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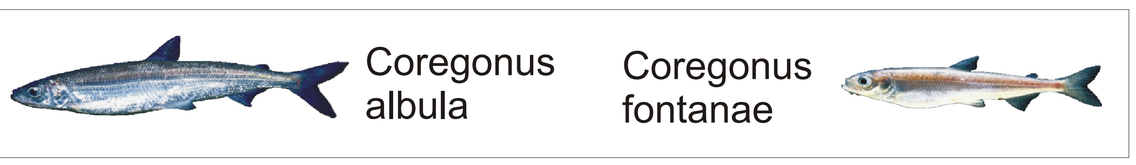
Sympatric ecological speciation associated with physiological adaptation to environmental temperature in a species pair of temperate freshwater fish

Introduction

The goal of my thesis is to identify mechanisms of the newly discovered sympatric speciation in two Coregonus spp. in Lake Stechlin, Germany. The habitat of the winter-spawning vendace (*Coregonus albula* (L.)) and the endemic spring-spawning Fontanae cisco (*Coregonus fontanae* (Schulz & Freyhof)) is predominantly defined by two abiotic (temperature, light) and one biotic (zooplankton) environmental factor, which decline continuously with depth (Mehner *et al*. 2005).

One main difference in the habitat use is the slightly lower mean temperature experienced by the Fontanae cisco (Helland *et al.* 2007). The fist part of my work was to test the hypothesis of a heritable phenotype-environment association in the swimming characteristics of the two species. This was done by raising them under identical conditions in the laboratory and testing for differences in swimming physiology according to their differential use of habitats in nature.



Method

We used intermittent-flow respirometry to study the energy expenditure during swimming in vendace and dwarf-sized Fontanae cisco of various body masses, swimming speeds and temperatures. From these swimming trails, we determined the net active metabolic rate (netAMR), i.e. the energetic costs for activity only, and the standard metabolic rate (SMR) at rest by extrapolation to zero speed. We then calculated the mass-dependency of the SMR (Fig. 1) and corrected the netAMR for size effects to present the metabolic cost to speed relationship (Fig. 2).

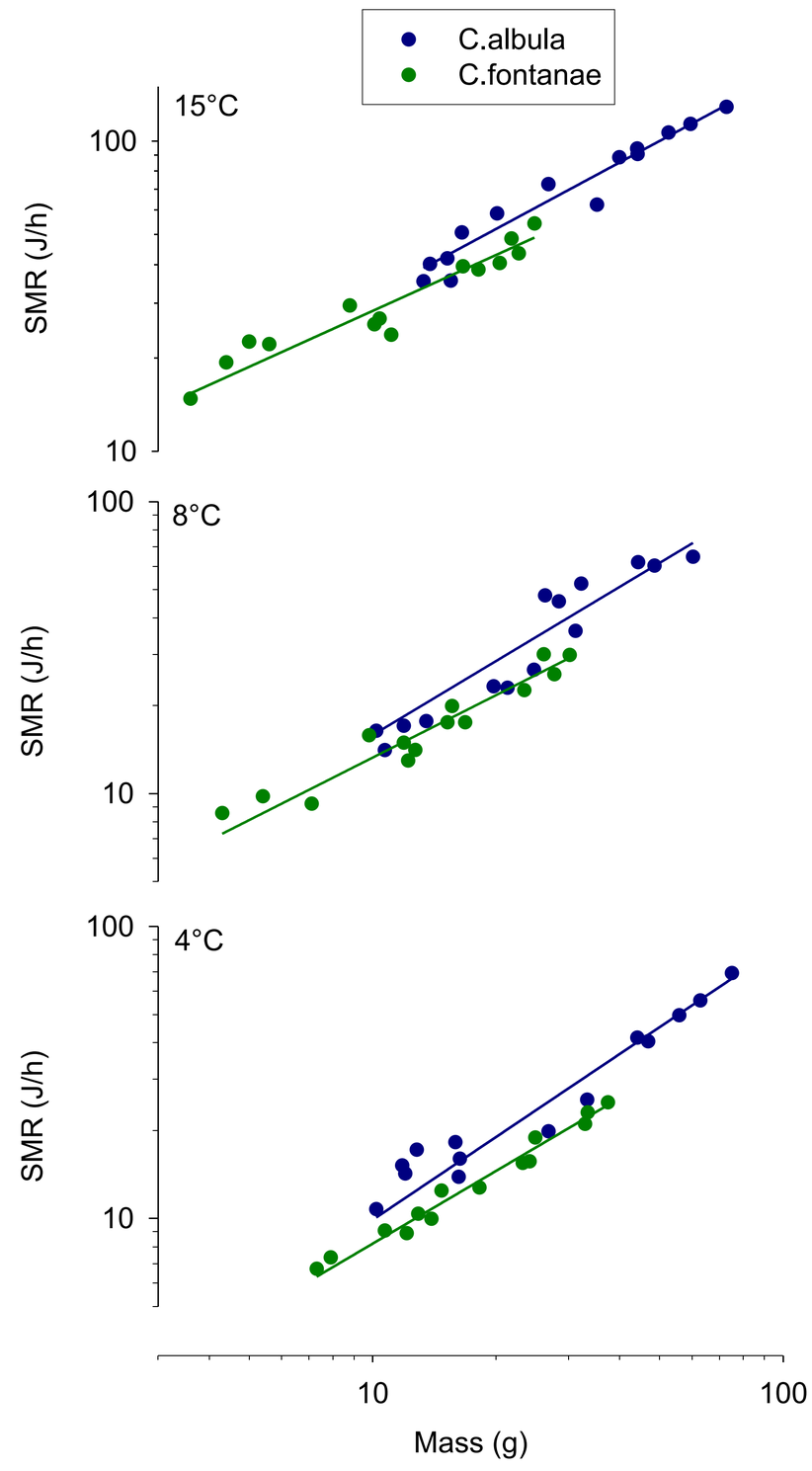


Fig.1: Standard metabolic rate (SMR) of C. albula (blue) and C. fontanae (green) at 4, 8 and 15°C over the investigated mass range. Fontanae cisco shows significantly lower SMR compared to vendace. The differences are significant at all three tremperatures according to F-statistics (P<0.01).

Results

The Fontanae cisco shows significant reductions in standard metabolism (SMR) at all three temperatures (Fig.1). Similar slopes suggest no effect of different size ranges for the two species. The active metabolism is higher at 8 and 15°C, but lower at 4°C compared to vendace (Fig.2). The increase in metabolic costs with swimming speed is similar between the species. This suggests that size and speed have no effect on this pattern, but that the differences observed represent species-specific physiological characteristics.

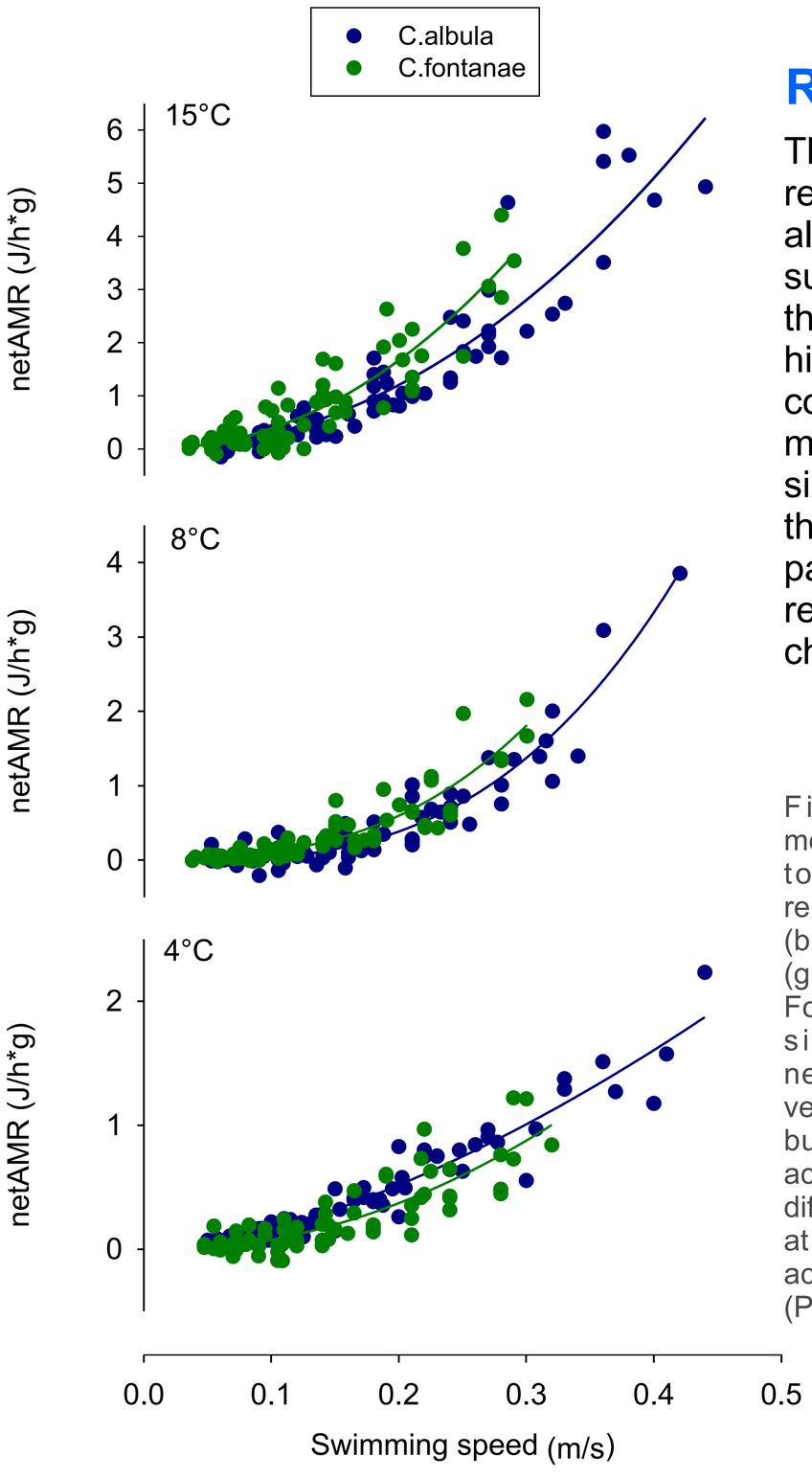


Fig. 2: Net active metabolic rate (netAMR) to swimming speed relationship for C. albula (blue) and C. Fontanae (green) at 4, 8 and 15°C. Fontanae cisco shows significantly higher netAMR compared to vendace at 8 and 15°C, but significantly lower activity costs at 4°C. The differences are significant at all three temperatures according to F-statistics (P<0.001).

Conclusion

The lower standard metabolism of the Fontanae cisco might represent an adaptation to energetic disadvantages associated with living in deeper waters and lower temperatures. This species is more efficient in swimming at low temperatures compared to sympatric vendace, which is in accordance with the slightly differencial habitat use of the two species. The results imply that the physiological differentiation between these sibling species is directly influenced by the environments they inhabit. The study thus provides evidence of a physiological phenotype-environment association, suggesting that the sympatric speciation was driven by divergent natural selection acting on metabolic traits. This leads to the conclusion that the process is likely to be adaptive in the sense of the adaptive speciation theory (Dieckmann *et al*. 2004, Schluter 2000).

References

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