Is Phenotypic Plasticity Associated with Colonization Success? Comparisons of Native, Non-Native, and Relict Populations of *Arabidopsis Thaliana* (Brassicaceae)

PROPOSAL

Weedy species cost society $120 billion a year in environmental damages[1] and identifying the reason for their colonization success is urgent as we face the consequences of climate change, ecosystem alteration, and the loss of biodiversity. Most weedy species are capable of significant range expansion through underlying mechanisms for colonization success[2] such as phenotypic plasticity[3]. Phenotypic plasticity is exhibited when a single genotype can produce varying phenotypes in response to heterogeneous environments[4,5]. Plasticity can 1) improve colonization success when plants are introduced to a new environment[6,7], 2) facilitate range expansion across environmental gradients[8], or 3) enable plants to cope with rapid environmental change such as anthropogenic disturbance[9]. As such, plasticity has been theorized to be an ideal characteristic of invasive species[10], which are known to be successful invaders in a diversity of habitats. However, there is conflicting evidence regarding the differences in phenotypic plasticity between invasive and native species. Several studies support[11,7] and refute[12] that invasive species are more plastic than their native species counterparts. At the population level, prior research also offers conflicting results depending on the taxon examined and the treatments imposed[13,14]. Therefore, we cannot conclusively identify if plasticity is being used as a mechanism to overcome colonization barriers. As society continues to redistribute species across the globe, it is essential that we understand what mechanisms allow for successful colonization and invasion. My study aims to 1) determine if plasticity plays a role in successful colonization and 2) identify if patterns of plasticity are differentiated across species ranges.

RESEARCH QUESTIONS & METHODS

My research aims to empirically test if non-native populations of a worldwide naturalized species, *Arabidopsis thaliana*, are more phenotypically plastic in the selected measured traits than those collected in the native range. The primary question is: **Do patterns of phenotypic plasticity differ between native, non-native, and relict source populations of *Arabidopsis thaliana*?** *Arabidopsis thaliana,* an ideal candidate for examining range expansion mechanisms, has demonstrated plasticity in traits relevant to fitness[15-20] and can be found in a diversity of climate extremes as well as wide range of habitats.[21,22] My hypothesis is that populations from the non-native range will show significantly greater plasticity in traits measured than the native range and the relict populations. If colonization filtered out non-plastic plants from establishing successfully in North America, then we would expect these recently introduced populations to have elevated levels of plasticity as it is the mechanism that allows their successful colonization and persistence. I hypothesize that the weedy European populations will exhibit an intermediate level of plasticity. While thousands of years have occurred since their post-glacial expansion throughout Europe[23], there may still be detection of residual levels of plasticity that facilitated their past range expansion. Furthermore, plasticity may also be present from current expansion patterns of these weeds into available habitats in European cities and agricultural fields[23]. In these habitats, these weeds can function as ecological generalists to survive by increasing their niche breadth[9]. Lastly, relict populations of *A. thaliana* will be used as an ancestral proxy to compare patterns of phenotypic plasticity throughout this species' range to assess if plasticity has changed during colonization. The relicts are hypothesized to have the lowest levels of plasticity since they have remained in their respective niches and have not undergone range expansion[24].

More time has occurred in this lineage to locally adapt to these habitats and for natural selection to fix plastic traits.

To address these questions, twenty-five natural populations were selected to represent *A. thaliana's* global range and purchased through the Arabidopsis Biological Resource Center. Whole genome sequences are available for all of the chosen populations. This enables direct pairing of native and non-native populations from the same genetic cluster[23] to identify associations of plasticity with the recent colonization of North America. Under climate and anthropogenic change, multiple abiotic and biotic shifts occur simultaneously;[9,25] therefore, a cross treatment design manipulating temperature, light, water availability, and nutrient availability will be implemented to mirror conditions under rapid environmental change. Plasticity is often measured through assessing the slope of reaction norms (a graph of the means of each phenotype expressed by the same genotype) in two environments; however, employing this methodology may be misleading because trait responses are often nonlinear across environmental gradients[26]. By employing a gradient of multiple treatments, my study will have the power to detect these nonlinear patterns of plasticity. Furthermore, I plan to compare plastic reproductive and vegetative plastic allocation strategies. In conducting a meta-analysis, Liao[27] found that phenotypic plasticity played an important role in traits relevant to fecundity and biomass allocation in invasive taxa. In my study, total number measurements of inflorescence branches and silique fruits will be contrasted with the number of rosette leaves and leaf blade length. I also plan to measure phenotypic plasticity in traits which have a strong effect on fitness such as days to germination, plant height, and trichome density. Data from this research will be made publicly available through the AraPheno database for future scientific use. This research will be instrumental in the completion of my Doctor of Philosophy in Biology degree.

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PREVIOUS USE OF GRAC RESEARCH FUNDS

I have never received Graduate Student Graduate Resource Allocation Committee research funds before, and this is the first time I am applying for the GRAC funding.

BUDGET			
Expenditure	**Description**	**Funding**	**Amount**
Seed stock	25 accessions @ ~$13/vial of 100 seeds for greenhouse experiment + shipping	**GRAC**	$ 365.00
Soil	2 bags Sun Gro Metro-Mix® 360	**GRAC**	$ 58.98
Arasystem kit	accommodates 360 plants (385 €)	PI's Grant	$ 435.00
Arasystem kit shipping	Arasystem Shipping from Belgium	PI's Grant	$ 209.00
SUBTOTAL			**$ 1,067.98**
	TOTAL		**$ 1,067.98**
	TOTAL FUNDS REQUESTED FROM GRAC		$ 400.00

BUDGET JUSTIFICATION

I am requesting funds from the Biology Graduate Student Graduate Resource Allocation Committee to be allocated to the purchase of soil and seeds for my experiment. In order to represent the global range of my study species, 25 vials of seeds plus shipping have been indicated in the budget. I have submitted a proposal to the Ada Lovelace Microsoft Fellowship as an additional funding source and will be notified in November if I receive an interview. Funds will also be applied for through the Ford Predoctoral Fellowship and the Botanical Society of America's Graduate Student Research Awards in December and January, respectively. If awarded, the funds from the BGSA Graduate Resource Allocation Committee will help me conduct research for the first chapter of my Doctor of Philosophy in Biology degree.