Character Displacement of Native Species and Closely Related Invasive Species

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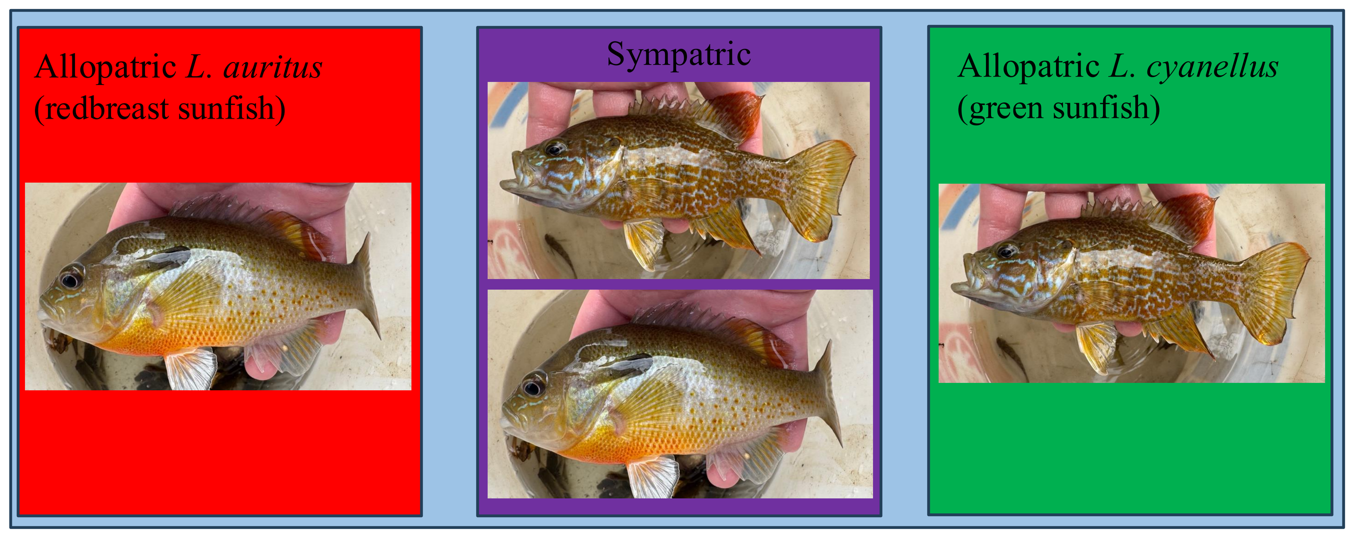
Introduction

When two closely related species coexist in the same area, they often separate their niches and habitats to reduce competition[1]. Character displacement occurs in sympatric populations of competing species, where their traits diverge from allopatric populations because of competition [2]. They achieve this through various biotic and abiotic factors, such as diet and habitat [4, 5]. One species is forced to specialize while the other can remain a generalist [1, 2]. *Lepomis auritus* (redbreast sunfish) and the introduced *Lepomis cyanellus* (green sunfish) are closely related generalists found in Virginia rivers. *L.cyanellus* outcompetes other *Lepomis* species, potentially threatening native *Lepomis* by monopolizing resources [5]. This research aims to deepen our understanding of community ecology by learning how two generalists can coexist.



Objectives

The objective of my research is to understand how two closely related generalists can live in sympatry. To do this, I will compare the morphology and diet of these species when they are together in sympatry and alone in allopatry. I hypothesize that one or both target species will exhibit a shift away from the other species, becoming more distinct in sympatry, which could minimize competition between both species in sympatry.

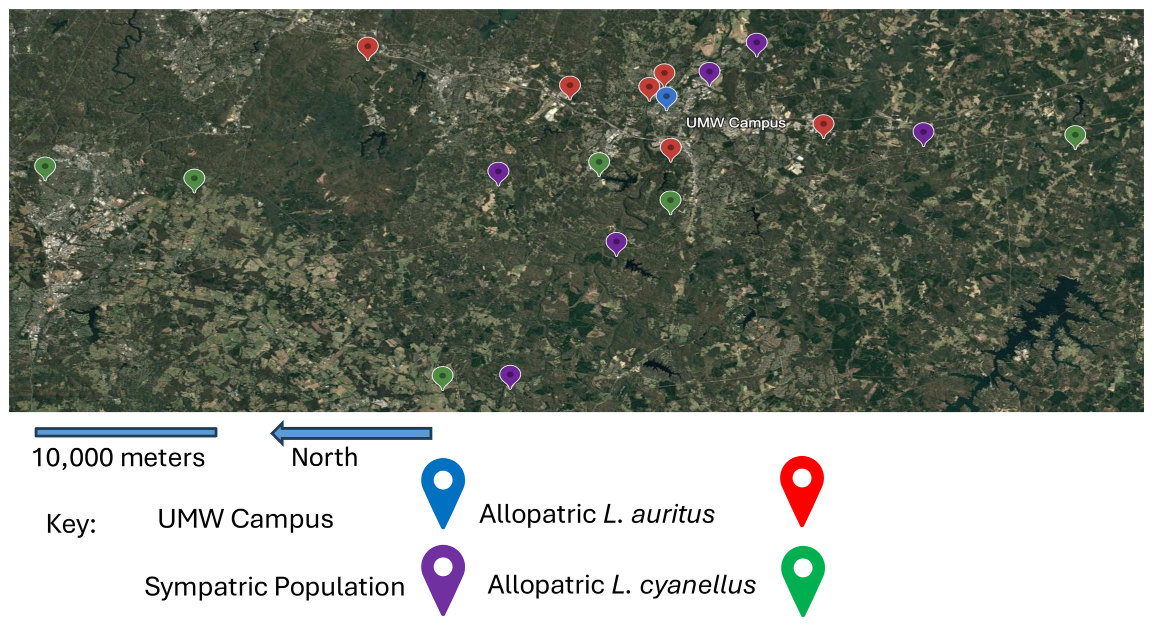


Figure 1: Satellite image marking locations of sampled rivers around the University of Mary Washington (UMW) Fredericksburg campus.

Methods

Fish samples were collected using backpack electrofishing in streams near the University of Mary Washington campus in Fredericksburg, VA. Sample sites were chosen based on whether *L. auritus* and *L. cyanellus* were allopatric or sympatric. Individuals less than 40 mm in length were excluded due to challenges with working with individuals of that size. Fish were photographed with an iPhone at 2x magnification, and key morphological landmarks were marked on the fish's bodies using TPS software. The landmarks chosen relate to mouth shape and body shape because these affect a fish's success in their habitat. After photographing, the digestive tracts were removed for diet analysis, and prey items were identified to the lowest taxonomic level. I then used Principal Component Analysis (PCA) to identify differences in the morphology and diet data collected for each population.

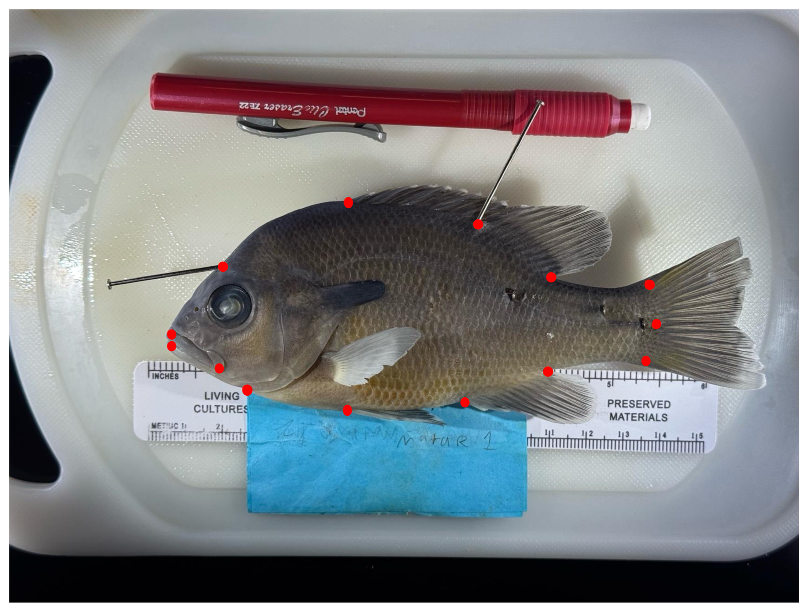
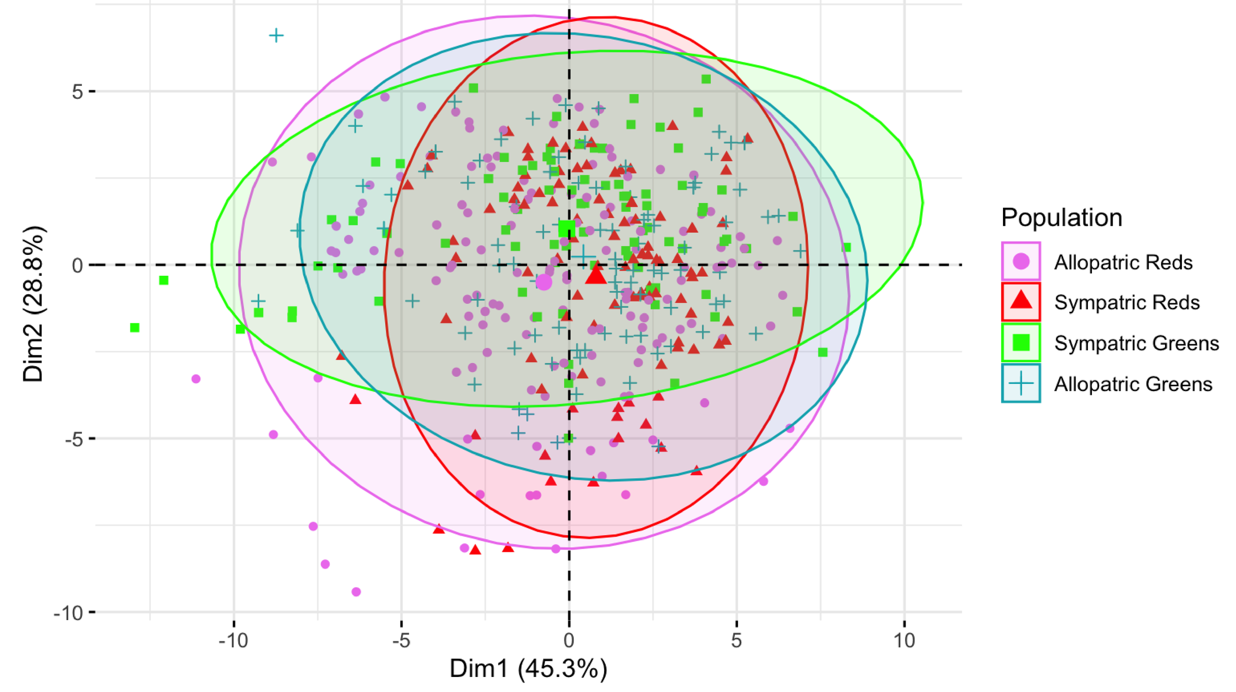


Figure 2: *L.auritus* with landmarks used to collect data for morphology study. The same landmarks were used on *L.cyanellus.*

Results

A

Strong Morphology Overlap Between Sympatric and Allopatric Populations



B

Body Shape of Extreme Individuals

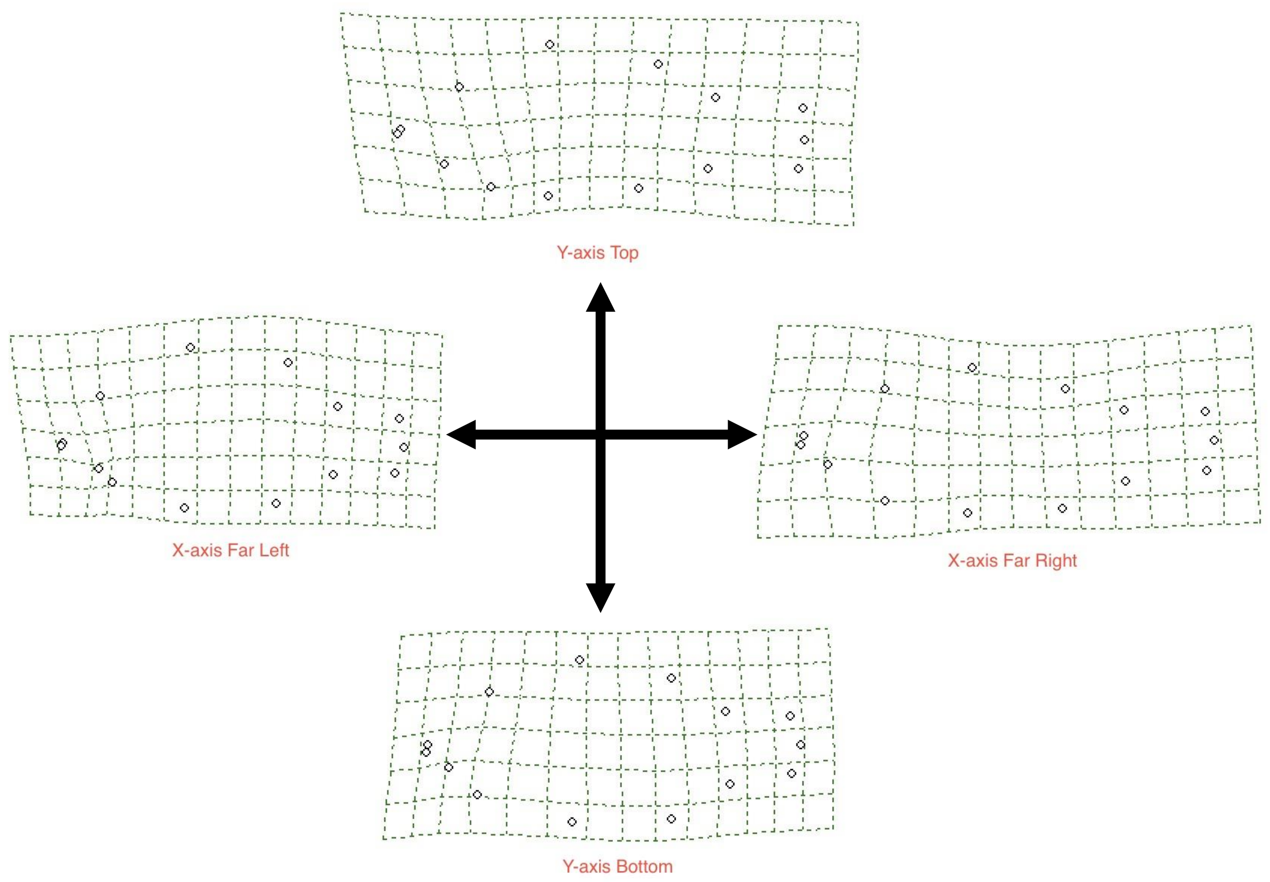
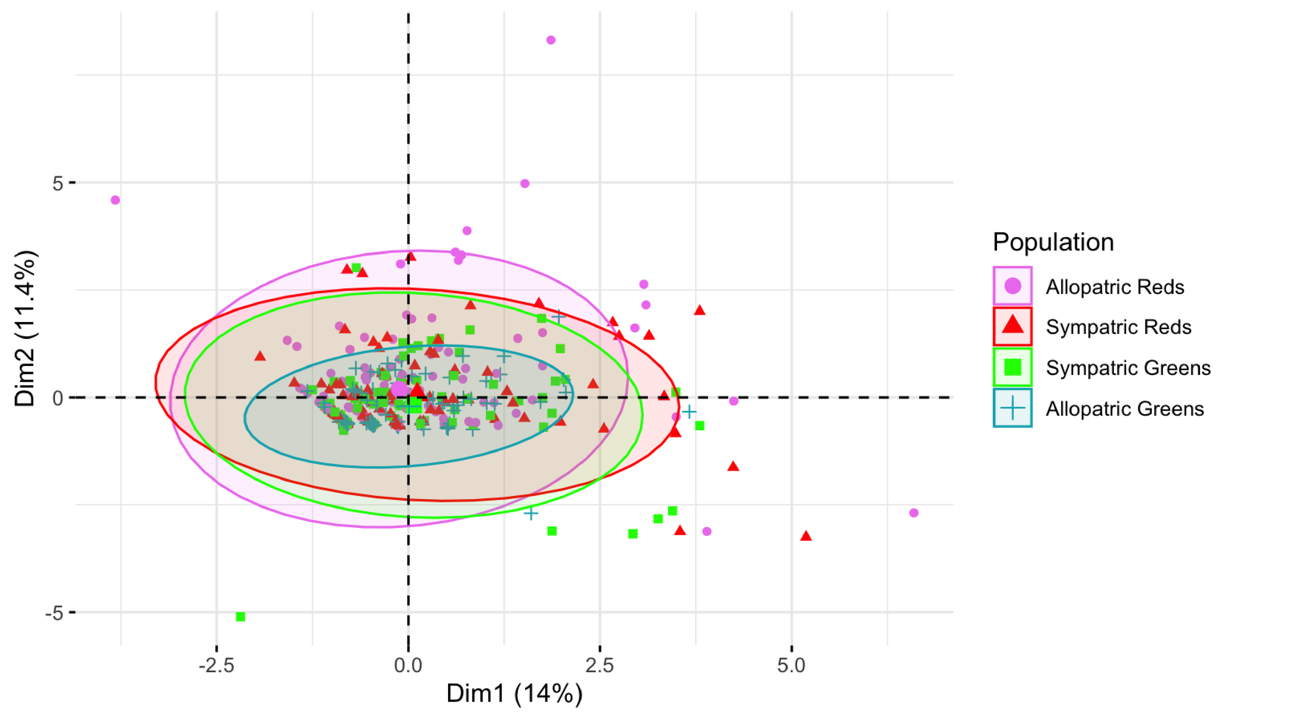


Figure 3: A shows PCA of morphology between allopatric and sympatric populations of *L. auritus* and *L. cyanellus* (n = 420 individuals) with concentration ellipses showing overlap. Dim 1 represents maxilla length along, and Dim 2 represents breast length. B shows the body shape of extreme individuality along each axis. Distortion represents areas that impact morphology variation and identifies the change associated with dimensions 1 and 2 (B).

My morphology PCA shows significant overlap between both species in sympatry and allopatry, shown by the concentration ellipses (Figure 3A). It identified two dimensions (Dim) as responsible for the most variation: head shape (Dim 1 = 45.3%), breast length (Dim 2 = 28.8%) (Figure 3B). The Diet PCA also has significant overlap in the concentration ellipses, showing significant diet overlap between both species in all types of populations (Figure 4A). Due to the wide range of prey items used by both species, the PCA struggled to identify any large differences; however, it does show that two dimensions have a similar impact on dietary variability, being: Terrestrial Insecta vs aquatic larvae (Dim 1 = 14%), Insecta vs fish (Dim 2 = 11.4%) (Figure 4B).

A

Strong Diet Overlap Between Sympatric and Allopatric Populations



B

Diet Variables Impact on Dimensions

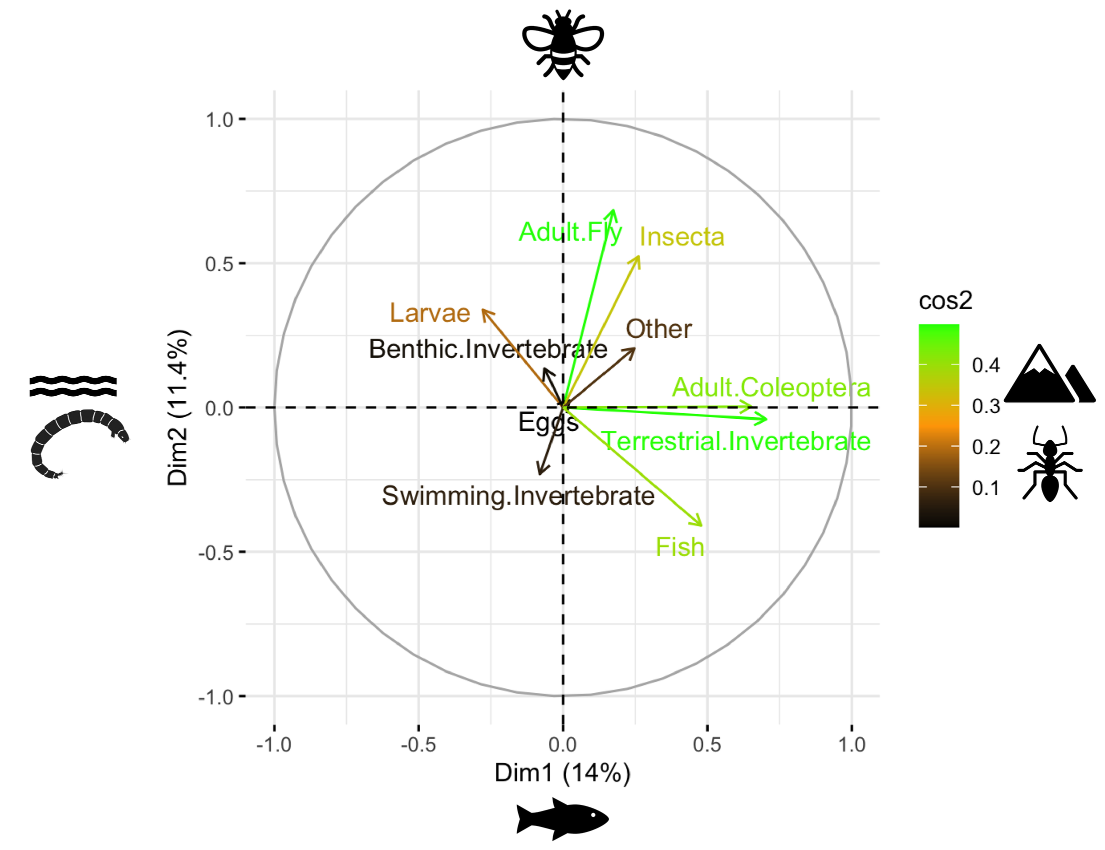


Figure 4: PCA of diet between allopatric and sympatric populations of *L. auritus* and *L. cyanellus* (n = 428 individuals) with concentration ellipses showing overlap (A). Dimensions are Dim 1: Terrestrial Insecta vs aquatic larvae (aquatic prey left, terrestrial prey right), Dim 2: Insecta vs fish (more insects top, fewer insects bottom) (B). Color gradient in B shows each variable's effect on dimensions 1 and 2, with green color lines having a stronger effect and black lines having weaker effects.

Discussion and Future Research

We can see that there is significant overlap between both species in allopatry and in sympatry, with little evidence of a shift away from each other that would show character displacement. Based on this, both species should be experiencing heavy competition when in sympatry. Not enough time has likely passed for any notable changes in morphology or diet to be present. The next step in this research would be to quantify the amount of competition and the source of competition, be it habitat, food, or both. One option is to sample populations in the Mississippi drainage, where *L. auritus* is the introduced species would provide useful information on how these species interact, showing how *L. cyanellus* reacts to invasion. Additionally, examining the genetics of the populations could show hybridization between *L. auritus* and *L. cyanellus*, as some of the fish seen may not have been purely one species, but these individuals were rare.

Citations

1. Benítez-López A, Viñuela J, Suárez F, Hervás I, García JT. 2014. Oecologia.
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Acknowledgements

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