is rare. The strategy has evolved in birds and social insects (ants, bees, wasps and some beetles), where it is termed social parasitism. Most of what we know about brood parasitism

comes from studies on birds, where interspecific brood parasitism has evolved seven times with over 100 parasitic species.

Recently, we began studying brood parasitism in a unique system, i.e. cuckoo catfish parasitising mouth-brooding cichlid fishes in Lake Tanganyika. Mouth-brooding cichlids incubate their offspring in the mother's buccal cavity, a widespread parental care strategy in Lake Tanganyika and other African lakes. The cuckoo catfish intrudes on a cichlid spawning event and lays its own eggs, which are mistakenly taken by the female cichlid for incubation. The cuckoo catfish hatches quickly inside the host's mouth and immediately starts to feed on its step-siblings (the host's own offspring). After 3–4 weeks, the parasitised female releases a clutch of juveniles from which her own progeny has often been entirely eliminated.

We conducted the first experimental study on cuckoo catfish ever, using a unique technique that combines *in vitro* production of parasitic offspring and experimental parasitism. We found that while host cichlids can defend against parasitism, their ability to defend varies due to a shared evolutionary history between the parasitic catfish and host cichlid. Mouth-brooding cichlid species naturally coexisting with cuckoo catfish in Lake Tanganyika can minimise the cost of parasitism by selective ejection of parasitic eggs. They also learn to deal with the parasite, with females that have experienced parasitism in the past being more successful at defending themselves the next time. In contrast,

The cuckoo catfish and its cichlid host. Top left: a 7-day-old cuckoo catfish embryo; top right: a juvenile cuckoo catfish; bottom: *Simochromis diagramma* from Lake Tanganyika, a common host of the cuckoo catfish.

(*Photos by Y. Wenjing (top left)* and R. Blažek)

cichlid species from other African lakes (where they naturally do not coexist with cuckoo catfish) are unable to defend against parasitism, and are unable to learn from previous experience of incubation failure. Nevertheless, such defensive behaviour can be costly. Cichlids from Lake Tanganyika, for example, sometimes mistakenly eject their own offspring, while this seldom happens to cichlids that lack antiparasitic defence abilities. It appears that parasite abundance is the critical factor that determines whether it is better to resist or tolerate the parasite.

BLAŽEK R, POLAČIK M, SMITH C, HONZA M, MEYER A, **REICHARD M**, 2018. Success of cuckoo catfish brood parasitism reflects coevolutionary history and individual experience of their cichlid hosts. *Science Advances* 4: eaar4380.

Post-copulatory sexual selection and sperm phenotypes in songbirds

In addition to choosing her social mate, females in socially monogamous birds frequently engage in extra-pair copulations outside their pair bonds. This exposes male gametes (sperm cells) to competition as gametes of more than one male often occur simultaneously in the female reproductive tract, and only one sperm can fertilise the ova. Surprisingly little is known about factors affecting sperm fertilisation capacity and male fertility in vertebrates, and in birds in particular.

We focused on two model songbird species, the zebra finch (*Taeniopygia guttata*) and collared flycatcher (*Ficedula albicollis*), to explore associations between sperm (ejaculate) quality, male ornamentation and male fertilisation success. While we found little evidence for a link between sperm traits and male fertilisation success in collared flycatchers, partner fertility may determine female lifetime reproductive success in zebra finches, where males and females form a life-long partnership and never change social partners. We showed that male ornamentation (carotenoid-based red beaks in zebra finch males) serves as a signal of sperm quality. Careful experiments manipulating oxidative stress and carotenoid intake in males revealed that investment in this 'male showiness' is traded-off against sperm resistance to oxidative challenge. More intense beak colouration predicted an increase in sperm velocity under controlled conditions but a decline under oxidative challenge. Interestingly, we confirmed an *in vivo* antioxidant capacity of carotenoids, as simultaneous carotenoid supplementation resulted in fewer sperm abnormalities and high quality ejaculates.

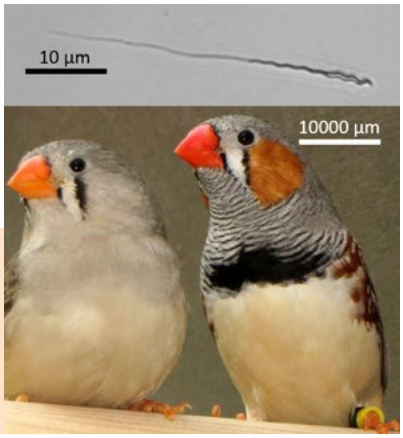
In another study, we demonstrated that inbreeding, resulting from close relatives breeding and producing homozygous offspring, has a negative effect on zebra finch sperm quality, resulting specifically in a higher proportion of abnormal sperm in the ejaculate. Interestingly, inbreeding also affected beak colouration. Taken together, this appears to show that male beak colouration could provide information on the quality of a males ejaculate to choosing females. Finally, our research revealed that there is yet another, and so far unexplored, mechanism associated with quality of ejaculate and male fertilisation success in zebra finches. Nearly half of the variance in sperm morphology in this species is explained by an inversion on the sex Z chromosome (males are ZZ and females ZW in birds). The sperm of males that are heterozygous for the inversion (ZZ*) have the longest mid-pieces and the highest velocity (so-called 'super sperm'). Furthermore, such males achieve highest fertility and highest siring success, both within-pair and extra-pair. In contrast, males homozygous for the derived allele (Z*Z*) show detrimental sperm characteristics and the lowest siring success. Our results suggest that heterozygote advantage as the mechanism that maintains inversion polymorphism, and hence variance in sperm design and fitness in zebra finches.

EDME A, ZOBAČ P, **OPATOVÁ P**, ŠPLÍCHALOVÁ P, MUNCLINGER P, **ALBRECHT T**, KRIST M, 2017. Do ornaments, arrival date, and sperm size influence mating and paternitz success in the collared flycatcher? *Behavioral Ecology and Sociobiology* 71:3.

FORSTMEIER W, IHLE M, **OPATOVÁ P**, MARTIN K, KNIEF U, **ALBRECHTOVÁ J**, **ALBRECHT T**, KEMPENAERS B, 2017. Testing the phenotype-linked fertility hypothesis in the presence and absence of inbreeding. *Journal of Evolutionary Biology* 30: 968–976.

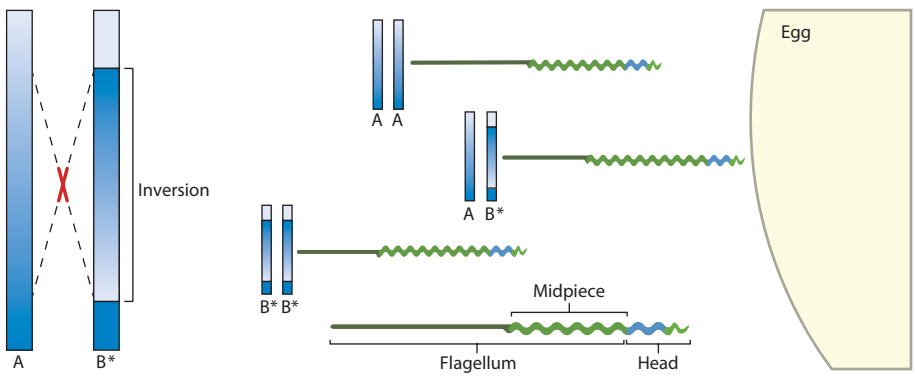
KNIEF U, FORSTMEIER W, PEI Y, IHLE M, WANG D, MARTIN K, **OPATOVÁ P**, **ALBRECHTOVÁ J**, WITTIG M, FRANKE A, **ALBRECHT T**, KEMPENAERS B, 2017. A sex-chromosome inversion causes strong overdominance for sperm traits that affect siring success. *Nature Ecology & Evolution,* 1: 1177–1184.

TOMÁŠEK O, **ALBRECHTOVÁ J**, NĚMCOVÁ M, **OPATOVÁ P**, **ALBRECHT T**, 2017. Trade-off between carotenoid-based sexual ornamentation and sperm resistance to oxidative challenge. *Proceedings of the Royal Society B – Biological Sciences* 284: 20162444.



Zebra finch sperm cell (*top*) and zebra finch female (*left*) and male (*right*). Sperm traits, such as length or speed, are important post-copulatory determinants of male reproductive success, whereas male beak colouration (*redness*) is associated with male attractiveness.

(*Photos by J. Albrechtová and O. Kauzál*)



In zebra finches, a large inverted region on the Z chromosome restricts genetic recombination and allows suites of mutations on different genes within the region to accumulate. Heterozygous males (*AB* on the picture*) produce the most successful sperm, also known as 'super sperm'.

(*from: Fisher SH (2017*). Supergene yields super sperm, *Nature Ecology & Evolution* 1: 1064).

Mate choice for genetic complementarity in grey partridges

Our view on bird mating systems has changed over recent decades with the advent of novel molecular methods to determine paternity. It is now apparent that sexual monogamy is an extremely rare system in otherwise socially monogamous birds. In most avian species studied to date, females are to some extent polyandrous, i.e. they mate with more than one male and extra-pair males are often of higher quality than within-pair partners. The grey partridge (*Perdix perdix*), in contrast, is one of just a few avian species for which genetic polyandry has never been documented, i.e. males and females form pairs but females do not cheat on the males. In order to ascertain how this "puritan"

avian species chooses its partners, we assessed genetic mechanisms of mate choice and social pair forming. Sexual selection has been hypothesised as favouring mate choice resulting in production of viable offspring with genotypes providing high pathogen resistance. Specific pathogen recognition is mediated by genes of the major histocompatibility complex (MHC) encoding proteins fundamental for adaptive immune response in jawed vertebrates. MHC genes are known to be involved in mate choice in a number of species, with "good genes" (absolute criteria, where certain males are bearers of beneficial alleles and are attractive to most females in the population) and "genetic complementarity" (self-referential criteria, where mate attractiveness is determined by the fit of each partner's genome allowing the most viable offspring to be produced) being used to explain MHC-based mating. Using pair formation data from a radio-tracked population, we found no evidence for absolute mate choice criteria in grey partridges; rather, mate choice at the MHC level was based on self-referential criteria as females preferentially paired with more MHC-dissimilar males. Our study thus provided one of the first pieces of evidence for MHC-based mate choice for genetic complementarity in a strictly monogamous bird.

RYMEŠOVÁ D, **KRÁLOVÁ T, PROMEROVÁ M, BRYJA J, TOMÁŠEK O,** SVOBODOVÁ J, ŠMILAUER P, ŠÁLEK M, **ALBRECHT T,** 2017. Mate choice for major histocompatibility complex complementarity in a strictly monogamous bird, the grey partridge (*Perdix perdix*). *Frontiers in Zoology* 14: 9.

The grey partridge (*Perdix perdix*), a strictly monogamous galliform.

(*Photo by M. E. Šálek*)

Bitterling fish ejaculate acts as olfactory sexual ornament

Chemical signals are a frequent component of mating systems, acting as pheromones to attract the opposite sex and signalling an individual's dominance, health status, genetic constitution or parasite burden. In fishes, olfactory signals elicit specific responses to other individuals and play a key role in courtship and mating. While we know that pheromones are involved in mate choice decisions, many aspects of this form of signalling are poorly understood, including signalling behaviour and signal structure.

One mechanism by which odour cues mediate mating preference in vertebrates is through the influence of an individual's major histocompatibility complex (MHC) genotype. The MHC is a family of highly polymorphic genes that play a key role in resistance to infectious diseases. MHC polymorphism generates a specific odour signature, which is perceived by potential mates and affects their mating decisions. While our previous work on rose bitterling (*Rhodeus ocellatus*) reproductive behaviour demonstrated that female mate preferences are

affected by MHC structure, with females preferring MHC-dissimilar mates, it is still not known how female bitterling recognise MHC compatibility in potential mates.

We first showed that female oviposition was positively stimulated by olfactory cues delivered in the form of male sperm solution. We then confirmed that females mated more often with MHC-dissimilar males and increased the probability of oviposition at high male ejaculation rate. Finally, we demonstrated that female mate choice decisions were adaptive, with embryo survival being greater when females mated with MHC-dissimilar partners. These results support a non-additive genetic basis to the rose bitterling mating system. We propose that sperm acts as a releaser pheromone in bitterling, functioning as a sexual ornament signalling male quality as a mate.

SMITH C, SPENCE R, **REICHARD M**, 2018. Sperm is a sexual ornament in rose bitterling. *Journal of Evolutionary Biology* 31: 1610–1622.

Male Chinese rose bitterling (*Rhodeus ocellatus*).
(*Photo by M. Reichard*)

What is the thermal niche? Conceptual and empirical approaches

The term "thermal niche" is frequently used in ecology. While the use of "thermal niche" has increased notably over the last 15 years, its meaning differs between studies. We present a new conceptual unification model for the term based on the proposition that the choice of commonly used thermal physiology traits for indirect thermal niche estimates depends on behavioural ability to buffer variation in thermal environments, during periods of both activity and inactivity (diel or seasonal). The resulting body temperature distribution determines the relative importance of key thermal physiology traits, thermal tolerance, thermal preferenda and temperature dependence of metabolic rate. This framework provides a guide for using the term 'thermal niche' in ecological literature and identifies key areas for further research.

Empirical results support the importance of thermoregulatory behaviour for thermal niche estimation, even in thermally-challenging aquatic environments. Competing amphibian taxa, used as a model system, varied in the effectiveness of their behavioural thermoregulation and thermal requirements, corresponding to differences in their habitat use. Using an optimality approach, indirect thermal requirement estimates produced similar results to those based on thermal dependence of factorial aerobic scope. Species interactions induced acute, rather than developmental, plastic responses in behavioural thermoregulation, suggesting stability of species thermal requirements within ecological communities. These results (i) clarify the meaning of thermal niche, which is a central concept across various ecological sub-disciplines; (ii) contribute to our understanding of interspecific competition among amphibian larvae; and (iii) help predict the impact of habitat destruction and climate change on populations of these threatened vertebrates.

GVOŽDÍK L, KRISTÍN P, 2017. Economic thermoregulatory response explains mismatch between thermal physiology and behaviour in newts. *Journal of Experimental Biology* 220: 1106–1111.

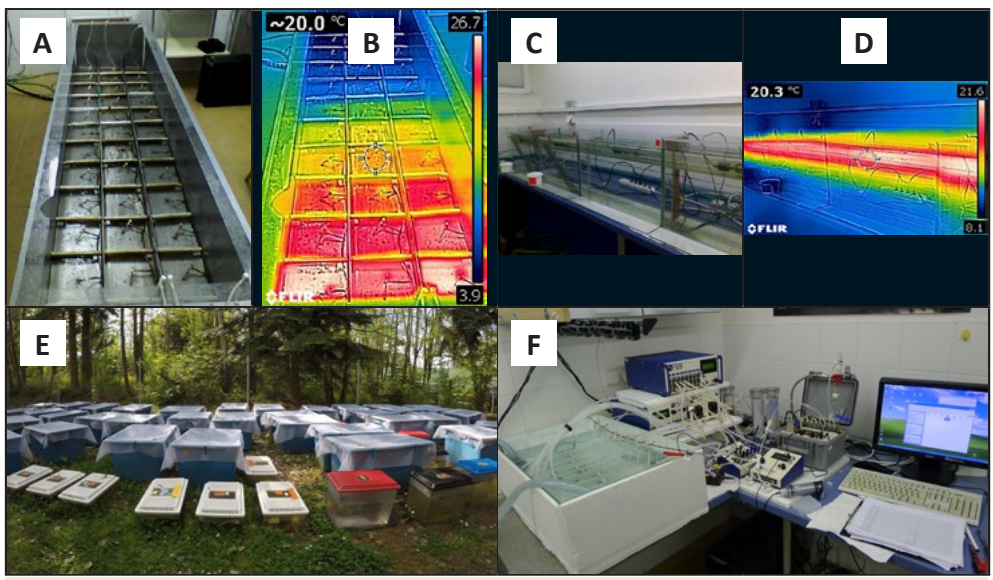
JANČA M, **GVOŽDÍK L**, 2017. Costly neighbours: Heterospecific competitive interactions increase metabolic rates in dominant species. *Scientific Reports* 7: 5177.

GVOŽDÍK L, 2018. Just what is the thermal niche? *Oikos* 127: 1701–1710.

HLOUŠKOVÁ M, BALOGOVÁ M, KRŠÁKOVÁ V, **GVOŽDÍK L**, 2018. No trade-offs in interspecific interference ability and predation susceptibility in newt larvae. *Ecology and Evolution* 8: 9095–9104.

WINTEROVÁ B, **GVOŽDÍK L**, 2018. Influence of interspecific competitors on behavioral thermoregulation: developmental or acute plasticity? *Behavioral Ecology and Sociobiology* 72: 169.

ŽÁK J, **REICHARD M**, **GVOŽDÍK L**, 2018. Limited differentiation of fundamental thermal niches within the killifish assemblage from shallow temporary waters. *Journal of Thermal Biology* 78: 257–262.



Our research on defining thermal niche was undertaken using horizontal (*A,B*) and vertical (*C,D*) thermal gradients, mesocosm experiments (*E*) and intermittent respirometry across temperatures (*F*).

(*Photo by L. Gvoždík*)

Winter activity of common bream (*Abramis brama*)

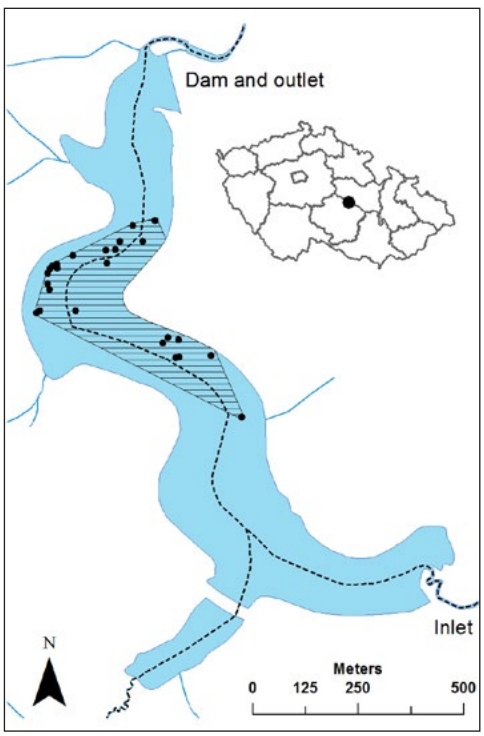
It is generally assumed that cyprinid fish overwinter in reservoirs by forming dense, static shoals in the deepest sections, their activity levels dropping drastically as their metabolisms slow due to the drop in temperature. While this widespread notion is still a feature of many textbooks, the actual behaviour of fish during their overwintering period has been the subject of relatively little study.

Using radio telemetry (remote monitoring with the use of radio transmitters placed into the abdominal cavity of the fish), we monitored the spatial distribution and activity of adult common bream (*Abramis brama*) during the winter at the 8-m deep Hamry drinking water reservoir in the Bohemian-Moravian highlands. Surprisingly, we found that overwintering bream did not cluster at the deepest point of the reservoir; instead, they remained relatively active throughout the winter, though less so than during the warmer growing season, with significant differences in activity patterns between

individuals. Night movements were somewhat shorter than day movements, confirming the maintenance of day time activity. As physical activity was maintained throughout the winter, it can be assumed that the fish were feeding as their energy reserves would not have been sufficient to survive the entire winter. Activity of almost all fish was limited to the middle section of the reservoir, coinciding with a 3–5 m zone of warmer, oxygenated water below an inverse thermocline. The fish appeared to avoid colder, shallow zones (<1.5 m) at the inlet and near the banks and the deepest zone (5–8 m) near the dam/outlet, possibly due to poor food availability.

Our study showed that, under certain conditions, common bream populations display much higher levels of winter activity (and feeding) than previously assumed, which has implications for both fisheries management and for future studies as regards common bream (and other cyprinid species') behavioural patterns, energy budgets and diet in deeper lakes and reservoirs. Clearly, there is still much to learn about the behaviour and ecology of fish under natural conditions, especially in relation to behaviour in winter when it is difficult to observe fish using classical ichthyological methods.

JURAJDA P, ROCHE K, HALAČKA K, MRKVOVÁ M, ZUKAL J, 2018. Winter activity of common bream (*Abramis brama* L.) in a European reservoir. *Fisheries Management and Ecology* 25: 163–171.



Individual telemetry readings (*black dots*) showing the minimum winter activity range (*shaded area*) for one of eight tagged common bream in Hamry reservoir over 2010.

(*Image by K. Roche*)

Common bream (*Abramis brama* L.) immediately after implantation with a small radio transmitter in its lower abdominal cavity.

(*Photo by P. Jurajda*)

Using radio telemetry equipment to pinpoint tagged common bream (*Abramis brama* L.) in Hamry reservoir over winter 2010.

(*Photo by P. Jurajda*)

Population changes and movement ecology of European migratory passerines

Study of movement ecology is crucial for understanding a wide array of evolutionary processes and for planning effective conservation interventions at both the local and global scales. To address this, we investigated the ecology of migratory birds at both population and multi-species levels. First, we employed light-level geolocators and stable isotopic assignments to study patterns in the migration of three species of *Acrocephalus* warblers and barn swallows (*Hirundo rustica*) breeding at several European sites. Moreover, we assessed population stability in 36 trans-Saharan migratory passerines at the continental level. We found that the majority of western European populations of Eurasian reed warbler (*Acrocephalus scirpaceus*) frequently used the western Mediterranean flyway. However, a higher absolute number of reed warblers used the eastern flyway, with a migratory divide found in southeastern Central Europe. Individual populations used different stopover areas during post- and pre-breeding migration, resulting in an anticlockwise loop migration pattern. Loop migration was also documented in Czech barn swallows, with most birds using an eastern route for both the spring and autumn migration, but shifted their spring migration eastwards (anti-clockwise loops). The remaining individuals used an eastern or central route, and shifted their spring migration route westwards (clockwise loops), while one individual utilised both the eastern (autumn) and western (spring) migratory flyway. When evaluating movements across non-breeding grounds, we discovered that three-quarters of great reed warblers (*Acrocephalus arundinaceus*) exhibited intra-tropical movements across sub-Saharan Africa. When vegetation conditions deteriorated at the first sites, migrating birds resided at their second sites, suggesting that the birds probably benefited from improved conditions over those at the sites they had left. Finally, unlike the other species studied, the paddy field warbler (*Acrocephalus agricola*) occupied non-breeding sites in southern Asia. One individual from a breeding site in Bulgaria retraced recent range expansion and followed a rather conservative route instead of migrating directly to India. In addition, evidence from stable hydrogen analysis indicated a low degree of migratory connectivity at the non-breeding grounds.

At the multi-species level, magnitude of population trends grew with decreasing absolute and relative size of sub-Saharan non-breeding ranges over 2001–2012. After repeating the analysis with trend direction, the relationship with non-breeding range size disappeared, indicating that both population decreases and increases were frequent among species with small non-breeding range sizes. Hence, species with small non-breeding ranges are at a higher risk of population decline due to adverse factors such as habitat loss or climatic extremes, though their populations are also more likely to increase when conditions improve.

BRLÍK V, ILIEVA M, LISOVSKI S, VOIGT C, **PROCHÁZKA P**, 2018. First insights into the migration route and migratory connectivity of the Paddyfield Warbler using geolocator tagging and stable isotope analysis. *Journal of Ornithology* 159: 879–882.

KLVAŇA P, CEPÁK J, MUNCLINGER P, MICHÁLKOVÁ R, **TOMÁŠEK O, ALBRECHT T**, 2018. Around the Mediterranean: an extreme example of loop migration in a long-distance migratory passerine. *Journal of Avian Biology* 49: jav-01595.

KOLEČEK J, HAHN S, EMMENEGGER T, **PROCHÁZKA P**, 2018. Intra-tropical movements as a beneficial strategy for Palearctic migratory birds. *Royal Society Open Science* 5: 171675.

KOLEČEK J, PROCHÁZKA P, IERONYMIDOU C, BURFIELD IJ, REIF J, 2018. Non-breeding range size predicts the magnitude of population trends in trans-Saharan migratory passerine birds. *Oikos* 127: 599–606.

PROCHÁZKA P, BRLÍK V, YOHANNES E, MEISTER B, AUERSWALD J, ILIEVA M, HAHN S, 2018. Across a migratory divide: divergent migration directions and non-breeding grounds of Eurasian reed warblers revealed by geolocators and stable isotopes. *Journal of Avian Biology* 49: e01769.

PROCHÁZKA P, HAHN S, ROLLAND S, VAN DER JEUGD H, CSÖRGŐ T, JIGUET F, MOKWA T, LIECHTI F, VANGELUWE D, KORNER-NIEVERGELT F, 2017. Delineating large-scale migratory connectivity of reed warblers using integrated multistate models. *Diversity and Distributions* 23: 27–40.

A great reed warbler (*Acrocephalus arundinaceus*) tagged with a light-level geolocator that records light intensity. Light data can be used to ascertain time of local sunset and sunrise, subsequently allowing calculation of geographical position.

(*Photo by J. Koleček*)

Biodiversity

Photo by V. Gvoždík.

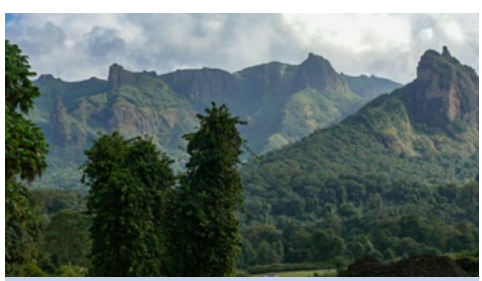
BIODIVERSITY

Complex speciation processes in Ethiopian rodents

The Ethiopian highlands are the largest mountainous complex in Africa and, together with the Great Rift Valley, provide a wide spectrum of model situations for evolutionary studies. The highlands have one of the most striking elevational ecological gradients on Earth, exactly the kind of place where ecological speciation associated with complex genetic changes is expected. Multiple steep climatic and vegetational gradients are separated by non-negligible migration barriers, though close enough to be connected under different climatic conditions, which could cause *in situ* differentiation to interfere with partial geographic isolation. As such, the extant species, often markedly differentiated and endemic, are expected to possess complex genetic features whose investigation could inform us about the relative importance of disruptive selection, temporary geographic isolation and introgression in adaptive radiations.

Researchers from the Institute of Vertebrate Biology, together with their Ethiopian and Russian colleagues, used a unique collection of rodents collected from across the Ethiopian highlands over the last three decades to reconstruct phylogenetic relationships in selected genera through combined analysis of multiple nuclear and mitochondrial markers. Previous models proposed a simple scenario of allopatric diversification following the separation of the highlands into two main parts by the Great Rift Valley. More recent genetic data, however, provide evidence for a more complex speciation process, often in the form of so-called reticulate evolution that combines divergence and hybridisation. During colder Pleistocene periods, Afroalpine ecosystems spread to lower elevations, allowing specialised high-elevation taxa to cross the Great Rift Valley where they then hybridised with local species, possibly facilitating the colonisation of high elevation mountains, e.g. through adaptive introgression of mitochondrial genomes already adapted to high altitudes and low oxygen concentrations. One implication of this finding is an inability to use mitochondrial DNA sequences for simple species barcoding, at least for Ethiopian rodents.

A further important feature of Ethiopian rodent diversification is the important role of selection in extreme Afroalpine conditions, which is reflected in the evolution of significantly distinct forms (e.g. *Tachyoryctes macrocephalus*, *Stenocephalemys albocaudata*, genus *Megadendromus*) adapted to life on high plateaus. However, all these taxa are internal lineages of more widespread congeners and their morphological (and possibly also physiological) adaptations are the result of rapid adaptive processes caused by strong selection.

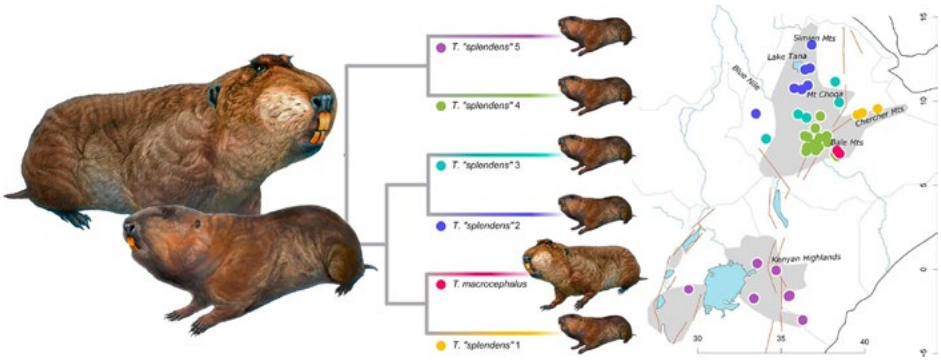


Ethiopian mountains provide a unique opportunity for evolutionary research. The Ethiopian Bale Mountains, east of the Great Rift Valley, have a remarkable elevational gradient that provides highly suitable conditions for studies on adaptation to high altitudes.

(*Photo by J. Hošek*)

The genus *Stenocephalemys* (*here S. albipes*) is an endemic Ethiopian clade of murid rodents. Six species (*two not yet scientifically described*) have evolved through a combination of ecological and allopatric diversification followed by hybridisation and (*adaptive*) introgression of mitochondrial DNA (*reticulate evolution*).

(*Photo by M. Polák*)



Root rats of the genus *Tachyoryctes* are ecologically specialised subterranean/fossorial African rodents. We found that Ethiopia represents a cradle of evolutionary diversity; with the morphologically and ecologically distinct species *T. macrocephalus* representing an internal lineage of the genus that has evolved under strong selection pressure in the Afro-alpine conditions of the Bale Mountain range. All 12 formally described "morpho-species" in the Kenyan Highlands and the Albertine Rift Mountains are descendants of a single, relatively recent, "out-of-Ethiopia" colonisation event and, as such, should be synonymised. The shaded areas on the right panel represent the distribution of the genus according to the IUCN.

(*Image by P. Říha and R. Šumbera*)

ŠUMBERA R, KRÁSOVÁ J, LAVRENCHENKO LA, MENGISTU S, BEKELE A, **MIKULA O**, **BRYJA J**, 2018. Ethiopian highlands as a cradle of the African fossorial root-rats (genus *Tachyoryctes*), the genetic evidence. *Molecular Phylogenetics and Evolution* 126: 105–115.

BRYJA J, KOSTIN D, MEHERETU Y, ŠUMBERA R, **BRYJOVÁ A**, KASSO M, **MIKULA O**, LAVRENCHENKO LA, 2018. Reticulate Pleistocene evolution of Ethiopian rodent genus along remarkable altitudinal gradient. Molecular *Phylogenetics and Evolution* 118: 75–87.

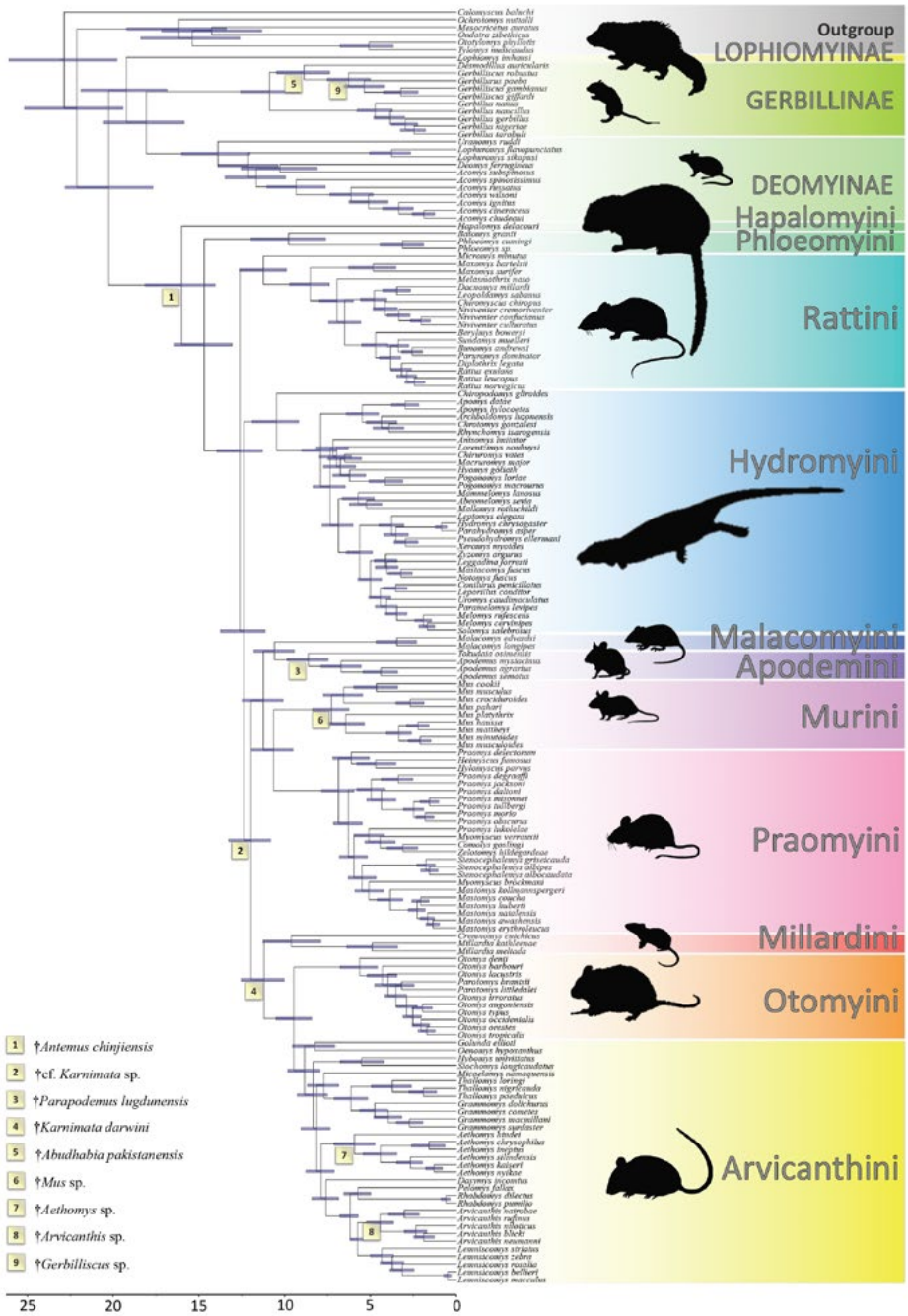
LAVRENCHENKO L, NADJAFOVA R, BEKELE A, MIRONOVA T, **BRYJA J**, 2017. Phylogenetic position of a monotypic Ethiopian endemic rodent genus *Megadendromus* (Rodentia, Nesomyidae). *Mammalia* 81: 71–82.

Dating of the evolution of murid rodents

Murid rodents (Muridae) are the most diverse mammal family, encompassing around 155 genera and more than 800 recognised species, including two major biomedical models, the brown rat (*Rattus norvegicus*) and the house mouse (*Mus musculus*). Despite their practical importance, their evolutionary histories have not yet been sufficiently resolved, and this is especially true for the dating of divergence. Researchers from the Institute of Vertebrate Biology, together with French mammalogists and a Japanese palaeontologist, reconstructed a dated complete family phylogeny using a large multilocus dataset (six nuclear and nine mitochondrial gene fragments) encompassing 161 species representing 82 distinct murid genera from four extant sub-families (Deomyinae, Gerbillinae, Lophiomyinae, and Murinae). Compared with previous studies, this

African Grass rats (*genus Arvicanthis*) are a highly successful group of murid rodents living in various types of open habitat in tropical Africa.

(*Photo by T. Aghová*)



Dated murid rodent phylogeny based on a large multi-locus analysis and nine fossil constraints reliably placed on the phylogenetic tree (numbers 1–9). Time axis in Million years before present.

(*Reproduced from Aghová et al. 2018*)

work stands out for its implementation of multiple fossil constraints within the family thanks to a thorough review of the fossil record, after which the fossils were reliably placed on the phylogenetic tree. Based on nine controlled fossil calibrations, the inferred temporal timeframe indicates that the murid family likely originated around 20 million-years-ago, and that most major lineages started their diversification around 10 million-years-ago. Three sub-families (Deomyinae, Gerbillinae and Lophiomyinae) are inferred to have originated in the Afrotropical region, while the most diverse subfamily, the Murinae, has its origin in the Indomalayan region. Biogeographic reconstructions also allowed us to show where and when distinct lineages of the latter subfamily colonised Africa (at least 3–4 times), the Palaearctic region and Australasia.

AGHOVÁ T, KIMURA Y, **BRYJA J**, DOBIGNY G, GRANJON L, KERGOAT GJ, 2018. Fossils know it best: Using a new set of fossil calibrations to improve the temporal phylogenetic framework of murid rodents (Rodentia: Muridae). *Molecular Phylogenetics and Evolution* 128: 98–111.

MtDNA heteroplasmia dynamics in mammals

DNA from mitochondria (mtDNA), the powerhouse of the cell, is part of the extra-nuclear genetic information complex and is passed down from mother to child. In mammals, the maternal mtDNA line is inherited as the embryo is derived from the egg. However, mutations may mean that the mother can have multiple types of mtDNA in her egg (heteroplasmia), and mothers that carry a mtDNA mutation may potentially pass a disease on to their child, such as hereditary diabetes.

We assessed heteroplasmic dynamics in mothers of different ages and their offspring using two mouse sp. models. Variability in the representation of different types of mtDNA was dependent on the mouse model (genotype) and increased dramatically with maternal age. This suggests that while the proportion of mtDNA in younger mothers is similar, the probability of transmitting more extreme (low and high) levels of a genetic feature increases with the mother's age as older mothers displayed greater mtDNA variability.

DNA from mitochondria (*mtDNA*), the powerhouse of the cell, is passed down from mother to child. There are many mitochondria in each cell and these may have different genetic features. If the mother carries a mixture of mitochondrial DNA types, this can make it hard to say which features their children will inherit. Family planning and clinical therapies can also be challenging if mothers carry a disease-causing mtDNA mutation.

(*Photo by A. Fornůsková*)

BURGSTALLER JP, KOLBE T, HAVLICEK V, HEMBACH S, POULTON J, **PIÁLEK J**, STEINBORN R, RÜLICKE T, BREM G, JONES NS, JOHNSTON IG, 2018. Large-scale genetic analysis reveals mammalian mtDNA heteroplasmy dynamics and variance increase through lifetimes and generations. *Nature Communications* 9: 2488.

Evolution and biogeography of anguid lizards

Our studies focus on the evolutionary history, biogeography and evolutionary-ecological relationships in legless lizards of the anguid family (Anguidae), and particularly of two genera, the slowworm (*Anguis*) and the glass lizard (*Pseudopus*).

A phylogeographic study on Central European populations of two slowworm species (*Anguis fragilis*, *A. colchica*) focussed on the situation in Poland and the surrounding regions as a mitochondrial contact zone was expected to occur between the two species. Haplotypes of both species were recorded in the study area based on both new mitochondrial DNA sequences and those available in previously published data from Central Europe and the northern Balkans. *Anguis fragilis* was represented by a single haplogroup, while three haplogroups were recorded for *A. colchica*, suggesting four independent sources/refugia for the postglacial recolonisation of northern Central Europe. The mitochondrial contact zone appears to mirror the border between the lowlands of the North European and East European Plains and the south-eastern Polish uplands, the River Vistula apparantly not representing a biogeographic barrier. Our confirmation of two slowworm species in Poland has implications for Polish conservation legislation.

A male European slowworm (*Anguis fragilis*). (*Photo by V. Gvoždík*)

A second phylogeographic study was undertaken on European glass lizards (*Pseudopus apodus*) from south-eastern Europe and western Asia. Based on analysis of DNA variation, we propose that the European glass lizard has survived historically unsuitable climatic periods in the Anatolian, Levant and Transcaucasian regions. Present low genetic variation indicates population extinctions during these unsuitable climatic periods, followed by subsequent rapid population expansion into their present-day range. This finding is in contrast with many other species of Western Palearctic reptile, which commonly survived in numerous smaller refugia and display more complex spatial genetic variation (phylogeographic pattern).

JANDZIK D, JABLONSKI D, ZINENKO O, KUKUSHKIN OV, MORAVEC J, **GVOŽDÍK V**, 2018. Pleistocene extinctions and recent expansions in an anguid lizard of the genus *Pseudopus*. *Zoologica Scripta* 47: 21–32.

MIKULÍČEK P, JABLONSKI D, PÁLENÍK M, **GVOŽDÍK V**, JANDZIK D, 2018. Characterization of microsatellite markers in the genera *Anguis* and *Pseudopus* (Reptilia: Anguidae). *Salamandra* 54: 158–162.

JABLONSKI D, NAJBAR B, GROCHOWALSKA R, **GVOŽDÍK V**, STRZAŁA T, 2017. Phylogeography and postglacial colonization of Central Europe by *Anguis fragilis* and *Anguis colchica*. *Amphibia-Reptilia* 38: 562–569.

Diversification in African amphibians

The study of species diversification assesses how new species arise, where they originate and how such species have diversified over time. It is our long-term aim to study the diversification (species formation, diversity and systematics) of amphibians within Sub-Saharan Africa.

As part of an international network, we have been involved in several research projects studying diversification processes in different anuran (frog) model taxa. There is growing support for the important role played by forest refugia in driving intraspecific divergence in the Guineo-Congolian rainforest and Gulf of Guinea archipelago of

Central Africa, particularly in relation to hyperoliid models (Hyperoliidae), particulrly *Afrixalus paradorsalis* and three *Hyperolius* species complexes (*H. cinnamomeoventris*, *H. ocellatus*, *H. tuberculatus*). It has been demonstrated that fluctuating sea levels periodically expose a land bridge connecting Bioko Island with the mainland Guineo-Congolian forest, and that habitats across the exposed land bridge likely enabled dispersal of some species but not others. To date, there is no evidence that rivers have acted as biogeographic barriers across any of the species complexes. Despite marked differences in the geographic extent of stable climates and temporal estimates of divergence among the species complexes, we recorded a shared pattern of intermittent climatic suitability with recent population connectivity and demographic expansion across the Congo Basin. This pattern supports the hypothesis that genetic exchange across the Congo Basin during humid periods, followed by vicariance during arid periods, has shaped regional diversity. In addition, several distinct lineages were identified among our focal taxa, some of which may reflect incipient or unrecognised species.

A second model was based on the Mascarene ridged frog (*Ptychadena mascareniensis*), a species complex that includes numerous lineages occurring mostly in humid savannahs and open forests of mainland Africa, Madagascar, the Seychelles and the Mascarene Islands. High levels of genetic differentiation yielding ten distinct lineages or operational taxonomic units were detected. Most speciation events took place throughout the Miocene, including "out-of-Africa" overseas dispersal events to Madagascar in the east and to Sao Tome in the west. The bioclimatic niche was remarkably well conserved, with most species tolerating similar temperature and rainfall conditions common to the Central African region. The *P. mascareniensis* complex provides insights into how the bioclimatic niche shaped current biogeographic patterns, with niche conservatism being exhibited by the Central African radiation and niche divergence shaping populations in West Africa and Madagascar. As such, central Africa, including the Albertine Rift region, has been an important centre of diversification for this species complex.

A male African leaf-folding frog (*Afrixalus paradorsalis*). (*Photo by V. Gvoždík*)

CHARLES KL, BELL RC, BLACKBURN DC, BURGER M, FUJITA MK, **GVOŽDÍK V**, JONGSMA GFM, TALLA KOUETE M, LEACHÉ AD, PORTIK DM, 2018. Sky, sea, and forest islands: Diversification in the African leaf-folding frog *Afrixalus paradorsalis* (Anura: Hyperoliidae) of the Lower Guineo-Congolian rain forest. *Journal of Biogeography* 45: 1781–1794.

DOLINAY M, TASSE TABOUE GC, FOKAM EB, **GVOŽDÍK V,** 2018. Geographic and altitudinal range extension of *Arthroleptis palava* (Anura: Arthroleptidae) from the Cameroon Volcanic Line. *Herpetology Notes* 11: 557–560.

BELL RC, PARRA JL, BADJEDJEA G, BAREJ MF, BLACKBURN DC, BURGER M, CHANNING A, DEHLING JM, GREENBAUM E, **GVOŽDÍK V**, KIELGAST J, KUSAMBA C, LÖTTERS S, McLAUGHLIN PJ, NAGY ZT, RÖDEL M-O, PORTIK DM, STUART BL, VANDERWAL J, ZASSI-BOULOU AG, ZAMUDIO KR, 2017. Idiosyncratic responses to climate-driven forest fragmentation and marine incursions in reed frogs from Central Africa and the Gulf of Guinea Islands. *Molecular Ecology* 26: 5223–5244.

ZIMKUS BM, LAWSON LP, BAREJ MF, BARRATT CD, CHANNING A, DASH KM, DEHLING JM, DU PREEZ L, GEHRING P-S, GREENBAUM E, **GVOŽDÍK V**, HARVEY J, KIELGAST J, KUSAMBA C, NAGY ZT, PABIJAN M, PENNER J, RÖDEL M-O, VENCES M, LÖTTERS S, 2017. Leapfrogging into new territory: How Mascarene ridged frogs diversified across Africa and Madagascar to maintain their ecological niche. *Molecular Phylogenetics and Evolution* 106: 254–269.

Population genetic modelling of the Chinese pond mussels (*Sinanodonta woodiana*) invasion history

Non-native species sometimes rapidly increase their abundance and distribution, often with associated negative impacts on native species, communities and ecosystems. As such, understanding the invasive potential of species outside their native range is one of the most pressing questions in applied evolutionary and ecological research. We know that different species vary in their propensity to become invasive when translocated outside their native ranges, but we are only beginning to understand the characteristics linked to invasiveness.

The Chinese pond mussel (*Sinanodonta woodiana*), easily recognised by its large shell, is native to a large part of East Asia. As with many other currently invasive species, *S. woodiana* persisted in European waters as several isolated populations locally restricted to zones with artificially elevated water temperatures and showed no signs of spreading. However, *S. woodiana* suddenly started to spread rapidly across Europe after 2005 and is now a very common species across most of the continent.

A large Chinese pond mussel (*Sinanodonta woodiana*) collected in Central Moravia.

(*Photo by R. Hečová*)

We described invasion pathways of *S. woodiana* using fine-scale sampling of populations and variable genetic markers. We rejected the hypothesis that the sudden spread of *S. woodiana* populations across Europe was associated with introduction of a new lineage, better adapted to colder waters than the initial European *S. woodiana* populations. Fish are often parasitised on their fins and gills by the mussel's larval stage and it appears to have been the repeated transport of fish between regions that established a regular connection (and frequent gene flow) between otherwise isolated populations. These frequent connections have facilitated adaptation to the colder conditions of European waters, compared with their native habitats in Asia.

Frequent transport of fish juveniles for fisheries purposes has not only helped *S. woodiana* populations to spread across Europe, but also to greatly increase their adaptive genetic potential, facilitating their adaptation to colder waters. In addition to understanding general patterns of biological invasion, our study also provides detailed mapping of *S. woodiana* colonisation within Europe, starting from a single isolated Romanian population in 1979 to its current widespread occurrence.

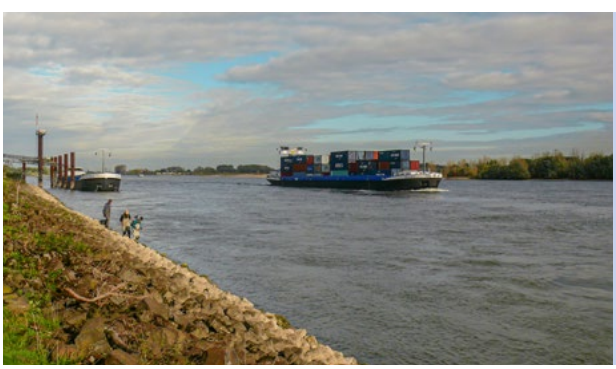
KONEČNÝ A, POPA O, **BARTÁKOVÁ V,** DOUDA K, **BRYJA J, SMITH C,** POPA LO, **REICHARD M,** 2018. Modelling the invasion history of *Sinanodonta woodiana* in Europe: tracking the routes of a sedentary aquatic invader with mobile parasitic larvae. *Evolutionary Applications* 11: 1975–1989.

Novel research on invasive gobiid fishes

Several Ponto-Caspian gobiid species have expanded their ranges throughout Europe and North America since the 1990s. For these species, rapid population explosions in newly colonised areas are typical. Abundant populations of non-native species have the potential to affect recipient systems in a number of ways, including predation on and competition with native fishes, predation on native macroinvertebrates or alterations to food-webs and host-parasite interactions. Consequently, our team has devoted much effort to studying mechanisms of invasions and impacts on recipient systems.

Our recent research has focused on tracing gobiid invasive histories in European freshwaters. While genetic studies have been widely used to assess the invasion history of gobiids in North America, complex genetic studies involving multiple sites and species have been less common in Europe, severely limiting our understanding of invasion processes along navigable rivers and their tributaries. We used both nuclear and mitochondrial markers to assess genetic diversity and structure in native and non-native populations of three gobiids, the Western tubenose goby (*Proterorhinus semilunaris*), round goby (*Neogobius melanostomus*) and bighead goby (*Ponticola kessleri*), sampled from the main areas of their joint distribution, i.e. the lower Danube, middle Danube and lower Rhine. Our research revealed significant differences in the invasion histories of these three species, despite their joint distribution. A founder effect observed in tubenose goby populations suggests one or very few introduction events and less dependence on shipping as a dispersal vector, while no genetic structuring in bighead goby populations suggests high initial propagule pressure, most likely connected with transport *via* shipping. Finally, an increase in the genetic diversity of round goby samples from non-native areas suggests strong propagule pressure with introductions from multiple sources followed by admixture, the latter stressing large inland ports as natural hot-spots for admixture of invasive aquatic species and their role in the onward spread of admixed populations to novel locations. This research provided support for (i) a Danubian origin for all three goby species in the Rhine, (ii) lower genetic diversity in fish colonising non-navigable tributaries, and (iii) provided early genetic data for a newly established round goby population on the River Elbe.

While Ponto-Caspian gobiids are believed to represent a significant negative threat to native fish assemblages, relatively few studies have tried to document actual impacts, most being short-term and/or laboratory based. To address this, we undertook further research focused on demonstrating observable *in situ* impacts on fish assemblages. To this end, long-term monitoring studies were conducted on the middle Danube and its tributaries. We observed no negative impacts on native fish diversity or abundance attributable to round goby in either the middle Danube or its tributaries. Especially surprising was the lack of impact on native European bullhead (*Cottus gobio*) in the Danube. Though cottids are presently considered to be most vulnerable to gobiid invasion, we observed no negative trend in bullhead abundance over the eight-year dataset, with populations remaining stable and at similar abundances to gobiids. In the context of other impact case studies, some of which have



Sampling non-native gobies by electrofishing along the banks of the lower River Rhine.

(*Photo by L. Mikl*)

demonstrated severe negative impacts on native fishes, our research suggests that gobiid impacts on ichthyofauna are region-specific, being driven by local idiosyncrasies of the invaded systems. The research also revealed potential negative impacts of round goby on tubenose goby, suggesting antagonistic interactions between the two gobiid invaders and providing an alternative exception to the 'invasional meltdown' hypothesis.

Long-term movements of invasive round gobies (*Neogobius melanostomus*) were assessed using mark-recapture techniques, with individual gobies tagged with colour- and number-specific pit-tags.

(*Photo by L. Šlapanský*)

JANÁČ M, **ROCHE K**, **ŠLAPANSKÝ L**, **POLAČIK M**, **JURAJDA P,** 2018. Long-term monitoring of native bullhead and invasive gobiids in the Danubian rip-rap zone, *Hydrobiologia 807: 263-275*.

JANÁČ M, **BRYJA J**, **ONDRAČKOVÁ M**, **MENDEL J**, **JURAJDA P,** 2017. Genetic structure of three invasive gobiid species along the Danube-Rhine invasion corridor: similar distributions, different histories. *Aquatic Invasions* 12: 551–564.

MIKL L, **ADÁMEK Z**, **ROCHE K**, **VŠETIČKOVÁ L**, **ŠLAPANSKÝ L**, **JURAJDA P,** 2017. Invasive Ponto-Caspian gobies in the diet of piscivorous fish in a European lowland river. *Fundamental and Applied Limnology / Archiv für Hydrobiologie* 190: 157–171.

ŠLAPANSKÝ L, **JANÁČ M**, **ROCHE K**, **MIKL L**, **JURAJDA P,** 2017. Expansion of round gobies in a non-navigable river system. *Limnologica* 67: 27–36.

Conservation genetics of Eurasian lynx in Central Europe

In a unique long-term research programme, we utilised genetic analysis of non-invasively collected samples from the Eurasian lynx (i.e. faeces, hair) to study the social structure of this elusive and endangered species. In doing so, we were able to reconstruct the genealogy of individual lynx in a small, partially isolated, population at the edge of their range in the West Carpathians. The results confirmed a low population density (eight adults on average) and a relatively high level of fluctuation in the number of individuals (of 40 genotyped individuals, just six were present in the study area for longer than four years). Female offspring usually settled in or near the maternal home range, which contributed to the formation of two separate family groups comprising closely related animals that mated together (i.e. father-daughter, grandfather-granddaughter). Breeding with close relatives not only significantly decreased the effective population size but also decreased population genetic variability. Our study confirmed that, even if this range-edge population were to be connected with

Two Eurasian lynx (*Lynx lynx*) kittens photographed in June 2013.

(*Photo by P. Konupka*)

the rest of the West Carpathian population, gene flow would be strongly limited as new lynx from outside would only settle in the region and participate in reproduction rarely.

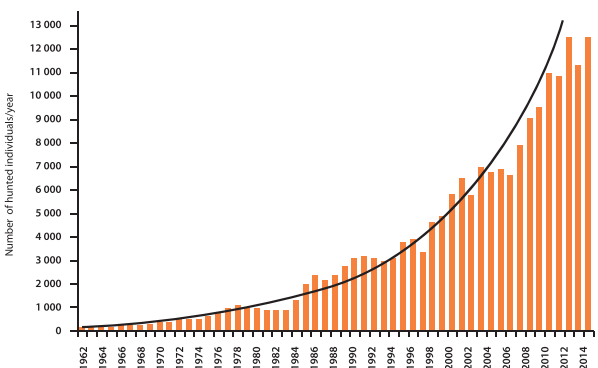
KROJEROVÁ-PROKEŠOVÁ J, **TURBAKOVÁ B**, JELENČIČ M, BOJDA M, KUTAL M, SKRBINŠEK T, **KOUBEK P**, **BRYJA J**, 2018. Genetic constraints of population expansion of the Carpathian lynx at the western edge of its native distribution range in Central Europe. *Heredity* 122: 785-799.

Two male adult lynx photographed in March 2015 using the same camera. Genetic analysis confirmed that the male on the left was the son of the male on the right.

(*Photos from parallel camera-trapping research undertaken in cooperation with Friends of the Earth, Olomouc*)

Genetic consequences of sika deer (*Cervus nippon*) introduction to Central Europe

In the late-nineteenth and early-twentieth century, sika deer were introduced into many countries across Eurasia and Australasia and to North America. Subsequently, free-living invasive populations became established in many countries, including the Czech Republic, where the expanding sika population now causes serious problems through overgrazing, browsing damage and through competition and hybridisation with native red deer. Our research focused on the effect of introduction on the genetic makeup of introduced sika deer in Central Europe (founder effect). We detected a high level of genetic differentiation between native Japanese sika and the introduced Czech populations. Genetic variability was generally low due to recent demographic events (founder effect in the Czech population, bottlenecks in Japanese populations); however, genetic variability differed greatly between subpopulations, with the Czech populations not displaying lowest variability. Multiple introductions, rapid population growth and possible hybridisation with red deer appear to have helped the successful expansion of sika within the Czech Republic. The



Increasing numbers of Japanese sika deer legally culled per year (*1962–2014*) confirm expansion of the Czech sika population.

(*Reproduced from Krojerová-Prokešová et al. 2017*)

results also indicate that male-mediated gene flow and human-mediated translocations have significantly influenced the current genetic structure of native sika populations in Japan. Hybridisation between introduced sika and native red deer is now being studied intensively in both the Czech Republic and the far east of Russia, where distribution ranges of these species naturally overlap.

KROJEROVÁ-PROKEŠOVÁ J, **BARANČEKOVÁ M**, KAWATA Y, OSHIDA T, IGOTA H, **KOUBEK P**, 2017. Genetic differentiation between introduced Central European sika and source populations in Japan: effects of isolation and demographic events. *Biological Invasions* 19: 2125–2141.

Sika females (*left*) and a male (*right*) in winter coat without the typical white spots.

(*Photo by J. Červený*)

Effective conservation of farmland biodiversity should support habitat heterogeneity and non-farmland habitats

Agricultural intensification has substantially reduced multi-scale habitat heterogeneity through increased field size and loss of semi-natural structures resulting in large-scale deterioration of farmland biodiversity. Within the European Union, substantial resources are currently spent on conservation measures aimed at halting the decline of farmland biodiversity; however, the effects of these measures are usually not clear and several studies have even reported no positive effects. One reason for the low effectiveness of such conservation measures could be incomplete identification of habitats acting as hotspots for farmland biodiversity. However, there is increasing evidence showing that a substantial number of rare and declining farmland taxa exclusively inhabit non-farmland habitats. In our research, we focused on the effects of habitat heterogeneity and non-farmland habitat as regards conservation of farmland biodiversity.

In our first study, we investigated the effects of habitat configuration and composition on various taxa in two adjacent, intensively managed, arable-dominated farmland landscapes. More specifically, we used data from fine-scale habitat mapping at two spatial scales and data on abundance and species richness of spiders, butterflies, birds and European hare abundance. Our study clearly demonstrated that smaller patch sizes and larger areas of non-cropped elements were related to higher farmland biodiversity of different taxonomic groups. Thus, conservation measures promoting habitat heterogeneity, namely decreasing field size and increasing the availability of non-cropped elements, may be valuable tools for conserving declining farmland biodiversity, especially in regions with substantial reduction of semi-natural habitats and large crop fields. Furthermore, promoting structurally diverse farmlands may contribute substantially to ecosystem function and

services as many taxa and species from diverse ecological guilds are considered important pest predators and crop pollinators.

In our second study, we investigated the importance of agricultural farmsteads for alpha and gamma diversity of farmland birds. We demonstrated that farmsteads, especially those with animal and plant production, are hotspots for farmland birds and key habitats for several species of conservation concern. Moreover, the importance of farmsteads increases in winter when many red-listed species and resident farmland birds change from a preference for farmland and abandoned farmsteads to active farmsteads producing food. Our study shows that there is a need to broaden our approach to conservation of rare and declining farmland birds by paying more attention to non-farmland habitats, such as farmsteads.

ŠÁLEK M, HULA V, KIPSON M, DAŇKOVÁ R, NIEDOBOVÁ J, GAMERO A, 2018. Bringing diversity back to agriculture: Smaller fields and non-crop elements enhance biodiversity in intensively managed arable farmlands. *Ecological Indicators* 90: 65–73.

ŠÁLEK M, BAŽANT M, ŻMIHORSKI M, 2018. Active farmsteads are year-round strongholds for farmland birds. *Journal of Applied Ecology* 55: 1908–1918.

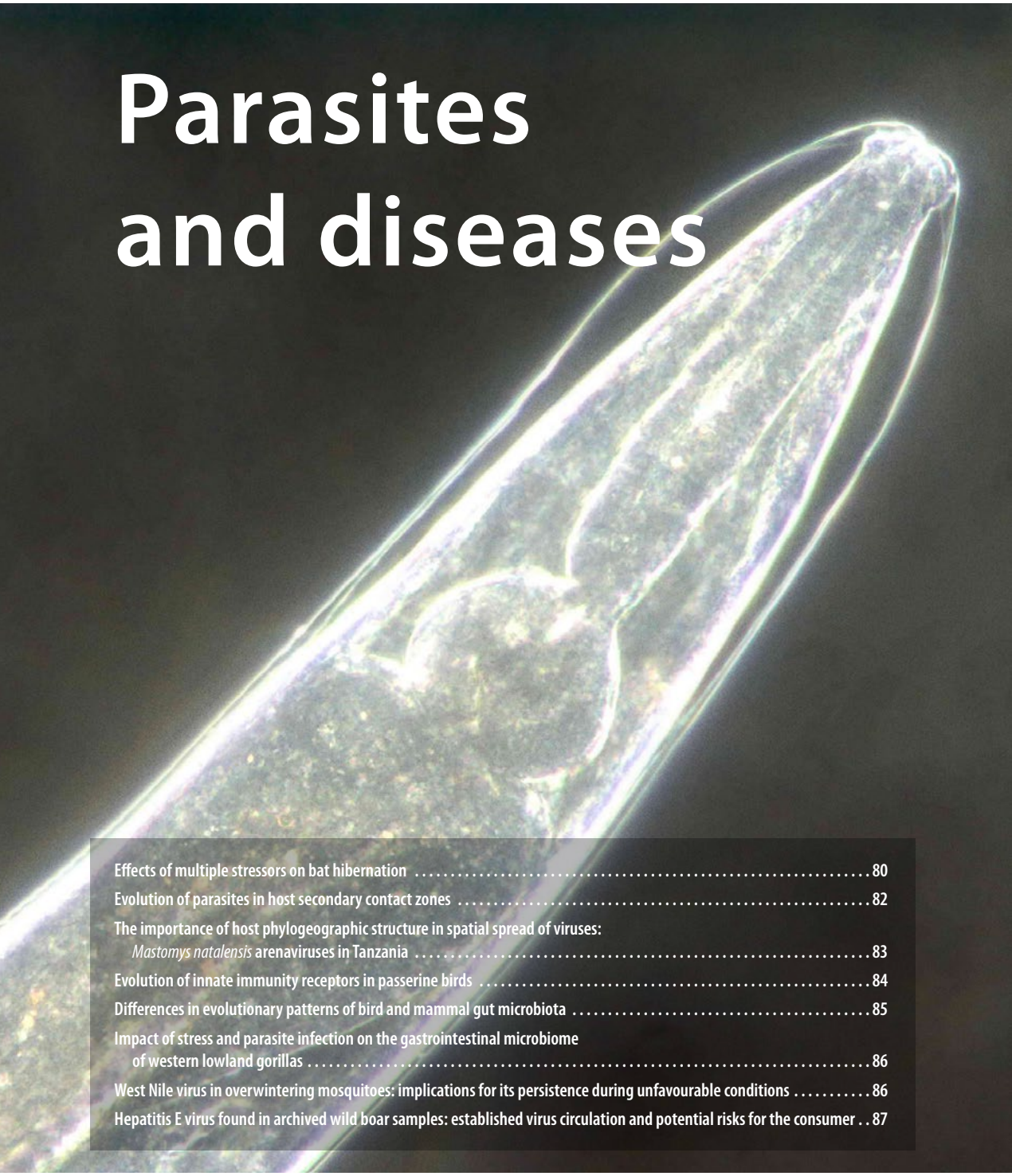
Smaller patch sizes and larger areas of non-cropped elements result in higher biodiversity.

(*Photo by M. Šálek*)

The Northern Lapwing (*Vanellus vanellus*), a species typical of agricultural landscapes, has shown a population decline over recent years.Presence of marshy patches and/or meadows at breeding grounds has been positively correlated with lapwing abundance. In addition, our results indicate higher hatching success in ploughed fields and at sites with marshy patches.

(*Photo by M. Šálek*)

Parasites and diseases



(*Photo by A. Ribas*)

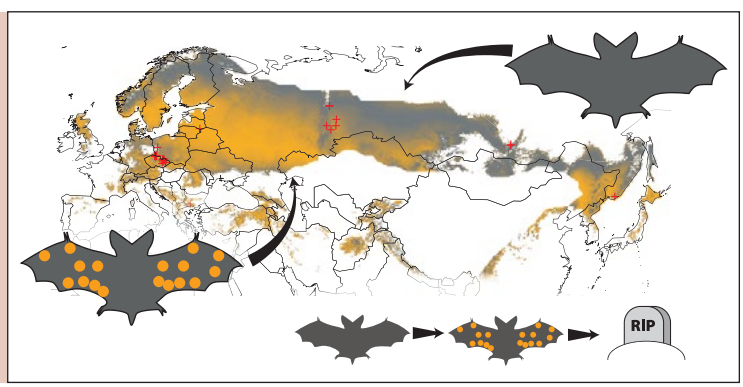
PARASITES AND DISEASES

Effects of multiple stressors on bat hibernation

Hibernation is an adaptation of temperate zone bats that allows them to survive scarcity of alimentary resources in winter. With lowered body temperature, the animal's metabolic functions are suppressed which, together with lowered energetic costs for thermoregulation, makes hibernation a behavioural adaptation of energy metabolism. The frequency of active euthermic periods during torpor is a key factor determining survival during hibernation as fat reserves are rapidly depleted with repeated arousals. In a recent study, we observed active hibernating bats that showed no body temperature elevation to the euthermic stage (low temperature movements). This ability to adjust roosting position (e.g. when microclimatic conditions or conspecific disturbances alter roost suitability) without body temperature elevation represents an important decrease in energy expenditure and significantly changes our understanding of basic hibernation principles.

Infection during hibernation poses a serious threat to animals because of the high energy demands of the immune response. Bats infected with the fungal skin pathogen *Pseudogymnoascus destructans* exhibit mild metabolic acidosis, lowered blood glucose and eosinophilia. We found that bats can mitigate the negative impacts of infection by modifying their selection of hibernation site. We have shown that bats in hibernacula with lower environmental temperatures develop less severe symptoms of white-nose syndrome, an infectious disease caused by *P. destructans*. As such, a shift by hibernators to lower temperature sites can be seen as a behavioural adaptation to presence of the fungus, whose growth is limited by low temperatures. In addition to behaviour promoting energy conservation during hibernation, we also found that bats have evolved genetic adaptations to skin infection, with genes involved in skin integrity and down-regulation of the immune reaction being under positive selection, indicating that energy conservation and the protective role of bodily barriers act together to improve host survival.

The survival of hibernating bats is affected by multiple endogenous and exogenous factors, including fat reserves, torpor length and arousal patterns, hibernation roost temperature, and pathogen infestation. Our results suggest that hibernating bats have evolved skin disease tolerance through a set of genomic, behavioural and physiology adaptations.

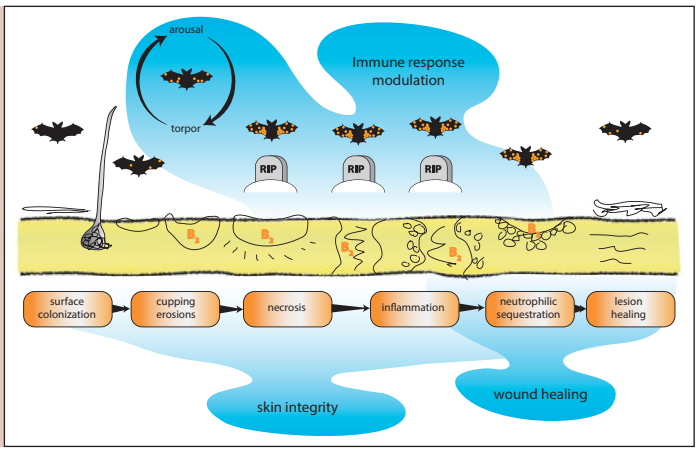


Bats from lower temperature hibernacula exhibit milder symptoms of white-nose syndrome as low temperatures limit fungal growth.

(*Adopted from Martínková et al. 2018.*)

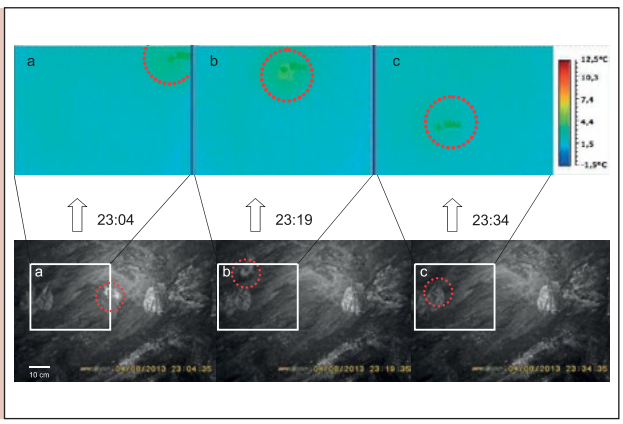
A molecular mechanistic model of white-nose syndrome tolerance in bats, showing important adaptations for surviving the skin disease. Disease tolerance is promoted by skin integrity, suppressed immune response during torpor arousals and increased wound healing capacity.

(*Adopted from Harazim et al. 2018*).



An example of a low body temperature movement, where a bat moves between clusters from left to right (*a, b, c*). The upper images were taken with a thermal camera and the lower images were taken simultaneously using photo traps. White rectangles in the photo-trap images indicate the position of the thermal image, while red circles indicate the moving bat. Tmax = maximum temperature of the thermal image.

(*Adopted from Bartonička et al. 2018*)



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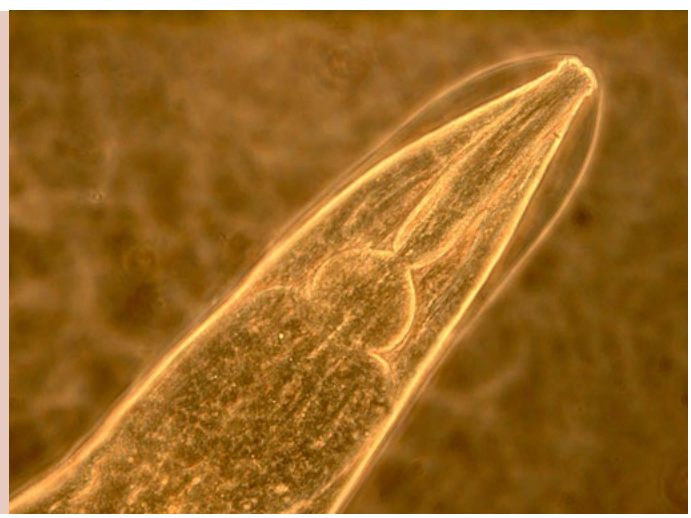
ZAHRADNÍKOVÁ JR. A, KOVÁČOVÁ V, **MARTÍNKOVÁ N**, ORLOVA MV, ORLOV OL, PIAČEK V, **ZUKAL J**, PIKULA J, 2018. Historic and geographic surveillance of Pseudogymnoascus destructans possible from collections of bat parasites. *Transboundary and Emerging Diseases* 65: 303–308.

Evolution of parasites in host secondary contact zones

Hybrid-zone studies of host-parasite systems have largely taken a host-centric viewpoint focussing on how parasitism might affect the outcome of host hybridisation by differentially impacting the fitness of host taxa *vs.* their hybrid descendants, the parasites being seen as an homogeneous entity with a single strong effect on hybrid *vs*. parental hosts. In contrast, the process creating secondary contact zones in hosts is also likely to give rise to secondary contact in their intimate parasites. These parasites will be two entities, each arising out of co-existence with a different host and having no clear singular effect on hybrids. We showed that this is the case in the European house mouse (*Mus musculus*) vhybrid zone with three different types of parasite, a DNA virus (the murine cytomegalovirus, MCMV), a yeast-like fungus (*Pneumocystis murina*), and a nematode (*Syphacia obvelata*). These three parasites clearly show host-specific genetic clustering, with 94% of the genome in the MCMV model showing host-specific genetic clustering while a small part of the genome encoding immune evasion genes showed maintenance of ancestral polymorphism. For the fungal and nematode parasites, we found clear host-specific genetic clustering, with presence of hybrid parasites at the centre of the host hybrid zone.

GOÜY DE BELLOCQ J, WASIMUDDIN, RIBAS A**, BRYJA J, PIÁLEK J, BAIRD SJE,** 2018. Holobiont suture zones: Parasite evidence across the European house mouse hybrid zone. *Molecular Ecology* 27: 5214–5227.

ČÍŽKOVÁ D, BAIRD STUART JE, TĚŠÍKOVÁ J, VOIGT S, ĎUREJE Ľ, PIÁLEK J**, GOÜY DE BELLOCQ J,** 2018. Host subspecific viral strains in European house mice: Murine cytomegalovirus in the Eastern (*Mus musculus musculus*) and Western house mouse (*Mus musculus domesticus*). *Virology* 521: 92–98.



Anterior part of *Syphacia obvelata*.

(*Photo by A. Ribas*)

The importance of host phylogeographic structure in spatial spread of viruses: *Mastomys natalensis* arenaviruses in Tanzania

Secondary contact between hosts can aid our understanding of the distribution of zoonotic viruses. Reservoirs of such viruses are usually equated with a particular wildlife species. However, it has rarely been assessed genetic groups below species level may instead represent the actual reservoir, despite this having major implications on estimations of zoonosis spatial distribution. We investigated whether geographically and genetically distinct sub-taxa of the Natal multimammate mouse (*Mastomys natalensis*), a widespread African rodent, carry distinct arenaviruses by detailed sampling across the contact zone of two of these sub-taxa. Ongoing hybridisation shows that individuals of the sub-taxa are in direct physical contact, in principle allowing viral exchange, yet neither of two arenaviruses (Gairo and Morogoro virus) were found to have crossed the zone. Such intraspecific genetic barriers to arenavirus spatial spread have important implications for our understanding of the related Lassa arenavirus, another *M. natalensis* virus potentially highly pathogenic to humans. Although Lassa virus appears to infect several secondary hosts, its distribution is restricted to West Africa and matches that of another *M. natalensis* sub-taxon. Hence, our data suggest that the human Lassa fever endemic area has not expanded to the rest of sub-Saharan Africa because of *M. natalensis* intraspecific distinctions.

GRYSEELS S, **BAIRD SJE**, BORREMANS B, MAKUNDI R, LEIRS H, **GOÜY DE BELLOCQ J,** 2017. When viruses don't go viral: the importance of host phylogeographic structure in the spatial spread of arenaviruses. *PLoS Pathogens* 13: e1006073.

Tanzanian Natal multimammate mice (*Mastomys natalensis*).

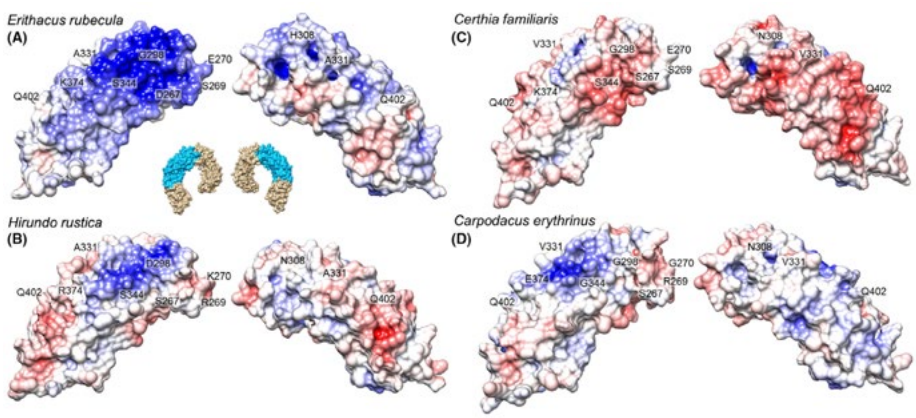
(*Photo by S. Gryseels*)

Evolution of innate immunity receptors in passerine birds

Recent developments in the scientific community calling for more interdisciplinary approaches in answering have given rise to brand new fields of biological study, e.g. ecoimmunology, which combines perspectives of classical immunology with ecology, physiology and evolution, mainly in free-living wild animals. Ecoimmunology focuses on describing and explaining natural variation in immune function, including its causal factors, thereby providing a unique and novel point-of-view on the evolution of immunity in the wild. Innate immunity is a complex system providing the first barrier between an organism and its pathogens. Presence of pathogens in an organism is recognised by various innate immune receptors, e.g. Toll-like receptors (TLR), which vary greatly between species, possibly mirroring the need of different species to recognise different pathogens correctly.

In our study, we focused on the ligand-binding region of TLR4 in 55 passerine species adapted to different climatic conditions. Using structural bioinformatics, we showed adaptations in the distribution of electrostatic potential on the surface of the TLR4 molecule, some of which have developed independently several times in birds (convergent). Even small changes in surface charge on key molecule sites may mean the difference between a strong or weak response and inhibition of immune reaction. Although we did not find a connection between these differences and basic ecological characteristics of the selected species (e.g. migration and latitudinal distribution, diet), our results potentially show functionally important sites on the TLR4 surface, and thus contribute to our understanding of host-pathogen co-evolution.

KRÁLOVÁ T, ALBRECHT T, BRYJA J, HOŘÁK D, JOHNSEN A, LIFJELD JT, NOVOTNÝ M, SEDLÁČEK O, VELOVÁ H, VINKLER M, 2018. Signatures of diversifying selection and convergence acting on passerine Toll-like receptor 4 in an evolutionary context. *Molecular Ecology* 27: 2871–2883.



Variability in TLR4 ligand-binding region (*LBR*) surface charge in four different passerine species. The two species showing greatest distance based on surface electrostatic potential of the whole TLR4 LBR were the Eurasian treecreeper (*Certhia familiaris*) and the European robin (*Erithacus rubecula*). The inner (*left-hand side*) and outer (*right-hand side*) surface of each TLR4 LBR is displayed with the ligand-binding surface shown in the left-hand view (*positive charge highlighted in red and negative charge in blue*).

(*Reproduced from Králová et al. 2018*)

Differences in evolutionary patterns of bird and mammal gut microbiota

The vertebrate digestive tract is inhabited by a taxonomically and functionally diverse community of microorganisms dominated by mutualistic and commensal prokaryotes. This gut microbiota can interact with a broad range of host physiological systems and provides valuable ecosystem services to the host, including increased digestion and vitamin synthesis efficiency, protection against pathogens and immune and nervous system regulation. To date, most attention has been paid to interactions between the host and its gut microbiota in mammals, knowledge of these interactions in other vertebrates being limited. Our research on passerines shows that this bird group has a substantially different gut microbiota composition than mammals, which is at least partially explained by major differences in their digestive tract physiology and anatomy. Similarly, the factors driving interspecific variability in gut microbiota composition appear to differ between birds and mammals. Unlike mammals, diet composition (and other ecological variables) affects the passerine gut microbiota only marginally. On the other hand, between-species similarity in passerine gut microbiota composition increases with their phylogenetic relatedness. This pattern may have arisen if divergence of genes regulating gut microbiota follows passerine phylogeny. At the individual level, we observed stochastic fluctuation in passerine gut microbiota composition over time, which again contrasts with some previous studies on mammals that report relatively stable microbiota in individuals over several years. Taken together, our work shows that host and gut microbiota interactions can vary substantially across the animal kingdom and that it is not possible to generalise findings obtained by studying a particular taxonomic group.

KREISINGER J, KROPÁČKOVÁ L, PETRŽELKOVÁ A, **ADÁMKOVÁ M**, **TOMÁŠEK O**, MARTIN J-F, MICHÁLKOVÁ R, **ALBRECHT T**, 2017. Temporal stability and the effect of transgenerational transfer on fecal microbiota structure in a long distance migratory bird. *Frontiers in Microbiology* 8: 50.

KROPÁČKOVÁ L, TĚŠICKÝ M, **ALBRECHT T**, KUBOVČIAK J, ČÍŽKOVÁ D, **TOMÁŠEK O**, MARTIN J-F, **BOBEK L**, **KRÁLOVÁ T**, **PROCHÁZKA P**, KREISINGER J, 2017. Codiversification of gastrointestinal microbiota and phylogenyin passerines is not explained by ecological divergence. *Molecular Ecology* 26: 5292–5304.

KREISINGER J, SCHMIEDOVÁ L, PETRŽELKOVÁ A, **TOMÁŠEK O**, **ADÁMKOVÁ M**, MICHÁLKOVÁ R, MARTIN J-F, **ALBRECHT T**, 2018. Fecal microbiota associated with phytohaemagglutinin-induced immune response in nestlings of a passerine bird. *Ecology and Evolution* 8: 9793–9802.

L. Kropáčková during DNA extraction from the passerine gut.

(*Photo by J. Kreisinger*)

Impact of stress and parasite infection on the gastrointestinal microbiome of western lowland gorillas

Relationships between gastrointestinal microbiome (GIM), stress and parasite infection are widely discussed topics across mammalian species due to their possible impact on the host's health. As part of a long-term monitoring programme of western lowland gorillas in the Dzanga Sangha Protected Area in the Central African Republic, we observed associations between (i) gastrointestinal parasites and GIM and (ii) physiological stress and GIM, using next generation sequencing (454 pyrosequencing of 16S rRNA bacterial gene amplicons), coprological methods and measurements of faecal glucocorticoid metabolites using enzyme immunoassays. We found that presence of Entamoeba spp. infections were associated with significant differences in the abundance of bacterial taxa that, aside from being characteristic members of the gorilla gut microbiome, likely play important roles in host nutrition and metabolism. On the other hand, exposure to stressors appears to be associated with minor changes in the gorilla GIM. In particular, members of the family Anaerolineaceae, genus Clostridium cluster XIVb and genus Oscillibacter were positively correlated with faecal glucocorticoid metabolite levels. Our results have implications for both conservation biology and for our overall understanding of factors influencing non-human primate GIM

Adult female with an infant from a habituatuated group in a forest clearing in Dzanga Sangha.

(*Photo by K. Shutt*)

VLČKOVÁ K, PAFČO B, **PETRŽELKOVÁ K**, MODRÝ D, TODD A, YEOMAN CJ, TORRALBA M, WILSON BA, STUMPF RM, WHITE BA, NELSON KE, LEIGH SR, GOMEZ A, 2018. Relationships between gastrointestinal parasite infections and the fecal microbiome in free-ranging western lowland gorillas. *Frontiers in Microbiology* 9: 1202.

VLČKOVÁ K, SHUTT-PHILLIPS KA, HEISTERMANN M, PAFČO B, **PETRŽELKOVÁ K**, TODD A, MODRÝ D, NELSON KE, WILSON BA, STUMPF RM, WHITE BA, LEIGH SR, GOMEZ A, 2018. Impact of stress on the gut microbiome of free-ranging western lowland gorillas. *Microbiology* 164: 40–44.

West Nile virus in overwintering mosquitoes: implications for its persistence during unfavourable conditions

West Nile virus (WNV) is currently the most important mosquito-borne pathogen spreading in Europe. Data on overwintering of WNV in mosquitoes are crucial for understanding WNV circulation in Europe. A total of 28,287 hibernating mosquitoes (27,872 *Culex pipiens*, 73 *Anopheles maculipennis* sensu lato, and 342 *Culiseta annulata*) caught in February or March between 2011 and 2017 in a WNV-endemic region of South Moravia, Czech Republic, were screened for the presence of WNV RNA. No WNV-positive pools were found from 2011 to 2016, though lineage 2 WNV RNA was detected in three pools of *Culex pipens* mosquitoes collected in 2017 at two study sites. To the best of our knowledge, this is the first record of WNV in overwintering mosquitoes in Europe. The data support the hypothesis of WNV persistence in mosquitoes throughout the winter season in Europe. As an epidemiological consequence, it can be assumed that lineage 2 WNV infections in Europe are sustained by virus persistence in mosquitoes followed by vertical

transmission and maintenance of the mosquito-bird transmission cycle, without the necessity of virus re-introduction.

RUDOLF I, **BETÁŠOVÁ L**, **BLAŽEJOVÁ H**, **VENCLÍKOVÁ K**, **STRAKOVÁ P**, **ŠEBESTA O**, **MENDEL J**, BAKONYI T, SCHAFFNER F, NOWOTNY N, **HUBÁLEK Z**, 2017. West Nile virus in overwintering mosquitoes, Central Europe. *Parasites & Vectors* 10: 452.

Collecting overwintering mosquitoes in a wine cellar.
(*Photo by I. Rudolf*)

Hepatitis E virus found in archived wild boar samples: established virus circulation and potential risks for the consumer

Nowadays, hepatitis E, a self-limited disease caused by the hepatitis E virus (HEV), is considered a worldwide public health threat. The genotypes HEV-1 and HEV-2 have been associated with human epidemics in developing countries where poor hygiene, sanitation and faecal contamination of drinking water can increase the risk of HEV outbreak *via* the faecal-oral transmission route. The genotypes HEV-3 and HEV-4, characterised as zoonoses, are not only detected in humans but also in a wide variety of animals, with pigs and wild boar the most important animal reservoirs. In order to determine whether HEV is distributed in South Moravian wild boar populations, 366 sera samples were obtained from archived wild boars collected between 1990 and 2008. Of these, 31 (8.5%) proved seropositive, with nested RT-PCR revealing two distinct sequences, the first (from a boar hunted in 2008) clustered together with sequences from German and Czech wild boar and the second (from a boar hunted in 1997) clearly differentiated. A positive sample from 1990 is the oldest HEV seropositive sample ever detected. Our results indicate that the wild boar acts as a reservoir of HEV in the Czech Republic and that this virus has been circulating in the study area for more than 20 years. From an epidemiological point of view, consumption of undercooked game or pork products should continue to be taken as a possible serious health threat.

STRAKOVÁ P, KUBÁNKOVÁ M, VAŠÍČKOVÁ P, **JUŘICOVÁ Z**, **RUDOLF I**, **HUBÁLEK Z**, 2018. Hepatitis E virus in archived sera from wild boars (*Sus scrofa*), Czech Republic. *Transboundary and Emerging Diseases* 65: 1770–1774.

Our research shows that Czech wild boars (*Sus scrofa*) act as reservoirs for the Hepatitis E virus.
(*Photo by J. Drimaj*)

4. OTHER ACTIVITIES

| POPULARISATION ACTIVITIES

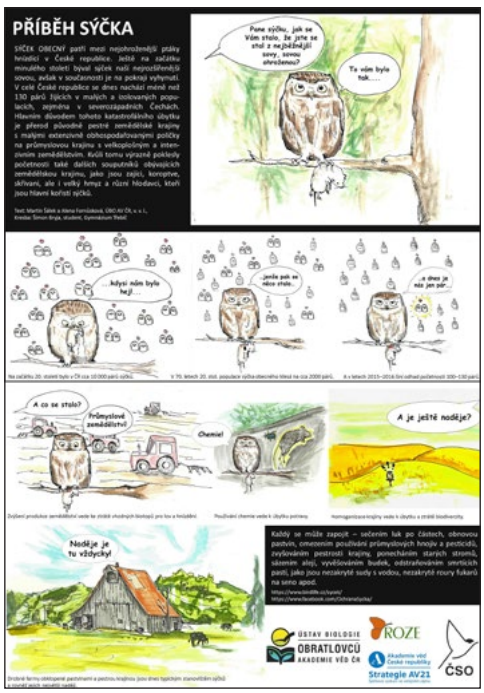
Popularisation of science is an important part of the IVBs activities and many seminars, workshops, field excursions, talks and open days are organised each year. During such activities, different scientific topics are presented to the wider public and students from different levels of education. We also organise workshops and conferences for university students and for other scientists. In 2017, our institute participated for the first time in the largest annual scientific exposition in Prague, The Science Exposition organised by the Czech Academy of Sciences.

(*A-C*): PhD students from the IVB present most interesting results of IVB to the wider public at the 2017 and 2018 Science Exposition in Prague, EXPO Letňany, (*D*): Scientific exposition was also attended by the President of the Czech Academy of Sciences, Prof. RNDr. Eva Zažímalová PhD.

(*Photo from IVB and CAS archive*)

Science exposition 2017 and 2018

In 2017 (8–10 June), 17,000 people attended the Prague Science Fair, while 25,000 attended in 2018 (7–9 June). Numerous novelties and attractions from the world of science and research were presented by the main research centres of the Czech Academy of Sciences, universities and innovative companies. One such attraction was the Zone for Students and Graduates, who had the opportunity to learn about vacancies in the various research institutions and companies seeking talented students. The IVB had its own stand where we presented our most interesting scientific results. In 2018, the IVB presented a new popularisation initiative based around six humorous posters covering a range of scientific topics, produced in collaboration with Šimon Bryja, a high school student.



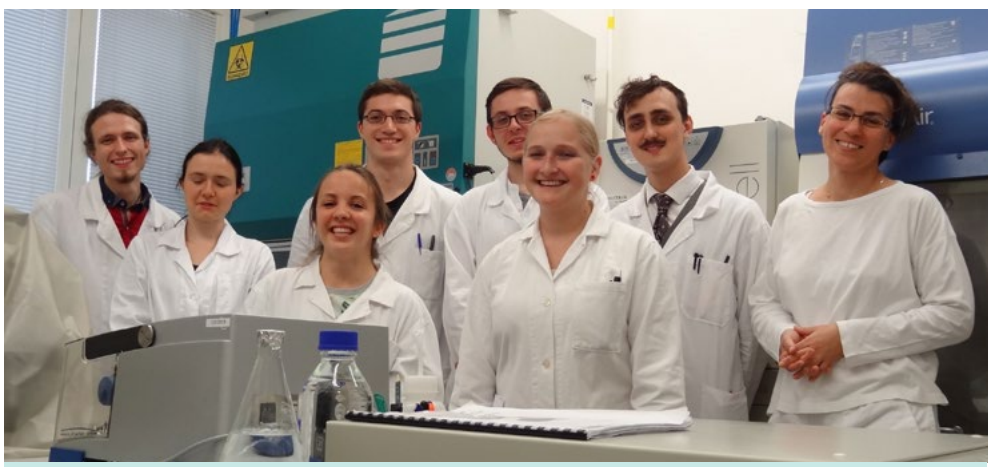
Examples of humorous posters produced by Šimon Bryja, a high school student, in collaboration with IVB scientists.

Open door days

Over the course of the Czech Republics 'Science and technology Week' (6–12 November 2017), the Czech Academy of Sciences opens its doors to the public in a series of open house events. All IVB research facilities participated in the event and welcomed a wide selection of the public through their doors. Visitors gained an insight into research taking place at the various facilities and were able to see the normal functioning of the laboratories and breeding facilities. In addition, a series of interesting lectures were provided, including two at the Brno Observatory and Planetarium in 2017 entitled 'The biodiversity of amphibians and reptiles in the Congo and following the footsteps of a new crocodile species' by Václav Gvoždík, and 'Newts – masters of transformation' presented by Lumír Gvoždík.

The Studenec Research facility welcomed students from a number of schools during the Science and Technology Week

(*Photos by A. Bryjová*)



Open house at the Valtice Research Facility

(*Photo by I. Rudolf*)

Visitors also had the possibility of visiting the fish breeding facility in Brno during the Science and Technology Week

(*Photo by M. Čapek*)

An invitation for Science and Technology Week 2018.

THE INSTITUTE OF VERTEBRATE BIOLOGY AND STRATEGY AV21

The IVB is an active institute within Strategy AV21, a new research strategy of the Czech Academy of Sciences aimed at increasing direct contact and collaboration between the Academy and the wider application sector. As part of these efforts, several activities were performed over 2017–2018 under the 'Diversity of Life and Health of Ecosystems Research Programme (ROZE)'.

Not only were the Studenec-based National Animal Genetic Bank and the experimental breeding facility founded through support from Strategy AV21 (see below), it also enabled the organisation of field excursions and seminars for the public, primary and secondary school students and university students, under the project 'Continuous education and popularisation of scientific research'. These activities were designed specifically to explain i) the role and relevance of biological research for society, and ii) how we can protect biodiversity.

Two further projects were funded under ROZE, 'Monitoring of fish communities using environmental DNA: introduction of a new method in the Czech Republic' and 'Invasive parasites and pathogens'. A popular science brochure was published in 2017 in relation to the second of these projects, entitled '*Invasive mosquito species as a potential risk for biodiversity and transmission of dangerous diseases*' (**Authors**: I. Rudolf, Academia Publishing House, 2017). The aim of this brochure is to create a platform for subsequent cooperation between the Czech Academy of Sciences, the South Moravian Regional Hygiene Station, the State Health Institute, the City of Břeclav and the Regional Authority of the South Moravian Region. These bodies will coordinate activities aimed at reducing the occurrence of dangerous invasive mosquito species (especially the tiger mosquito *Aedes albopictus*) and introducing measures to reduce the risk of transmission of dangerous diseases.

Ornithologic excursion in Studenec for schools in 2017.

(*Photo from IVB archive*)

Public excursion at research facility in Studenec in 2018.

(*Photo from IVB archive*)

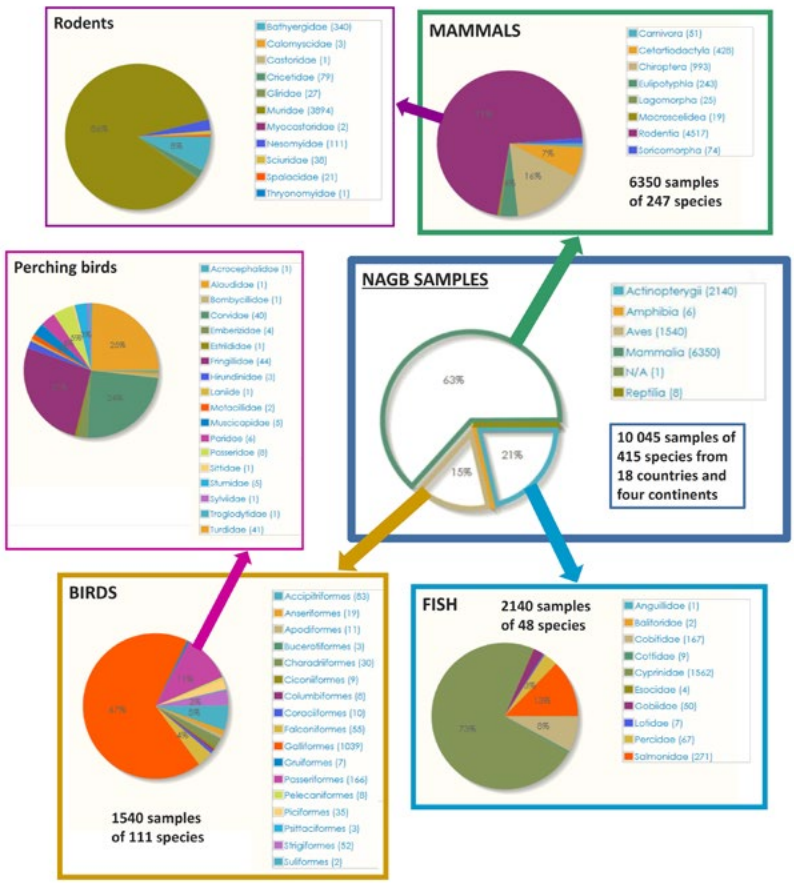
NATIONAL ANIMAL GENETIC BANK OF THE CZECH REPUBLIC

In the face of current levels of extreme biodiversity loss and increasing technological development, the significance of biodiversity biobanking is increasing and institutions in many countries have now realised the importance of making their DNA and tissue collections available for research. In the Czech Republic, the National Animal Genetic Bank of the Czech Republic (NAGB, http://ngbz.cz/eng/) was established in 2015 by two organisations, the IVB, which also supports NAGBs Secretariat, and the Department of Zoology of the Faculty of Science, Charles University in Prague (CUNI). Since then, four other organisations have signed a Memorandum of understanding and become members of the NAGB network, which now has ten supporting organisations contributing their genomic samples. The primary goal of NAGB is to ensure availability of the highest possible number of high-quality animal genomic samples to the broad scientific community. To achieve this, NAGB aims to i) digitise and (through collaboration with the Global Genome Biodiversity Network (GGBN)) allow publication of data on samples from completed scientific projects and other providers in freely accessible databases, ii) provide information on wildlife biobanking and its importance to professionals and expand the network with new members, iii) collaborate with other institutions to address technical, legislative and financial issues related to biobanking, and iv) establish a network of sample providers, i.e. organisations that come into contact with carcasses of Czech fauna but do not store the samples themselves.

Over 2017 and 2018, more than 8000 tissue samples were processed and published by the IVBs Genetic Bank; consequently, data on 10 045 NAGB samples of 415 species from 18 countries and four continents are now available on the GGBN (http://www.ggbn.org/ggbn_portal/search/index) and NAGB (http://data.ngbz.cz/search/index) Data Portals under biorepository codes IVB and CUNI. The published collections mainly cover mammals, fish and birds, with the largest collection consisting of ca 4450 genomic samples of small African rodents from Zambia, Tanzania, Kenya, Ethiopia and Mozambique. A further 140 African samples cover the bats. The collection also includes 850 samples of *Pipistrellus* bats, 160 samples of Alpine and Tatra chamois and a further 1600 samples of different mammal species from Central Europe. Another 110 small mammal samples originate from the Balkans, the Middle East and Russia. The fish collection includes 2140 samples originating mainly from Central Europe, while most of the bird collection (1540 samples) has been provided by Czech rescue stations. In addition to wild species, the bird collection includes around 1000 samples of domestic chicken breeds.

The NAGB collaborates with other world gene collections as a member of a global network of biorepositories, which together aim to publish data on samples representing the 'tree of life'. In addition to sample processing and publication, the NAGB is also active in other fields, including participating in state administration negotiations concerning biodiversity protection and the popularisation of science. NAGB members have participated in the preparation of the 'concept for national protection of wildlife genetic diversity' and cooperate with the Ministry of the Environment and other organisations on the preparation of specific guidance documents complementing implementation of the Nagoya Protocol and the related European Regulation No 511/2014 into national legislation.

NAGB uses its collections to promote the importance of biobanking, the role of the Czech Academy of Sciences and science as a subject to the public. The NAGB has made presentations at many events, including the Prague Science Fair, open days and organised excursions. With support from Strategy AV21, the NAGB prepared an exhibition, in collaboration with 10 biological collections from six different Academy institutes, consisting of 23 large bilingual panels entitled 'Stories of the Biological



In cooperation with the Global Genome Biodiversity Network, two NAGB members (IVB and CUNI) have published data on 10 000 mammal, fish and bird genomic samples held on the NAGB and GGBN Data Portals. A further 12 000 samples are currently waiting to be processed and will be published over the coming years. The NAGB welcomes new samples, especially for reptiles and amphibians, which are presently underrepresented in the bank.

Collections of the Czech Academy of Sciences'. A corresponding brochure is available at http://ngbz.cz/soubory/dokumenty-ke-stazeni-679.pdf.

In addition to the new genetic bank, a highly valuable collection of vertebrate skulls, skeletons, skins and formaldehyde-preserved exhibits is held at the IVB. Founded in the 1950s, the collection now includes several thousand items, mostly represented by small terrestrial mammals from the former Czechoslovakia but also including samples from Eastern Europe and Asia, most of which have yet to be digitised. Prof. Jan Zima had already started collecting tissue samples for genetic analysis as early as the 1990s, having recognised the benefits of simultaneously studying different types of characteristics (e.g. genetic and morphological) for evolutionary biological research. Many of the skulls and genetic samples from some of his early field collections are still available at the IVB, and others now continue the trend set by J. Zima. As part of

this work, the NAGB now stores unbroken animal skulls and carcass tissue samples (e.g. taken during the study of speciation in East African small rodents, or taken specifically for the IVB Genetic Bank) in the IVB collection.

Since its foundation, the NAGB has received support from Czech Academy of Sciences' Strategy AV21 (ROZE). The IVB Genetic Bank is also supported by a GGBN-GGI Award (2017–2018) and the Genetic bank of the Department of Zoology, Charles University, *via* INTER-Cost Grant No. LTC18060 (2018–2020) of the Czech Ministry of Education, Youth and Sports.

If someone decides to sequence the genome of the Baikal seal (*Pusa sibirica*), Danube ruffe (*Gymnocephalus baloni*) or Scops owl (*Otus scops; pictured above*), the necessary material is now available at the National Animal Genetic Bank of the Czech Republic.

(*Photo by I. Shah, Flickr*)

The Institute also maintains an extensive collection of skeletons and skins from many vertebrate species. Shown in the photo are skulls of a squirrel (*Sciurus vulgaris*), hedgehog (*Erinaceus roumanicus*) and marten (*Martes foina*) (*from left to right*).

(*Photo by A. Fornůsková*)

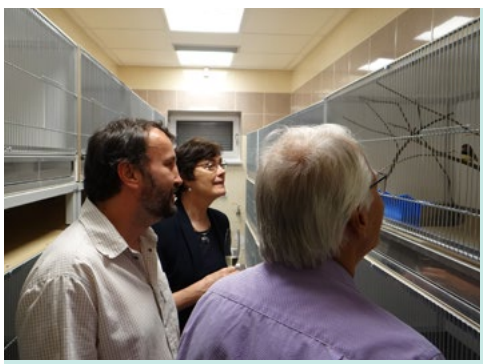
Eleven different biological collections from six Academy institutes have now been combined to tell their stories. Based on 23 large exhibition panels (one of which is shown here), it is now possible to learn not only about what kinds of collections exist at the Czech Academy of Sciences but also how they are used. One can, for example, listen to a story on resistance to drugs that can spread through the environment in the same way as the treated pathogens, about cyanobacteria that can help us with the reduction of soil erosion, Alzheimer's disease, or the story of the little owl that is calling out for rescue.

| IVB EXPERIMENTAL BREEDING FACILITIES

Studenec experimental breeding facility

On 22 June 2017, a new breeding facility was officially opened at the IVBs Studenec research facility (Highland Region). The opening was attended by the President of the Czech Academy of Sciences, Prof. RNDr. Eva Zažímalová PhD.

The breeding facility specialises in experimental research and presently focuses on i) the study of speciation (especially as regards hybrid zones between mice subspecies), ii) behavioural and ecophysiological research of caudate amphibians, and iii) sexual selection and the study of life strategies (e.g. evolution of aging) in birds. The new breeding facility provides scientists with a unique base for research into different life strategies in vertebrate species. Construction of the building began in 2015 and was financed from investment funds of the Czech Academy of Sciences (total amount 38 mil CZK).



The study of reproductive mechanisms and mating systems can help explain the emergence of infertility and find ways to avoid it.

(*Photo by A. Fornůsková*)

Understanding the mechanisms of speciation is key to protecting biodiversity. Our unique collection of inbred mouse strains derived from wild populations (*about 80 lines depicting the evolution of Mus over 6 million years*) also offers a wide range of uses in biomedical research.

(*Photo by A. Fornůsková*)

The results of thermal ecology research will make it possible to better predict the impact that intensive human-induced changes will have on individual ecosystems. A greater understanding of vertebrate temperature-physiological dependence will improve our chances of reversing the present risks of global climate change.

(*Photo by A. Fornůsková*)

Brno fish breeding facility

The Brno fish breeding facility was upgraded and re-accredited in 2018. It currently consists of seven indoor rooms with aquaria, 100 outdoor tanks and a large pond for underwater behavioural observations. The facility is indispensable for several ongoing projects on various aspects of fish behaviour, evolution and ecology.

The major fish groups housed at the facility include several species of bitterling fishes, African and Neotropical annual killifishes and the Tanganyikan cuckoo catfish and its cichlid host.

(*Photo by M. Vrtílek*)

| COMMERCIALISATION OF RESEARCH OUTPUTS

The IVB has formed a partnership with the Technology Agency of the Czech Republic (TA CR) under the GAMA program to encouraging the utilisation of research and development results arising that have a high potential for deployment into new or improved products, manufacturing processes or services with high added value and a high probability of being marketed.

The overall aim of the project is to contribute to utilisation and commercialisation of the results of the zoological research at the IVB in accordance with national priorities in the fields of practical nature conservation, and the biological diversity of European fauna in particular. Over 2017 and 2018, several partial proof-of-concept projects were completed. The most significant results to date include i) the first Czech patent for reliable identification of European freshwater fish and hybrids (S7iCAPS), ii) utility models of flat anodes that allow catching of small benthic fish species or salmonid fry to be caught in shallow waters without harm and retractable anodes allowing small benthic fish or fry to be caught where other anodes cannot be used due to the shallow depth; and iii) an immunoassay sampler (ELISA) for detection of bats showing a seropositive response to antigens prepared from the *Pseudogymnoascus destructans* fungus, which is responsible for the deadly"white nose syndrome". All three of these products have great potential for conservation and research practice.

White nose syndrome is an infection of bats causing severe problems in American bat populations.

(*Photo by J. Pikula*)

| OUTREACH PROJECTS

Project ATHENE – The Little Owl in danger

The main aim of the ATHENE project is to care for the residual populations of the little owl (*Athene noctua*) and support it's spreading through monitoring, research and conservation measures. The ATHENE project is based on a cooperative partnership between the Dresden Environmental Centre, the Czech Society for Ornithology, the Museum of the City of Ústí nad Labem and the IVB, and forms part of the 2014–2020 Czech Republic-Free State of Saxony cross-border cooperation program. The project is supported by the European Union under the European Regional Development Fund.

The little owl is a sedentary nocturnal predator inhabiting a range of open and semi-open habitats, though it is mainly associated with human-modified agricultural landscapes in Western and Central Europe. The species also breeds in urban environments,

"In recent decades, the availability of suitable little owl habitat has been increasing; however, owl numbers have not yet increased to match" says Martin Šálek of the IVB, and adds "equally alarming is the reduction in the owl's area of occurrence and the decline in density of individual populations, which are already sparsely scattered in the Czech Republic and, therefore, much more prone to extinction".

(*Photo by M. Šálek*)

Floats or mesh folded over the edge of a water barrel, allowing birds to climb up and escape, can save hundreds of birds a year, including species of conservation concern such as the little owl.

(*Photo by M. Šálek*)

The installation of nest boxes in suitable habitats is one of the conservation measures provided by ornithologists to support safe nesting.

(*Photo by M. Šálek*)

and urban populations are known from Teplice, Ústí nad Labem and Chomutov, where it is often found in man-made habitats in human settlements, including farms and residential buildings. Farmsteads, in particular, are very important breeding sites due to the high availability and diversity of suitable foraging, resting and breeding habitats. Such sites also host a number of other farmland birds, including species of conservation concern.

Little owls are similar in size to a starling (*Sturnus vulgaris*), have large heads with wide-set yellow eyes and can be identified by their grey-brown upperparts covered in white dots and heavily streaked front. The little owl eats small mammals, birds and invertebrates and can be seen hunting during dawn and dusk. Males produce a single 'woop' hoot, though a sharp 'keew keew' is the most common call heard.

Over the last 20 years, the Czech breeding population has declined by around 87–94 %. A similarly rapid decline has also been recorded over Central Europe and, in some countries of Western and Northern Europe, the situation is even more critical. In neighbouring Poland, East Germany, Austria and Slovakia, populations have fallen dramatically, while in Denmark and Luxembourg, the species is on the verge of extinction. Agricultural intensification and subsequent loss of suitable foraging and nesting habitat (bottom-up effect) and predation (top-down effect) have previously been identified as crucial factors in little owl and barn owl (*Tyto alba*) population declines. Moreover, anthropogenic mortality, especially through collision with vehicles and entrapment in "technical traps" (including vertical hollow objects and drowning in liquid reservoirs), is also likely to have contributed significantly to the decline in the Czech Republic. In order to improve the population status of this species, there is a need to reduce the risk of vehicle collision entrapment in urbanised landscapes alongside restoration of foraging habitats. The main aims of the ATHENE project, therefore, are to i) promote habitat management and restoration (i.e. spatio-temporal grassland management and supporting grazing during the little Owl breeding season), ii) supplement nest-sites (i.e. providing safe sites, especially nest boxes, for nesting and roosting), and iii) reduce anthropogenic mortality (i.e. preventing mortality in hollow objects and liquid reservoirs). An important part of the projects work is to increase public awareness as regards the population decline and the main threats facing the little owl, particularly among local stakeholders such as farmers and hunters, who represent crucial key players for effective little owl conservation.

The 2nd European Mammal Atlas (2017–2023)

The first Atlas of European Mammals was published in 1999, some 15 years ago, and is now out of print. The Atlas has been widely-used, with more than 450 citations on the Web of Science, and the data in the Atlas has been included in a number of European distributional data collections. Though the Atlas data remains available through these channels, or via the *www.european-mammals.org* website, it must be recognised that the dataset, which was finalised in 1998, is ageing and, therefore, we can be less confident as time goes on that it accurately reflects the current distribution of mammals in Europe.

Distributional atlases remain a fundamental tool for research and conservation. While most conservation delivery is at a national level, it is important that a broader picture of the distribution of species is available to help set contexts and priorities. Conservation requirements for species protected by the EU Habitats Directive provide a good example of this approach.

With this in mind, some members of the original Editorial Group proposed the idea of a second edition of the atlas in 2015, updating information for areas already covered and extending the area to the whole of geographic Europe. Early discussions with mammologists across Europe indicated that there was a high level of interest in this proposal, and so an open meeting was held in Rome at the end of November 2016. Discussions at the meeting set the direction for the new project and work began on defining the scope of the project and recruiting volunteers across Europe to help with its delivery.

Prof. RNDr. **Jan Zima**, DSc., † 2019, was the main co-investigator in the Czech Republic.

More information on the Atlas of European Mammals may be found at:

The European Mammal Foundation (*www.european-mammals.org*)

Discover the Mammals of Europe (*www.discovermammals.org*)

The Habitat Foundation (NFBIF), The Nature Conservation Agency of Luxembourg, The European Mammal Foundation and, of course, in the 2nd European Mammal Atlas.

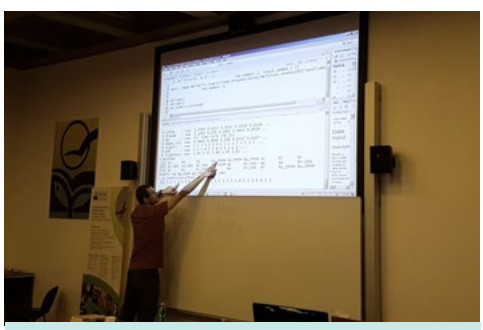
| MEETINGS ORGANISED BY THE INSTITUTE

"Zoological days" Conference 2017 (Brno) and 2018 (Prague)

As in previous years, the IVB was the main organiser of the annual 'Zoological days' conferences in 2017 and 2018. These conferences, organised in Brno since 1969, are in fact the national zoological congresses of the Czech Zoological Society and are a traditional and very popular meeting place for Czech and Slovak zoologists. Since 2008, the conference has been held in Brno in odd years only, while other Czech university towns hosted it every even year.

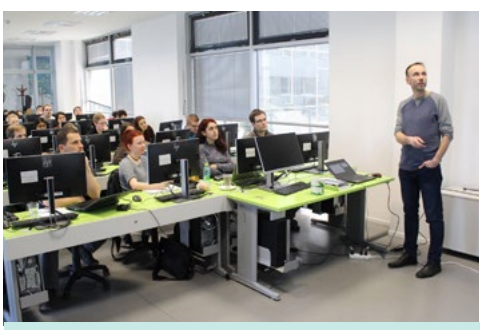
In 2017 (9–10 February), the conference was organised in Brno in collaboration with the Institute of Botany and Zoology of Masaryk University's Faculty of Science. The conference took place at Masaryk University's Faculty of Economics and Administration, which is an ideal site situated just next to the IVB's headquarters and provides a fine location for such a large and important conference. We welcomed a total of 518 zoologists (including 272 students) to Brno in 2017. In 2018 (8–9 February), the conference was organized in partnership with the Faculty of Environmental Sciences, Czech University of Life Sciences in Prague. The highest number of participants (584, including 308 students) in the history attended the 2018 conference, which again confirmed the increasing popularity of these meetings.

In both years, we organized a pre-conference workshop focused on zoological research methodology (supported by the Education for Competitiveness Operational Programme). In 2017 it was focused on the use of multidimensional approaches in the community ecology analyses and in 2018 on meta-analyses. Both the number of participants and the number and quality of presentations unequivocally shows that the Zoological days have become a serious scientific event of importance to the whole Czech and Slovak zoological community. For more information, please see http://zoo.ivb.cz/.



Pre-conference workshop „Traditional multidimensional methods in R" (*8 February 2017*), led by Vít Syrovátka from Masaryk University in Brno.

(*Photo by Z. Hiadlovská*)



Pre-conference workshop „A roadmap to meta-analysis" (*6–7 February 2018*), led by Tiit Teder from the University of Tartu in Estonia.

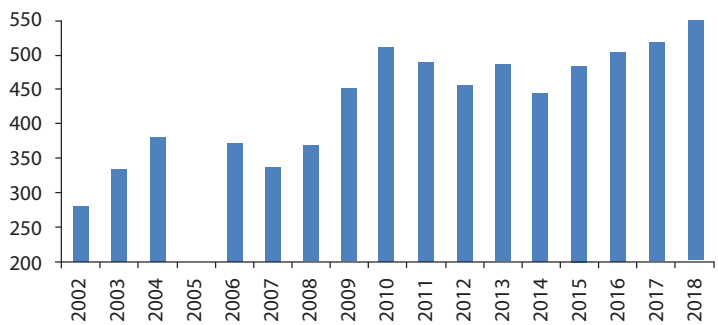
(*Photo by Z. Hiadlovská*)

Plenary talk by Natália Martínková from IVB about the white-nose syndrome in bats, Zoological days Brno 2017.

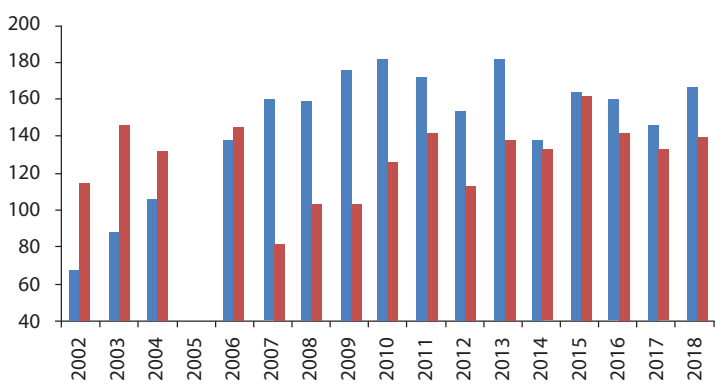
(*Photo by O. Michálek*)

In 2018, 146 posters were presented at the conference in Prague.

(*Photo by O. Michálek*)



The number of registered participants at the Zoological days has reached a plateau of 450–500 individuals. No conference was organised in 2005.



The Zoological days conference offers a unique opportunity to see hundreds of presentations covering all areas of zoological research performed in the Czech Republic and Slovakia over two days.

The Czech Congress of Herpetology

The 33rd Conference of the Czech Herpetological Society was held on Mohelský Mill field station between the 23 and 25 April 2018. Thirty-seven herpetologists from all around the Czech Republic and Slovakia attended and provided 20 oral presentations and two posters. The conference closed with the first public presentation of a new documentary film by Matej Dolinay on the Congo crocodile (*Osteolaemus osborni)*, and by a field excursion around the Mohelno National Nature Reserve.

Examining a slow-worm lizard (*Anguis fragilis*) sampled during the congress field excursion as part of the research project of Václav Gvoždík.

(*Photo from the archive of M. Dolinay*)

Participants in the Czech Congress of Herpetology 2018.

(*Photo from the archive of M. Dolinay*)

Hybrid zone workshop

In September, 4–7, 2017, a four-days workshop on hybrid zones was organised at the IVBs Mohelský mill field station for Czech Masters and PhD students and post-doctorate researchers. Twenty-eight participants attended the event, including 12 from abroad. The workshop focused on different aspects of hybrid zones and was led by Stuart J. E. Baird (IVB) and Nick Barton (IST Austria). The workshop was funded by the Czech Academy of Sciences under the framework of the project "International cooperation for young students".

Participants of hybrid zone workshop at Mohelský mill field station.

(*Photo from IVB archive*)

Rybikon 2018 – XVI Fisheries and ichthyological conference

In October, 10–11, 2018, the IVB, the Faculty of AgriSciences of Mendel University in Brno (MENDELU) and the Czech Limnological Society co-organised the XVI Fisheries and Ichthyological Conference at MENDELU in Brno, which was attended by 120 people. The main lecture topics were 'nutrient and mass balance in pond aquaculture', 'invasive fishes in the Central European region' and 'effects of hydromorphological alteration on fish assemblages'.

Participants at the XVI Fisheries and Ichthyological Conference at MENDELU in Brno.

(Photo from MENDELU archive)

Lynx and wolf in the Western Carpathians: current population status, ecology and conservation

In December 2018, a conference focused on Eurasian lynx (*Lynx lynx*) and grey wolf (*Canis lupus*) conservation was organised at Dolní Lomná (URSUS centre) by the Friends of the Earth Czech Republic (Olomouc local group), the IVB, the Administration of the Beskydy Protected Landscape Area, The State Nature Conservancy of Slovak Republic and the National Forest Centre. The conference was organised within the framework of the international Czech-Slovak project "Selmy SKCZ" and was funded through the EUs INTERREG V-A SK-CZ programme. The primary focus of the workshop was the current population status of both species in the West Carpathians, and especially at the Czech-Slovak border. Twenty-nine people (including five from abroad) representing a wide range of stakeholder groups (e.g. conservationists, hunters, breeders, foresters, state administrations) attended the conference.

Participants of the conference in the URSUS centre.

(*Photo by J. Krojerová*)

The grey wolf (*Canis lupus*). The rapid recovery of this large carnivore species in Central and Western Europe has led to increasing conflicts with agricultural stakeholders due to livestock depredation.

(*Photo by J. Červený*)

Evolutionary workshop for PhD students

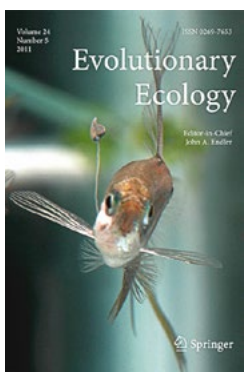
In October, 1–3, 2018, a workshop on evolutionary ecology was organised for PhD students by the Faculty of Science of Charles University in Prague and the IVB. The program included talks of advanced students (in the 3rd or 4th year of their PhD study); however, other students, including undergraduates, were also encouraged to attend and introduce their work. Thirty-seven students attended the workshop, including 15 foreign students and two tutors.

Students in lecture hall at the Mohelský mill field station.

(*Photo by P. Munclinger*)

| MEMBERSHIP OF EDITORIAL BOARDS

A number of researchers at the IVB are editorial board members for international peer-reviewed journals (e.g. Herpetology Notes, Cryobiology, International Journal of Primatology, Zoology and Ecology, Folia Zoologica, Comparative Cytogenetics, Mammal Research, Acta Zoologica Bulgarica, Archives of Biological Science). Of particular note has been the appointment of research fellows to the important position of Associate Editor in such well-known journals as Evolutionary Ecology (M. Reichard), Evolution (S. J. E. Baird) and Aquatic Invasions (M. Janáč).

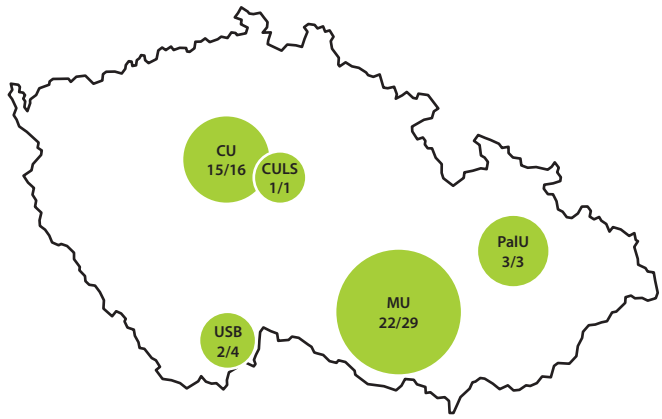


| EDUCATION AND TEACHING ACTIVITIES

Teaching at universities and supervision of students

IVB employees are very active in lecturing at five universities around the country, providing a total of 477 hours lecturing in 2017, and 571 hours in 2018. Many graduate students are also involved in IVB research programs. The Institute's researchers supervised 35 Bachelor and 56 Masters students over 2017–2018. Twenty five students graduated in 2017 (10 Bachelors and 15 Masters) and 16 students graduated in 2018 (5 Bachelors and 11 Masters).

Undergraduates students 2017/2018



Number of Bachelor and Masters students supervised by IVB researchers in 2017 and 2018. MU = Masaryk University, Brno; CU = Charles University, Prague; CULS = Czech University of Life Sciences, Prague; USB = University of South Bohemia, České Budějovice; PalU = Palacký University, Olomouc. Numbers in circles indicate number of Bachelors/Masters students supervised at particular universities.

PhD students working at the Institute and/or supervised by the Institute's fellows

Over 2017–2018, researchers at the IVB supervised 55 PhD students, 14 of them successfully defended their theses during that period.
Names of PhD students supervised by IVB researchers over 2017–2018.

Student	Supervisor or Consultant (*)	Start of the study	Defended the thesis	Faculty **
ABRAHAM Marek Mihai	Honza	2011	2018	1
ADÁMKOVÁ Marie	Albrecht/Tomášek*	2013		1
AGHOVÁ Tatiana	Bryja	2012	2018	1
ALBRECHTOVÁ Jana	Piálek	2007		2
ANANDAN Sampath Kumar	Tomášek / Albrecht*	2017		1
BADJEDJEA BABANGENGE Gabriel	Gvoždík V	2017		4
BAINOVÁ Hana	Vinkler/Albrecht*	2011		2
BARTÁKOVÁ Veronika	Bryja/Reichard	2013	2018	1
BARTOŇOVÁ-Marešová Eva	Mendel	2007	2017	1
BASKIERA Senka	Gvoždík L	2017		1

Student	Supervisor or Consultant (*)	Start of the study	Defended the thesis	Faculty **
BETÁŠOVÁ Lenka	Rudolf	2016		1
BLAŽKOVÁ Barbora	Albrecht	2015		1
BOBEK Lukáš	Albrecht/Tomášek*	2013		1
BURGUNDER Jade	Petrželková	2013	2018	1
CUYPERS Laura	Goüy de Bellocq/ Baird*	2017		3
DIANAT Malahat	Bryja*	2018		1
DOLINAY Matej	Gvoždík V	2015		1
GARCÍA Daniel	Reichard	2015		6
HÁNOVÁ Alexandra	Bryja*	2016		1
HARAZIM Markéta	Martínková	2018		1
HEGER Tomáš	Zukal	2017		8
CHRENKOVÁ Monika	Šálek	2011		5
JABLONSKI Daniel	Gvoždík V*	2013	2017	9
JELÍNEK Václav	Procházka	2010	2017	2
KALOUSOVÁ/PAFČO Barbora	Petrželková*	2013	2017	8
KAUZÁL Ondřej	Albrecht/TomášekK	2017		2
KRÁLOVÁ Tereza	Bryja/Albrecht*	2012		1
KRÁSOVÁ Jarmila	Bryja*	2015		5
KRKAVCOVÁ Eva	Kreisinger/Javůrková*	2012		2
LOTANA LOKASOLA Albert	Gvoždík V	2018		4
MARTINCOVÁ IVA	Piálek	2012		1
MAZOCH Vladimír	Bryja*	2009		5
MÍČKOVÁ Kristýna	Albrecht	2018		2
MICHÁLKOVÁ Romana	Albrecht	2012		2
MICHÁLKOVÁ/NEZHYBOVÁ Veronika	Ondračková/Reichard*	2012		1
MIKL Libor	Adámek	2012	2018	1
MIKULA Peter	Albrecht	2015		2
MIZEROVSKÁ Daniela	Bryja	2018		1
OPATOVÁ Pavlína	Albrecht	2012	2017	1
PAVLISKA Petr	Šálek	2015		5
PAVLUVČÍK Petr	Tkadlec	2010	2017	7
PETRUŽELA Jan	Goüy de Bellocq/ Baird*	2018		1
PRAVDOVÁ Markéta	Ondračková	2015		1
PTÁČKOVÁ Olga	Albrecht	2018		1
SCHULZ Doreen	Petrželková	2013		1
SOSNOVCOVÁ Kateřina	Procházka/Koleček*	2015		2

Student	Supervisor or Consultant (*)	Start of the study	Defended the thesis	Faculty **
SOUDKOVÁ Martina	Albrecht	2011		2
STRAKOVÁ Petra	Hubálek	2013	2017	1
ŠLAPANSKÝ Luděk	Jurajda	2012		1
TĚŠÍKOVÁ Jana	Goüy de Bellocq / Bryja*	2014		1
TOMÁŠEK Oldřich	Albrecht	2009	2018	2
TURBAKOVÁ Barbora	Bryja/ Krojerová*	2015		1
VINKLEROVÁ Jitka	Bryja/Vinkler*	2013		2
VLČKOVÁ Klára	Petrželková	2012	2017	8
ŽÁK Jakub	Reichard	2017		2

** 1 = Faculty of Science, Masaryk University, Brno; 2 = Faculty of Science, Charles University, Prague; 3 = University of Antwerp; 4 = Université de Kisangani, Faculté des Sciences, RD Congo; 5 = Faculty of Science, University of South Bohemia, České Budějovice; 6 = Universidad de la República, Montevideo, Uruguay; 7 = Faculty of Science, Palacký University in Olomouc; 8 = Faculty of Veterinary Medicine, University of Veterinary and Pharmaceutical Sciences, Brno; 9 = Faculty of Natural Sciences, Comenius University in Bratislava, Slovakia.

PhD theses defended over 2017–2018 and supervised by Institute fellows

ABRAHAM MAREK MIHAI, 2018: *Host-parasite interaction as an extreme form of parent-offspring conflict*. Faculty of Science, Masaryk University, Brno. Supervisor: M. Honza.

AGHOVÁ TATIANA, 2018: *Comparative phylogeography of the Somali-Maasai region in eastern Africa using selected rodent species as a model*. Faculty of Science, Masaryk University, Brno. Supervisor: J. Bryja.

BARTÁKOVÁ VERONIKA, 2018: *The effects of non-native species on host-parasite relationships*. Faculty of Science, Masaryk University, Brno. Supervisor: J. Bryja/M. Reichard.

BARTOŇOVÁ-MAREŠOVÁ EVA, 2017: *Genetic diversity of the Alpine bullhead (*Cottus poecilopus*, Heckel, 1837) in the Carpathian arc (Baltic and Black Sea basins contact zone)*. [In Czech; Genetická diverzita vranky pruhoploutvé (*Cottus poecilopus*, Heckel, 1837) ve vodách Karpatského oblouku (hraniční oblast Baltského a Černého moře)]. Faculty of Science, Masaryk University, Brno. Supervisor: J. Mendel.

BURGUNDER JADE, 2018: *Complexity in Behavioral Organization: a novel approach to assessing clinical outcomes of parasitic diseases*. Faculty of Science, Masaryk University, Brno. Supervisor: K. Petrželková.

JABLONSKI DANIEL, 2017: *Genetic diversity and phylogeography of the family* Anguidae *in the Balkans and their comparison with biogeography of other herpetofauna*. [In Czech; Genetická diverzita a fylogeografie zástupců čeledi *Anguidae* na Balkánském poloostrově a její komparace s biogeografií dalších druhů herpetofauny]. Faculty of Natural Sciences, Comenius University in Bratislava, Slovakia. Supervisor: V. Gvoždík

JELÍNEK VÁCLAV, 2017: *The role of nest in reproduction of the Great Reed Warbler.* Faculty of Science, Charles University, Prague. Supervisor: P. Procházka.

KALOUSOVÁ PAFČO BARBORA, 2017: *Molecular epidemiology and transmission of strongylid nematodes between non-human primates and humans*. Faculty of Veterinary Medicine, University of Veterinary and Pharmaceutical Sciences, Brno. Co-supervisor: K. Petrželková.

MIKL LIBOR, 2018: *Non-native gobies (*Gobiidae*) of the food chain in the lower River Dyje*. [In Czech; Nepůvodní hlaváčovité ryby (*Gobiidae*) v potravních řetězcích dolního toku Dyje]. Faculty of Science, Masaryk University, Brno. Supervisor: Z. Adámek.

OPATOVÁ PAVLÍNA, 2017: *Genetic and environmental factors affecting sperm phenotype in the zebra finch (*Taeniopygia guttata*)*. Faculty of Science, Masaryk University, Brno. Supervisor: T. Albrecht.

PAVLUVČÍK PETR, 2017: *The effects predators on populations of small mammals*. [In Czech; Vliv drobných hlodavců na populace predátorů]. Faculty of Science, Palacký University in Olomouc. Supervisor: E. Tkadlec.

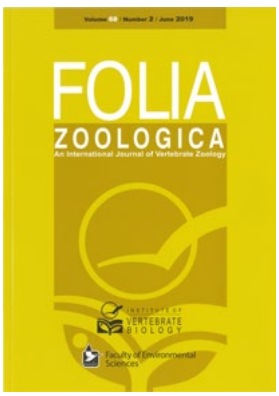
STRAKOVÁ PETRA, 2017: *Zoonotic viruses associated with free-living endotherm vertebrates*. [In Czech; Zoonotické viry u volně žijících endotermních obratlovců]. Faculty of Science, Masaryk University, Brno. Supervisor: Z. Hubálek.

TOMÁŠEK OLDŘICH, 2018: *Condition dependence of sexually selected ornaments in birds*. Faculty of Science, Charles University, Prague. Supervisor: T. Albrecht.

VLČKOVÁ KLÁRA, 2017: *Application of Next Generation Sequencing Approach to Study Gastrointestinal Microbiota of Free-Ranging Great Apes*. Faculty of Veterinary Medicine, University of Veterinary and Pharmaceutical Sciences. Supervisor: K. Petrželková.

| EDITORIAL ACTIVITIES – FOLIA ZOOLOGICA

The Institute publishes the international journal *Folia Zoologica* jointly with the Faculty of Environmental Sciences of the Czech University of Life Sciences in Prague. The journal has a publishing tradition going back more than 80 years and is currently covered by many reference journals, and bibliographic databases including Web of Science, Scopus and EBSCO. *Folia Zoologica* published in 2017–2018 59 articles, covering various areas of mammology, ornithology, herpetology and ichthyology.



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Aims & Scope

Folia Zoologica publishes articles containing original insights into various aspects of vertebrate zoology that have not previously been published and are not presently under consideration for publication elsewhere. The journal welcomes significant papers presenting new and original data of more than regional significance. Studies testing explicitly formulated hypotheses are preferred to those presenting primarily descriptive results. Review papers are particularly welcomed and should deal with topics of general interest or of current importance, being synthetic rather than comprehensive in emphasis. Authors should consult with the editors before submitting reviews.

The journal is published quarterly and one volume usually consists of four issues. However, additional issues may be published occasionally. There is no page charge except for colour pages.

The full text of articles published in *Folia Zoologica* from 2010 is available at *www.bioone.org/loi/fozo*.

Folia Zoologica is indexed by CAB Abstracts, EBSCO, Elsevier Bibliographic Databases incl. Scopus and Clarivate Analytics databases incl. Web of Science.

Submission of manuscripts

All manuscripts should be submitted online at *http://mc.manuscriptcentral.com/folia_zool*. Correspondence concerning editorial matters should be addressed to the Editorial Office. A comprehensive version of the 'Instructions to Authors' is available on *https://www.ivb.cz/vyzkum/folia-zoologica/*.

AWARDS

Michal Šulc won the 3rd Marcin Antczak Award

The 3rd Marcin Antczak Award for the most inspiring work in ornithology published in 2016 in a peer-reviewed journal and dedicated to young researchers from Poland, the Czech Republic and Slovakia, goes to Michal Šulc (IVB).
Michal received the award in 2017 for two manuscripts, which consisted of two dissertation chapters that he defended at the IVB:

Michal Šulc, Petr Procházka, Miroslav Čapek, Marcel Honza 2016. Birds use eggshell UV reflectance when recognizing non-mimetic parasitic eggs. Behavioural Ecology 27: 677–684. DOI: 10.1093/beheco/arv206

Michal Šulc, Miroslav Čapek, Marcel Honza 2016. Common cuckoo females are not choosy when removing an egg during parasitism. Behavioural Ecology 27: 1642–1649. DOI: 10.1093/beheco/arw085

The award is presented by The International Board of the Marcin Antczak Award.

Michal Šulc

(*Photo from IVB archive*)

Jaroslav Koleček awarded by the Czech Association of Scientific and Technical Societies

Jaroslav Koleček received a letter of thanks from the Czech Association of Scientific and Technical Societies for supervising a high school student, Ondřej Pelánek, during his participation in the Students Professional Activities contest.

The letter was awarded on 12 December 2018 by the CASTS Bureau. Ondřej succeeded in the competition with the thesis "*Bird abundance in forests in the vicinity of Brno – a comparison of traditional and innovative methods*". Jaroslav Koleček is also an active populariser of birds and conservation and has been involved in the organisation of a wide range of activities for the wider public (e.g. Bird Chorus Day, EuroBirdwatch, owl night).

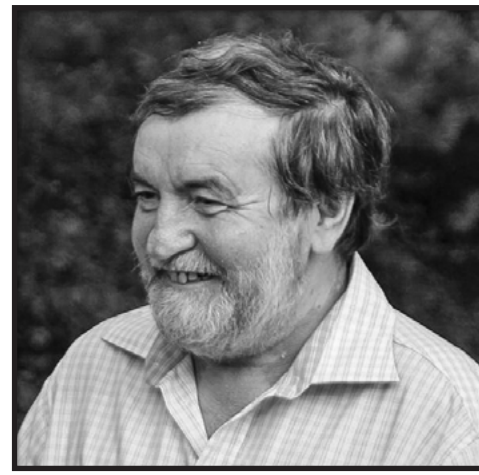
Jaroslav Koleček showing birds to children on Bird Chorus Day in Rožnov pod Radhoštěm.

(*Photo from archive of J. Koleček*)

OBITUARY

Jan Zima

(1952–2019)



We are sorry to announce that our dear friend, the leading European mammologist Jan (Honza) Zima, passed away on 26 March 2019, following a long and courageous fight against cancer.

Honza was born on 14 August 1952 in Prague. Encouraged by both his father and grandfather, his choice of future career was highly influenced by his school mate and life-long friend, Ivan Horáček, and by his advisor at Charles University in Prague, Vladimír Hanák, who directed him toward Mammology, and chiropterology in particular. The topic of his graduation thesis, karyotypes of bats, went on to become the main theme of his scientific career, comparative cytogenetics of mammals. In 1976, Honza entered the then Institute of Vertebrate Zoology of the Czechoslovak Academy of Sciences (now Institute of Vertebrate Biology, Czech Academy of Sciences), where he started his postgraduate study as a "research candidate" in the Morphological Department under the supervision of the distinguished comparative embryologist, Oldřich Štěrba. Over the following years he went on to evolve and accelerate his career in cytogenetics. In collaboration with his "lab mate", the karyologist Bohumil Král, he went on to build a respected centre of mammalian karyology, collaborating with colleagues from the U.K. (Jeremy B. Searle), Italy (Ernesto Capanna, Carlo Redi, Silvia Garagna), Switzerland (Jacques Hausser), Germany (Marianne Volleth), Poland (Stanisław Fedyk, Jan M. Wójcik), Sweden (Karl Fredga, Erland Dannelid), France (Vitaly T. Volobouev) and the former Soviet Union (Nina S. Bulatova, Alina Mishta). Honza's collaboration with B. Král peaked with publication of the highly cited, three-volume review Karyotypes of European Mammals (1984), a "gold standard" in the field. Honza was an excellent field zoologist and participated in many expeditions, not only throughout former Czechoslovakia but also in the Balkans, Ukraine, Poland, Turkey, Mongolia, Kyrgyzstan, Tian Shan, Pamir and Siberia. During this time, he rapidly became known as an outstanding and respected international expert in the field of comparative karyology; however, his scientific activities went well beyond the realm of chromosomes. Honza was interested in many facets of animal biodiversity, with an especial interest in the systematics, biogeography and phylogeny of mammals and other vertebrates, as well as conservation biology. He always strived for wide interdisciplinary collaboration, as illustrated by the high number and wide range of collaborators with which he published. A further characteristic of his scientific work was the introduction of new methods to zoological research. Though Honza always saw himself as a zoologist, he initiated the application of biochemical, and later, molecular genetic approaches to addressing zoological questions. He was one of the founders of the Czech Republic's National Animal Genetic Bank as well as the molecular laboratories at Charles University's Department of Zoology and the Studenec research facility of the Institute of Vertebrate Biology; this latter case representing a crucial turning point, triggering subsequent dynamic advances for the department. Prior to this, Honza initiated a series of informal lectures entitled "Genetic Methods in Zoology" for colleagues from a range of institutions. These lectures later became official teaching courses for Charles University in Prague and Masaryk University in Brno, where we now have the honour of "picking up the baton" and further evolving the subject in the future. Honza has educated, trained and advised around 30 students, many of whom went on to become respected experts in their

fields. His educational activities extended beyond the Czech Republic, however, as he has also acted as a dissertation reader and/or external examiner at universities in Switzerland, Sweden, the U.K., France and Germany. He authored or co-authored a number of student textbooks, including the second and third editions of Vertebrate Zoology (Academia, in Czech; together with Jiří Gaisler). In addition to more than 160 original research papers he co-authored several books such as The Atlas of European Mammals (Poyser Natural History, 1999), Mammals of Europe, North Africa and the Middle East (A & C Black Publishers, 2008) and Shrews, Chromosomes and Speciation (Cambridge University Press, 2019).

From the very beginning of his scientific career, Honza was deeply involved in organisational and management activities, including the organisation or co-organisation of several international conferences. Even as a postgraduate student, he joined the organising committee of the 2nd International Theriological Congress in Brno (1978), which would, in his own words, "strongly influence his future career by allowing him to make a number of contacts with scientists from behind the Iron Curtain". Exactly a quarter of a century later, he organised the 4th European Congress of Mammology (Brno, 2003). During his lifehe carried on his shoulders the weight of dozens of administrative duties in miscellaneous scientific, supervisory and editorial boards or other committees, the most important being his appointments as director of the Institute of Vertebrate Biology, a member of the Academic Council of the Czech Academy of Sciences and the long-term Editor-in-Chief of Folia Zoologica. We always admired Honza for his ability to continue his scientific work in the face of such a heavy organisational and administrative load. Perhaps more important, however, was that Honza was above all, an upright, tolerant, fair and inspiring person. Both as students and subsequently, we enjoyed numerous informal meetings over a pint of beer, full of amusing stories, apt comments and valuable lessons. He never hesitated to make fun of himself and was an excellent raconteur and storyteller with an admirable sense of humour.

Although we were aware of his illness, the sad news of his death hit us like a bolt out of the blue. Honza was still working without restraint to the very end, to the point where no one could admit he might pass away. Unbelievably, with time running out, his work drive was actually increasing. He even refused to take painkillers in order to focus on finishing a number of uncompleted projects. As such, he was happy to see the publication of Vertebrate Zoology and this year's Shrews, Chromosomes and Speciation. Without his tireless work, these books would probably neverhave existed. For the upcoming update of The Atlas of European Mammals, he managed to prepare a sample chapter and had finished the manuscript for an extensive monograph on The Classification and Phylogeny of Mammals. Unfortunately, Honza will now never have the chance to see these works on the bookshelf.

We all miss him painfully.

Miloš Macholán & Josef Bryja

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