Ecological Observations

9. The evolution of traits in complex environments: switching in plant defenses

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ABSTRACT: Organisms exist in complex environments, yet the evolution of traits is usually studied in isolation. Plants, for example, exist in diverse communities, yet we know little about the effect of evolution in response to neighboring plants, or other environmental factors, on the evolution of plant defenses against herbivores. Optimality theory for the evolution of plant defenses, however, does suggest that adaptations to other environmental factors may compromise defense evolution simply because there may be insufficient resources to support multiple traits at maximum levels. In a set of recent studies, we asked whether the evolution of competitiveness in plants affected defense expression. We have been comparing two very closely related species of Arabis, which are close wild relatives of the model organism Arabidopsis thaliana. The two species segregate into habitats that differ in several correlated environmental factors. Arabis drummondii, for example, exists in diverse communities where below ground competition with neighbors should be relatively intense, while A.holboellii exists in less dense habitats, but more often in forest understories where above ground competition, or tolerance for shade, should be important. Growth chamber experiments showed that indeed A. drummondii grew relatively fast next to neighbors, while A.holboellii grew faster in response to shading, suggesting that these species have evolved differentially according to their habitats. We then compared the two species for resistance and tolerance defenses, where resistance is defined as traits that reduce damage, whereas tolerance is defined as traits that help the plant compensate for damage that has occurred. In contrast to optimality theory, we found that competitiveness and defenses were sometimes positively correlated. The better below ground competitor A. drummondii, for example, exhibited greater changes in toxic glucosinolate profiles in response to herbivory. Traits with dual functions in defense and competition would allow the apparent simultaneous evolution of traits. Further, traits with multiple functions may be regulated according to current environmental effects. We found that A.drummondii switched from toxins to tolerance when attacked in competitive environments. We are currently investigating the effects of other environmental factors, quantifying natural selection, and examining gene expression.