Evolutionary toxicology: The acute and chronic effects of chemical exposure and climate change on the life history traits and gene expression of resurrected Daphnia magna clones in a multiple-stressor world

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Introduction

• Resurrected Daphnia as a model organism to investigate micro-evolutionary adaptations of natural populations to multiple environmental stressors
• Resurrection ecology: Diapausing eggs as indicators of historical lake and landscape development.
• Through sexual reproduction, Daphnia produce sexual eggs (oostegites), which can persist as resting stages embedded in the sediment for centuries (Fig. 1) [1]

• Evolutionary toxicology: Examines the effects of environmental pollutants on genetics of modern and ancient Daphnia magna clones and their multi-generational and population-wide effects [2]
• Daphnia sp.: Keystone species with an important central role in the food web dynamics of limnetic ecosystems. Model organism in ecology, ecotoxicology and biomedicine based on short generation time, sequenced genome and transparency [3]
• Goal: Based on this project, the morphological and molecular adaptation mechanisms of the genus Daphnia to multiple stressors in the form of climate change and chemical exposure will be considered at different levels of a multiscale approach over a period of several hundred years

Fig. 1: Reproduction cycle of Daphnia (4)

Material & Methods

• Ephippia of historical D. magna clones were sampled at Lake Ring, Denmark, established by Orsini et al. [5] & at Stadtsee, Germany within the Bad Waldsee project
• Sexual eggs are resurrected according to protocol of Orsini et al. [6] and maintained in culture under optimal conditions
• Daphnia were exposed to phenanthrene (PHE), a model polycyclic aromatic hydrocarbon (PAH)

Fig. 2: Test strategy: Single stressors in the form of (1) chemical exposure, (2) temperature increase/decrease and multiple stressors (3) with chemical exposure and temperature change

• According to OECD guidelines Daphnia were cultured at 20 ± 1°C, 16:8 Light/Dark in M4 Medium
• The chronic effects according to OECD 211 [7] of two D. magna clones from Lake Ring, Denmark have already been investigated


Results & Discussion

• First results for chronic effects of modern D. magna clones (2.1 from 2004) and ancient clones (88.1 from 1866) from Lake Ring with phenanthrene exposure at 20 ± 1°C

Fig. 4: Number of offspring for 1_1(A), 2_1(B), and 88.1 brood (C) and total number of living offspring in the 21-d Daphnia magna reproduction test at 20 ± 1°C with PHE exposure (µM)

• Modern D. magna clones showed higher sensitivity in terms of their reproductive rate to chronic PHE exposure at 20 ± 1°C

Conclusion & Future plans

• In addition to the effects on reproductive rate with modern and ancient D. magna clones, data were also collected for reproductive time, morphology, and acute effects, which also showed stronger effects for modern Daphnia (data not shown)
• In addition to continuing the multiscale approach, more different aged Daphnia will be tested
• Daphnia will be examined in the future mainly from the sediments of the Stadtsee, Bad Waldsee, Germany within the DFG funded Bad Waldsee project
• Bad Waldsee project: An interdisciplinary research team of geoscientists, biologists, and historians was assembled to conduct high temporal resolution diatom and pollen analyses and geochemical-sedimentological investigations on existing sediment cores from the profundal of Stadtsee and to intersect and calibrate them with information from historical written records, deeds, charters, and maps
• This completeness of contemporary historical information, rarely found elsewhere, allows phenotypic differences of modern and ancient clones, such as different sensitivities to certain stressors, to be better discussed, represented, and placed in the overall ecological-athropogenic context.
• First sediment samples were taken at the Stadtsee and are currently being processed

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