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Evolution of morphological plasticity with respect to an invasive predator

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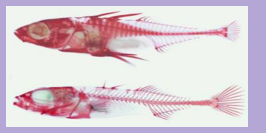

Introduction

- In ecological systems, prey show phenotypically plastic responses to predator cues.
- These responses can be morphological or behavioral and they evolve over time (Levis and Pfennig; 2016).
- The strength of these responses are variable across populations and are determined by selection pressures in the environment.
- About 70 years ago, Northern Pike (*Esox lucius*) were introduced to Threespine Stickleback (*Gasterosteus aculeatus)* populations in south-central Alaska, USA.
- Northern Pike appear to impose selection pressures on Stickleback in the form of affecting female reproductive effort (Heins et al. 2016).
- Some stickleback populations have even gone extinct following Pike invasions (Patankar et al. 2006).

Questions

1.) Do Stickleback show similar morphological plasticity that we see in other prey species?

2.) Do these responses evolve following Pike introduction?

Prediction: The fish should display morphological plasticity. Specifically, there should be increased body mass and increased pelvic spine length.

Methods

- This experiment consisted of 6 experimental populations: 3 of which were originally pike-invaded and 3 were originally pike-free.
- The populations of fish were split into two rearing groups: one group was "attacked" by a replica Northern Pike on Mondays, Wednesdays, and Fridays for 7 months.The second group was not attacked, thus not exposed to predator cues.
- After the 7 month period, the fish were preserved in formalin (CH_2O) to collect measurements on four dimensions: standard length, body depth, mass, and left pelvic spine length. Digital calipers and scales were used to collect these data.
- Statistical analyses were completed in R Studio and the figures were created using Statistica.

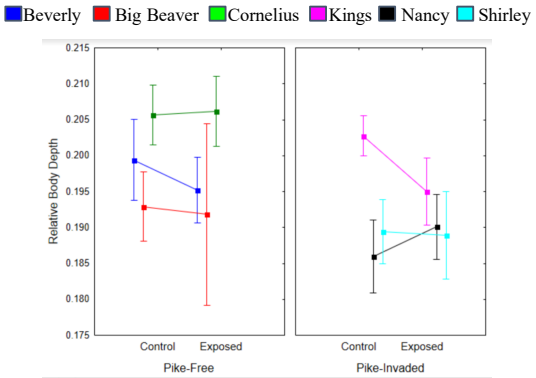

Figure 1: Change in relative body depth following "attack" treatment or control treatment.

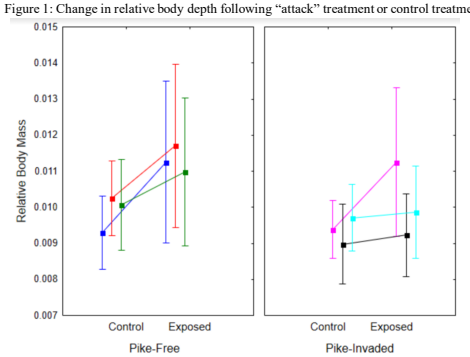

Figure 2: Change in relative body mass following "attack" treatment or control treatment.

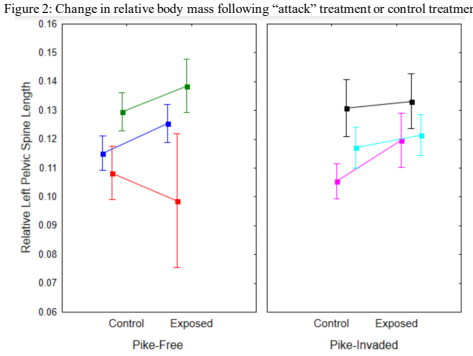

Figure 3: Change in relative left pelvic spine length following "attack" treatment or control treatment.

Results

- Body Depth ANOVA: We found a non-significant effect of Pike Status ($F_{1,4}$=1.25, p=0.32), a non-significant effect of Treatment ($F_{1,245}$=1.74, p=0.18), and a non-significant interaction ($F_{1,245}$<0.001, p=0.98) on the Relative Body Depth (**Figure 1**).
- Body Mass ANOVA: We found a non-significant effect of Pike Status ($F_{1,4}$=4.94, p=0.08),a significant effect of Treatment ($F_{1,245}$=8.93, p<0.001), and a non-significant interaction ($F_{1,245}$=0.80, p=0.37) on the Relative Body Depth (**Figure 2**).
- Left Pelvic Spine ANOVA: We found a non-significant effect of Pike Status ($F_{1,4}$<0.001, p=0.98), a significant effect of Treatment ($F_{1,245}$=7.96, p<0.001), and non-significant interaction ($F_{1,245}$=0.07, p=0.78) on the Relative Body Depth (**Figure 3**).

Discussion

- The results of the experiment demonstrate that populations exposed to Northern Pike predator cues have greater body mass and longer pelvic spines.
- These changes in body mass and spine length did not differ between pike-invaded and pike-free groups.
- Thus, there is evidence of phenotypic plasticity.
- The presence or absence of Pike in the origin populations does not appear to have an effect on the evolved morphology.
- These results indicate that Northern Pike are not strong enough predators to have an effect on the majority of Stickleback, except for in a few special cases.
- In the Patankar et al. 2006 study, the Stickleback population lacked pelvic armor, and did not have the capacity to defend themselves against predators morphologically, though they display specialized defensive behaviors..

Future: Future research will likely geometric morphometrics, to produce a more exact understanding of where the morphological changes are occuring, and to what extent (Wund et al. 2008). Additionally, additional experiments will be instrumental in better understanding the strengths and weaknesses of Northern Pike as predators in Stickleback-Pike systems.

Literature Cited

1. Levis and Pfennig 2016. TREE
2. Patankar et al. 2006. Ecology of Freshwater Fish
3. Wund et al. 2008 American Naturalist

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