PROGRESS REPORT: 2004

Characterization of the Common Sunflower, *Helianthus annuus*, in Pristine Prairie Versus Anthropogenically Modified Habitat

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OBJECTIVES

The overall objective of my research is to examine the possibility that human-altered landscapes present significant selective pressures to the species that persist there, and that those pressures affect the population genetic structure of those species. What, if any, phenotypic changes result from adaptation to anthropogenically modified habitats? Are these responses strictly plastic, or are they under genetic control? How have the patterns of anthropogenic disturbance shaped the genetic structure of populations? The research I have performed to date largely answers the first of these three questions. Preliminary conclusions are presented here.

BACKGROUND

Ecology of disturbed habitats

Disturbed habitats, for the most part, are those that have undergone rapid and/or thorough modification. Disturbance may be caused by physical or by biotic events (such as fire, flood, insect outbreaks, disease), or may be caused directly by human activity (plowing, grazing, construction). Such modification of habitat usually results in reduction of species diversity and changes in the stability of the plant community at the disturbed site. This, in turn, often creates open and invasible habitat. The breadth and frequency of habitat modification and the scale of fragmentation of natural landscapes caused by humans may further increase a resident community's susceptibility to invasion (Vitousek et. al. 1996).

I focus on alterations of landscapes in the context of urbanization and road-building, and on how such alterations might select for unique adaptive strategies in the common sunflower, *Helianthus annuus*. The sunflower is an ideal species with which to study recent evolutionary responses to human activity because populations exist in many grassland preserves, as well as within the landscapes humans dominate.

Weediness as an adaptation to disturbance

H. G. Baker, in a symposium on The Genetics of Colonizing Species, defined as "weedy" those plants whose "populations grow entirely or predominantly in situations markedly disturbed by man." He went on to define and describe a "general purpose genotype" that grants plants a broad environmental tolerance—a formidable advantage in colonizing new habitats. In general, Baker predicted that the evolution of weediness would involve r-selected strategies: rapid growth, short generation time, and high fecundity (Baker 1965).

Herbaceous growth and abiotic dispersal are also common traits of invading species (Sakai et al. 2001), as are plasticity and tolerance of environmental heterogeneity (Baker 1965, Lee 2002). It bears mentioning, however, that in studies where plasticity has been explicitly tested, it has been found that additive genetic variance in the source populations may instead account for traits that confer invasibility (Lee 2002).

That humans create environmental disturbance goes without question. That such disturbance may affect the evolution of wild (i.e., not domesticated) species has also been demonstrated

(McNeilly and Bradshaw 1967, Allen and Sheppard 1971, Feder et al. 1990). It is likely that the forces of selection in disturbed areas differ from those in more pristine settings, and that selection favors weedy traits among plants that colonize disturbed landscapes (Rejmanek 1996, Lee 2002). Identification of r-selected strategies in plants might allow predictions about which introduced species could become weedy, but they do little to address the evolution of weediness itself. My research focuses on this crucial step: that selection imposed by disturbance may result in the evolution of weedy forms.

Sunflowers are adapted to natural disturbance (Heiser 1965), which occurs in even the largest tracts of unbroken and untouched prairie. I shall make the distinction between prairie sites and disturbed sites on the basis of scale: human disturbance generally covers a greater area and is more frequent than the natural disturbances to which the sunflower is historically adapted. I will argue that there may be aspects of a weedy form of sunflowers that allow these plants to invade and persist in disturbed landscapes.

RESEARCH PROGRESS

In the summer and early autumn of 2004, I visited seven different areas of prairie that are undisturbed by anthropogenic activity and which harbor *H. annuus* populations. Near each of these prairie sites I also identified a population of sunflowers occupying an anthropogenically disturbed habitat such as are found near roads or construction sites. The total study consists of 14 total populations, two of which are in the vicinity of Boulder, Colorado. The prairie site in Boulder County is at Marshall Mesa Open Space; the disturbed site is just west of the Flatirons Crossing shopping mall, near a recent construction project.

Within each of these 14 populations, I measured plant height (which results from rates of germination and growth) and the number and average size of inflorescences per plant (which influence seed set) for each of 30 plants. A two-way ANOVA was performed for each dependent variable: height, inflorescence set, and average inflorescence size, with environment (prairie versus disturbed) and locale (geographic location for each of the seven paired sites) as factors. The data were rank-transformed to meet assumptions of normality, and acceptable levels of Type I error were adjusted to account for multiple dependent variables. For each measurement overall, plants in disturbed sites were significantly more successful at growth and potential reproductive output than plants in the prairie (height: $F_{(1,338)}=135.54$, $p<0.0001$; inflorescence set: $F_{(1,340)}=63.26$, $p<0.0001$; inflorescence size: $F_{(1,339)}=189.38$, $p<0.0001$). Data for populations near Boulder, CO are presented in Table 1. These data and the six other within-locale comparisons (data not shown) demonstrate that plants in human-disturbed habitats are "weedier" than plants in prairie habitats.

Location	Habitat type	Height (cm)	Inflorescences Set (count)	Avg. Inflorescence Diameter (mm)
Marshall Mesa	Prairie	**29.6**	**3.2**	**11.7**
Flatirons Crossing	Disturbed	**53.7**	**9.9**	**17.6**

Table 1. Average values for the three metrics of growth and reproductive output for the two populations studied near Boulder, CO. All within-location comparisons (*a priori* analysis of prairie versus disturbance) are statistically significant ($p<0.05$).

I collected these same data at the two Boulder-vicinity locations described above in 2003 as well. The differences between the prairie and disturbed sites were also then significant, with plants in disturbed sites always being larger and setting more and larger inflorescences. It is interesting to note that although there was a substantial decline in all three metrics across both the prairie and disturbed sites in 2004 compared to 2003 (likely because 2004 was comparatively

quite hot and dry in the early part of sunflower's growing season), the relative difference in growth and reproductive potential between the two environments remained significant (data not shown).

DISCUSSION

The data presented here characterize the phenotypic differences among plants in prairie and disturbed habitats and provide evidence that weedy traits, as measured by three separate (but likely correlated) variables, are demonstrated by plants in disturbed sites but are relatively absent in prairie sites.

Most studies of weeds attempt to *predict* which species will become weedy if introduced to disturbed sites based on biological or physiological traits that set those species apart from their congeners (Gray 1986, Rejmanek 2000, Sutherland 2004). There are many comparative studies between typically weedy species and typically non-weedy ones, but these do not address how traits conferring "weediness" arose. My future research will address if selection imposed by disturbance may have resulted in the evolution of weedy forms. Genetic analyses will be employed in the coming year to ascertain the the genetic differentiation between populations in prairie and disturbed sites. The results will suggest whether weediness evolves in sunflowers each time a prairie is disturbed and the plants recolonize, or whether weedy traits arose once and the progeny of those plants have since successfully spread across the Great Plains.

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