Interactive effects of population genetic diversity and resident community composition on the success of an annual exotic invasive species.

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ABSTRACT

Abstract: Ecological theory predicts that the success of exotic invasive species may be affected by the genetic diversity of the exotic population as well as the species diversity of the invaded community. We tested how exotic population genetic diversity and resident community species diversity affected the success of the invasive annual grass, *Avena barbata*. We tested whether: (1) increased genetic diversity of the exotic population caused increased invasion success, (2) positive genetic diversity effects were greater in communities containing species functionally similar to the exotic invader, (3) diverse resident communities better resisted exotic invasion, and (3) resident communities composed of species functionally similar to the exotic better resisted invasion. In a fully factorial greenhouse experiment, we established resident communities which varied in species diversity (1, 2, or 3 species) and functional group composition (annual grass, perennial grass, and annual forb). These communities were invaded by *A. barbata* populations, which varied in genetic diversity (1, 5, or 10 genotypes). We measured invasion success using above ground biomass of *A. barbata*. There was a significant, positive effect of genetic diversity on *A. barbata* performance, while increasing resident community diversity decreased *A. barbata* performance. There was a negative main effect of the presence of *Nassella pulchra*, indicating that the presence of a perennial grass, not the functionally similar annual grass, was responsible for increasing community resistance to invasion. However, in functionally similar communities (composed of annual grass) increased genetic diversity positively affected *A. barbata* performance. These results indicate that understanding the interaction of invasive genetic diversity and resident community composition may be important for predicting potential invasiveness of exotic species in differing communities.

INTRODUCTION

Exotic Species Invasion Success: **Genetically diverse exotic species populations may be more successful invaders**

- Increased genetic diversity decreases intra-specific competition and increases resource partitioning, allowing for more efficient and complete resource use
- Increased genetic diversity increases the chance a population contains a highly functioning or productive genotype
- Increased genetic diversity may increase partitioning of resources and decrease competition between functionally similar species (species sharing similar growth or resource use characteristics)

Resident Community Invasion Resistance: **Species diverse resident communities may be more resistant to invasion**

- Diverse resident communities have greater partitioning of resources leading to more efficient and complete resource use
- Increased diversity increases the probability that communities include highly productive or competitive species

METHODS

Study System: California grasslands were historically dominated by native perennial bunchgrasses, but are now dominated by exotic annual grasses like *Avena barbata*. We tested our hypotheses in the context of invasion into native California grassland communities by establishing resident communities that varied in species and functional group composition. We then invaded these communities with *A. barbata* populations that varied in genetic diversity.

Experiment: Resident species were organized based on their functional similarity to *A. barbata* (exotic annual grass) according to growth patterns (exotic annual grass (*Lolium multiflorum*)> native perennial grass (*Nassella pulchra*)> native annual forb (*Amsinckia menziesii*)). Communities were established based on species natural growth form at the beginning of the growing season (annual species=seeds, perennial species=small plants). In a fully factorial design, we invaded communities composed of all possible species mixtures (1, 2, or 3 resident species) with populations of *A. barbata* that varied in genetic diversity (1, 5, or 10 genotypes) for a total of 63 pots. All resident communities were planted at a density of 20 plants per pot and invaded with 20 individual *A. barbata* seeds.

At peak biomass (approximately three months) all above ground biomass was harvested by species and dried at 60ºC for 48 hours. Relative invasive success was measured based on dried above ground biomass of *A. barbata*. The overall biomass of each invaded community did not vary based on treatment indicating that each community was constrained in carrying capacity and therefore in competition for resources.

Analysis: We used an ANOVA statistical model to asses the main and interactive effects of *A. barbata* genetic diversity (1, 5, 10 genotypes), resident community diversity (1, 2, 3 species), and resident community species (presence, absence).

HYPOTHESES

Exotic Species Invasion Success

1) **Increasing the genetic diversity of exotic species populations will increase their invasion success regardless of resident community diversity.**
2) **Positive genetic diversity effects will be greatest in communities containing species functionally similar to the invader.**

Resident Community Invasion Resistance

3) **Increasing the species diversity of resident communities will cause increased invasion resistance regardless of exotic population genetic diversity.**
4) **Resident communities containing species functionally similar to the invader will better resist exotic invasion.**

RESULTS

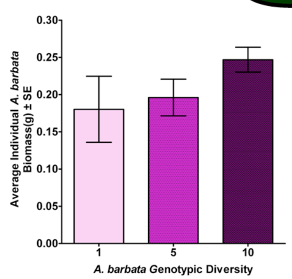

Figure 1: H1 Supported - Increasing genetic diversity of *A. barbata* populations did significantly increase its invasion success (individual biomass) (P<0.05). However, the effect of genetic diversity depended on the composition of the resident community (see Fig. 2).

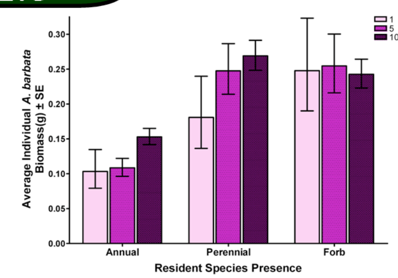

Figure 2: H2 Supported – Increasing genetic diversity of *A. barbata* populations did significantly increase its invasion success in communities containing species more functionally similar to *A. barbata*: annual grass, *L. multiflorum* (P<0.05), and perennial grass, *N. pulchra* (P<0.05). While in communities containing the annual forb, *A. menziesii, A. barbata* genetic diversity had no affect on its invasion success.

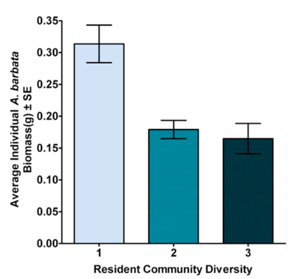

Figure 3: H3 Supported - Increasing resident community species diversity did significantly decrease *A. barbata* invasion success (P<0.001). However, most of this effect was due to the presence of one species, *Nassella pulchra* (see Fig 4).

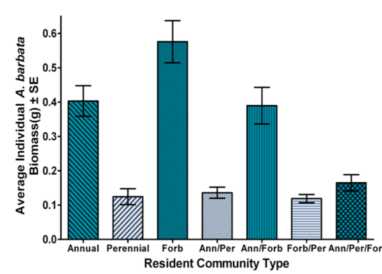

Figure 4: H4 Not Supported -Communities that were functionally similar to *A. barbata* did not better resist invasion (P>0.05). Instead, communities that contained the perennial grass, *N. pulchra*, best resisted invasion (P<0.001). It is the presence of this species that accounted for the resident species diversity effect, where more diverse communities had a greater chance of containing *N. pulchra*.

DISCUSSION

Ecological theory predicts that genetically diverse exotic species will have increased invasive success and species diverse resident communities will have increased invasive resistance. This experiment provided support for both effects.

Exotic Species Invasion Success: Although many successful invaders, such as those with clonal reproduction, have low genetic diversity our results indicate that genetic diversity may increase the invasive potential of exotic plant populations under specific invasion scenarios. We found that genetically diverse exotic populations had increased invasive success in communities containing annual and perennial grass species (Fig. 1 and 2), which are functionally similar to *A. barbata*. This suggests that genetic diversity may be an important predictive indicator of invasive potential when resident community members share similar growth habits and resource use characteristics as the exotic species.

Resident Community Species Diversity: Increasing resident community species diversity significantly decreased invasion success (Fig. 3), but this invasion resistance was attributable to the presence of the native perennial grass, *N. pulchra*, not the functionally similar annual grass species (Fig. 4). These results indicate that the presence of a specific resident species is responsible for creating community resistance to invasion. Increasing community diversity increases the chances the community contains these resistant species, not that diverse communities have more efficient and complete resource use.

MANAGEMENT

Exotic species genetic diversity:
Exotic populations with high levels of genetic diversity

1) **may have increased invasive potential in a single environment**
2) **have the genetic variability necessary to rapidly adapt to new environments increasing the risk of invasive spread**

Risk Assessment: Management agencies should consider including genetic diversity characteristics into risk assessment models for potential invasive species.
Genetic monitoring: Genetic sampling of exotic species populations may provide insight as to standing levels of diversity. This information may be useful in assessing the invasive potential of the species, but may also be used to track changes in the exotic populations due to multiple introductions and gene flow as these processes act to increase genetic diversity. Increases in exotic population genetic diversity may indicate when a species range is beginning to spread. Therefore, monitoring these changes will allow managers to select potentially invasive populations for eradication before large scale spread occurs.

Resident Community Species Diversity:
Conserving Biodiversity: Diverse communities have a higher probability of containing resident species that help exclude potential exotic invaders. Protecting existing biodiversity may help communities remain naturally resistant to invasion by exotic species.
Nassella pulchra: Our perennial grass, *N. pulchra*, was once a dominant species in California grasslands and seems to provide resistance to exotic annual grass invasion. These data suggest that *N. pulchra* may be an ideal species for use in California grassland restoration where reinvasion by annual exotic grasses may be a problem.

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