Beyond cyanogenesis: Temperature gradients drive environmental adaptation in North American white clover (*Trifolium repens* L.)

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Abstract

Species that repeatedly evolve phenotypic clines across environmental gradients have been highlighted as ideal systems for characterizing the genomic basis of local environmental adaptation. However, few studies have assessed the importance of observed phenotypic clines for local adaptation: conspicuous traits that vary clinally may not necessarily be the most critical in determining local fitness. The present study was designed to fill this gap, using a plant species characterized by repeatedly-evolved adaptive phenotypic clines. White clover is naturally polymorphic for its chemical defense cyanogenesis; climate-associated cyanogenesis clines have evolved throughout its native and introduced range worldwide. We performed landscape genomic analyses on 415 wild genotypes from 43 locations spanning much of the North American species range to assess the relative importance of cyanogenesis loci vs. other genomic factors in local climatic adaptation. We find clear evidence of local adaptation, with temperature-related climatic variables best describing genome-wide differentiation between sampling locations. However, landscape genomic analyses indicate no significant contribution of cyanogenesis loci to local adaptation. Instead, several genomic regions containing promising candidate genes for plant response to seasonal cues are identified — some of which are shared with previously-identified QTLs for locally-adaptive fitness traits in North American white clover. Our findings suggest that local adaptation in white clover is likely determined primarily by genes controlling the timing of growth and flowering in response to local seasonal cues. More generally, this work suggests that caution is warranted when considering the importance of conspicuous phenotypic clines as primary determinants of local adaptation.

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