Post-doc position at the Institute of Vertebrate Biology of the Czech Academy of Sciences

available from July 2019 to December 2020

Adaptive evolution of mitochondrial DNA and its nuclear counterparts in Ethiopian rodents

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Project background:
It has been suggested that a relatively small number of genes encoded by mitochondrial DNA (mtDNA) can play a disproportionately large role in reproductive isolation. The model of compensatory mitonuclear co-evolution even suggests that accumulation of mutations at mtDNA is an important integral process of speciation ("mitonuclear compatibility species concept"). Numerous mtDNA-nDNA interactions create an evolutionary dynamics where rapid mtDNA evolution favours compensatory nuclear gene evolution, ultimately leading to co-adaptation of mitochondrial and nuclear genomes. Although understudied so far, mito-nuclear incompatibilities, in conjunction with ecological selection, could be prevalent driver of speciation, particularly in response to climate or altitude. Among possible targets of such compensatory evolution, the most prominent is the process of oxidative phosphorylation (OXPHOS), which is essential for cell metabolism and where both mitochondrial and nuclear genes are involved. However, there is a general lack of empirical studies analysing compensatory co-adaptation in mitochondrial and nuclear (N-mtDNA) parts of the OXPHOS system. Relatively frequent observations of interspecific mtDNA introgression, which are often not paralleled by equivalent nuclear introgression, are paradoxical and reinforce the interest of studying the adaptive relevance of mitonuclear evolution. The adaptive nature of mtDNA introgression has been suggested in numerous taxa, but based solely on patterns of DNA polymorphism; the disentangling the relative contributions of neutral demography and natural selection remains a challenge.

The model system:
Ethiopian rodents provide excellent opportunity to study evolutionary processes on altitudinal gradients at the genetic level. The system is unique in that it involves evolutionary as well as geographical replicates. Our pilot studies showed clear spatial and altitudinal separation of relatively recently diverged rodent species from several genera (Fig. 1). Their distribution is affected principally by elevational ecotones and the presence of the Rift Valley, separating western and eastern mountain blocks as two replicates. Besides the important role of elevation on differentiation of rodent taxa, preliminary data suggest several mtDNA introgression events and reticulate evolution in multiple rodent groups.

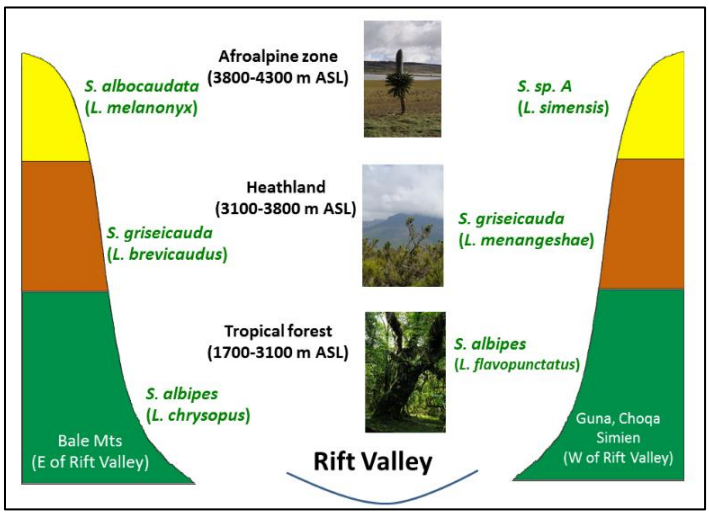

Fig. 1: Schematic distribution of *Stenocephalemys* species across altitudinal gradients in Ethiopian mountains. Note that a more or less similar situation exists in other genera of small mammals, e.g. *Lophuromys* (in parentheses), or *Arvicanthis* (not shown). The comparison of mitochondrial and nuclear phylogeny suggests either convergent evolution on cytochrome *b* as a result of strong selective pressure in high altitude (e.g. low partial pressure of oxygen) or past (adaptive?) introgression of mtDNA during cold periods in Pleistocene, when currently isolated Afroalpine populations could meet.

Goal of the project:
Complete mtDNA genomes are being obtained from selected individuals by genomic NGS sequencing of tissues with a high ratio of mitochondrial/nuclear genomes. Assembled mitogenomes will allow the comparative method to be applied to phylogenetic analyses, comparing non-coding, rRNA, tRNA and OXPHOS compartments in parallel for all individuals, which is necessary to evaluate the potential for adaptive selection, especially in high-altitude species. Sequences of nuclear OXPHOS genes will be obtained either by sequencing of transcriptomes or by whole-genome sequencing from already collected samples selected on the basis of preliminary analyses of previously assayed nuclear and mitochondrial markers (with special focus on populations with mtDNA introgression patterns of interest). After assembly, OXPHOS genes will be identified by comparison with annotated mouse genome data). Selection acting on both mitochondrial and nuclear OXPHOS genes will be analysed as well as co-introgression pattern of N-mtDNA genes. The results will test predictions regarding the long-standing debate about evolutionary (non)neutrality of mtDNA and assess the selective forces arising from the higher mutation rate of mtDNA on nuclear counterparts of OXPHOS complexes.

Research conditions:
The post-doc will work in a small team at Institute of Vertebrate Biology CAS, at Research Facility Studenec (https://www.ivb.cz/en/workplace/external-research-facility-studenec/). The Studenec campus (two hours from Prague) is situated in woods beside a lake in the Czech-Moravian highlands, half an hour from Brno, the second city of the Czech Republic, where the new large biological campus of the Masaryk University was recently built. The region's rolling hills and woods are popular with cyclists. The candidate will work in the joint office and lab building recently constructed with funding from Academy of Sciences of the Czech Republic. The research groups in Studenec are heavily biased toward early-career researchers, with a good gender balance at all levels, many young families and shared crèche/childcare services. On campus work discussion is in international English. The position is well suited to candidates who wish to broaden their experience and skills in an area of evolutionary study that will always be in demand, while at the same time maintaining a healthy work/life balance.

Requirements:
The successful candidate will have wide interests and a thirst for deep understanding. They will be intellectually mature and quick to learn. They will have experience in several of the following: population genetics, speciation, evolution, analyses of high-throughput sequencing data, phylogenetics. The postdoc academic advisors are trained in zoology, population genetics, and evolutionary studies. The candidate's existing and proposed work will be judged on its quality and utility to the scientific community rather than gross number of publications.

Candidates should submit a short CV and letter of interest in a single PDF file to Josef Bryja (bryja@brno.cas.cz), who is the principal investigator of projects focussing on evolution of African small mammals (https://www.ivb.cz/en/person/josef-bryja/). The work will be done in close collaboration with other specialists in speciation genetics/genomics working at Institute of Vertebrate Biology CAS (especially D. Čížková, O. Mikula, S. Baird and others). The applications will be read directly by the academic advisors and interviews will be held until a suitable candidate is found.

The deadline for applications is 15th of June 2019, the contract can start as early as 1st of July 2019 (it must end 31st of December 2020).