Evidence of local adaptation to fine- and coarse-grained environmental variability in Poa alpina in the Swiss Alps

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In the alpine landscape, characterized by high spatiotemporal heterogeneity and barriers, divergent selection is likely to lead to local adaptation of plant populations either through adaptive genetic differentiation or through phenotypic plasticity. The relative importance of these processes has rarely been investigated in relation to the spatial scale of environmental heterogeneity. In this study, we used reciprocal transplantation experiments of populations across nearby and distant field sites to shed light on these complementary processes. We reciprocally transplanted populations of the widespread alpine grass, Poa alpina, within and across regions in the Swiss Alps. We inferred local adaptation at the metapopulation level by comparing fitness of plants transplanted to their site of origin and to nearby or distant novel sites. Additionally, we measured specific leaf area (SLA) and performed selection analyses to investigate directional selection on mean trait value at each field site and on the degree of plasticity of this trait to assess whether plastic responses were adaptive. In parallel, all populations were genotyped with microsatellite markers to assess neutral molecular differentiation. Molecular differentiation was high among populations within and among regions, indicating restricted gene flow among P.alpina populations. Reproductive biomass was highest in individuals grown in their region of origin, revealing local adaptation to coarse-grained environmental variability. Similarly, inflorescence height, associated with reproductive biomass, reflected adaptation to fine- and coarse-grained environmental variability. Furthermore, we found evidence that plasticity in SLA across coarse-grained habitats was correlated with plant fitness, suggesting that plasticity in this trait is adaptive.Synthesis. Our results revealed adaptive genetic differentiation between P.alpina populations in the Swiss Alps reflecting local adaptation. Furthermore, high phenotypic plasticity in SLA contributed to the maintenance of fitness homoeostasis across habitats. Hence, adaptive genetic differentiation and phenotypic plasticity play a complementary role for adaption of P.alpina to environmental heterogeneity in the Swiss Alps and both may be critical to mitigate local extinction risk under rapid climate change.

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