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On the Effects of Radioactive Contamination in Natural Populations:

Oxidative Balance and Genetic Stability

Abstract

The global demand for cheap nuclear energy grows, and so do the risks of an accidental release of nuclear products into the environment. Therefore, understanding the health and ecological effects of contamination by radionuclides should be of greatest interest for biomedical specialists and the public. Empirical studies unequivocally show that high doses of ionizing radiation (IR) shift the redox-balance of many biological systems and increase the rates of genetic errors. However, the effects of chronic low doses of radiation vary significantly between tissues and between species. The present dissertation comprises the results of experimental and meta-analytical research of a variety of biological effects of environmental contamination by radioactive isotopes.

In the review part (Chapter 1), we performed a rigorous literature analysis of the environmental consequences of the three most serious nuclear accidents – the Fukushima Daiichi nuclear power plant (NPP) accident in Japan (2011); meltdown at the Chernobyl NPP in 1986; and the explosion at the Mayak plutonium production site (both former USSR) in 1957. Our results demonstrate significant effects of the low (<0.1 Sv) doses of IR exposure on the redox systems of humans as well as animals from the surrounding environment affected by the nuclear accidents. We show significant heterogeneity in radiation effects between species and tissues, suggesting different sensitivity of biological models to IR.

In the experimental part (Chapter 2&3), we presented the results of several tests, by which we aimed to detect the detrimental genetic effects of low dose IR. We tested for the presence of radiation-induced damage in DNA and related that to the approximated data on radiation load and fitness of a sampled animal. We chose the bank vole as a vertebrate model and wild downy dragonfly as an invertebrate model. Both species were sampled in the Chernobyl Exclusion Zone (CEZ), as it remains significantly contaminated by the biologically effective isotopes: cesium-137 and strontium-90. We show that natural variation in comet-visualized DNA damage exceeds the additive effect of damage from ionizing radiation. We also show that accounting for morphological co-variates, such as sex and age, and random co-variates, such as sampling period, is important in prediction of genetic damage from the comet assay.