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Adaptation to elevation in Brassicaceae species of the central Alps

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Author Maccagni, Alessio
Author at UniBasel Maccagni, Alessio ;
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Supervisor(s) / **Fachvertreter/in** Willi, Yvonne ; Hoch, Günter ; Alexander, Jake ;
Species are restricted in their spatial distribution, but the reasons behind this phenomenon are still not(entirely known. Temperature has been considered to play an important role for a long time, for(example because of the commonly observed overlap between isoclines and distribution limits, or for(the direct impact that temperature has on the physiology of organisms. From an evolutionary point of(view however, it is unclear why the climate niche of species does not seem to evolve such that species(ranges can extend unlimitedly. To shed light on the evolutionary constraints limiting species(distribution, I studied patterns of adaptation along an elevational gradient, which is essentially a(thermal gradient. I chose a macro-evolutionary approach and included in my analyses 100(Brassicaceae species covering a high diversity of restricted elevational ranges in the European Alps.(Species were compared in their thermal responses and thermal adaptation based on a climate chamber(experiment and a transplant experiment on a mountain slope, with 5 transplant sites from 600 to 2000(m of elevation. Climate chamber experiments revealed that low- and high-elevation species mainly(differed in the response of growth to temperature, with high-elevation species being better at growing(when daily temperatures reached a high maximum, but worse at growing to large size when night(frosts occurred. Therefore, results indicated a trade-off between fast growth under warm conditions(and frost tolerance. Analyses on an association between elevational range size and phenotypic(plasticity revealed no support for a positive link. However, I found that increased thermal(heterogeneity selected for stronger thermal specialisation, countering the hypothesis that temporal(environmental variability selects for increased plasticity. The transplant experiment demonstrated(that species were indeed adapted to their optimal elevation of occurrence; lifetime performance(declined if the transplant site was at a different elevation than the typical elevation of occurrence of(a species. Patterns established not via temperature-dependent mortality, but because reproduction(declined with increasing difference in elevation relative to the typical elevation. The probability of(fruit set decreased with increasing distance. Furthermore, I found that reproduction negatively affected survival to the next year, suggesting an allocation trade-off between reproduction and(longevity that may be also important in constraining the climate niche and its evolution. Overall, this(body of work supported that elevational range limits generally reflect niche limits, and that species(seem to have been selected for thermal specialisation. Evolutionary constraints in the widening of the(climate niche seem to include genetic trade-offs in growing fast under warm conditions and being(frost tolerant, and an allocation trade-off between reproduction and longevity. It is these two axes of(trade-offs or four axes of

life-history aspects that future micro-evolutionary studies should focus on(to confirm their role in constraining the evolution of the climate niche within species.

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