How Do Short Winters Affect Energy Allocation Trade Offs in Coolwater Fish?

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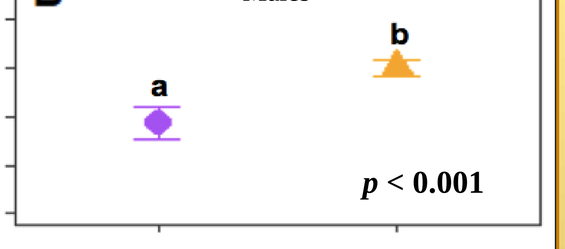
Introduction

- Yellow Perch, *Perca flavescens*, is a species that inhabits a wide latitudinal range across North America and prefers cool, well oxygenated water.
- This species is well studied in northern latitudes, however information on basic life history traits is lacking in the southern portions of this species range.
- Climate change could profoundly affect coldwater fish species, especially those that require long, cold winters to develop viable eggs prior to spawning during spring.
- In this study our objective was to understand how winter duration affected Yellow Perch reproductive and somatic growth during winter in both South Carolina and Ohio populations.
- We hypothesized that 1) long winters would increase reproductive growth, while short winters would increase somatic growth and 2) the Ohio population would allocate more energy to reproduction than the southern population.

Figure 1. Locations of both Ohio and South Carolina Yellow Perch collection sites that contributed to the lab experiments.



Methods

- Controlled experiments were conducted to simulate recently observed long and short winter durations for both Ohio and South Carolina populations (Figure 1).
  - OH: Lake Erie, collected fall 2011, long (107 d) and short (52 d) winter durations at 4C.
  - SC: Savanah River, collected fall 2018, long (42 d) and short (21 d) winter durations at 8C.
- Both OH and SC fish were fed at basal metabolic rates as determined from bioenergetic models.
- Sex-specific linear regressions relating gonad mas to body mass were developed from a subset of individuals sacrificed at the start of the lab experiments. They were used to predict initial gonad mass for each fish in the experiment.
- One-way ANOVAs were used to assess winter duration effects on overwinter change in gonad and somatic mass to compare overwinter change among both OH and SC.

Results

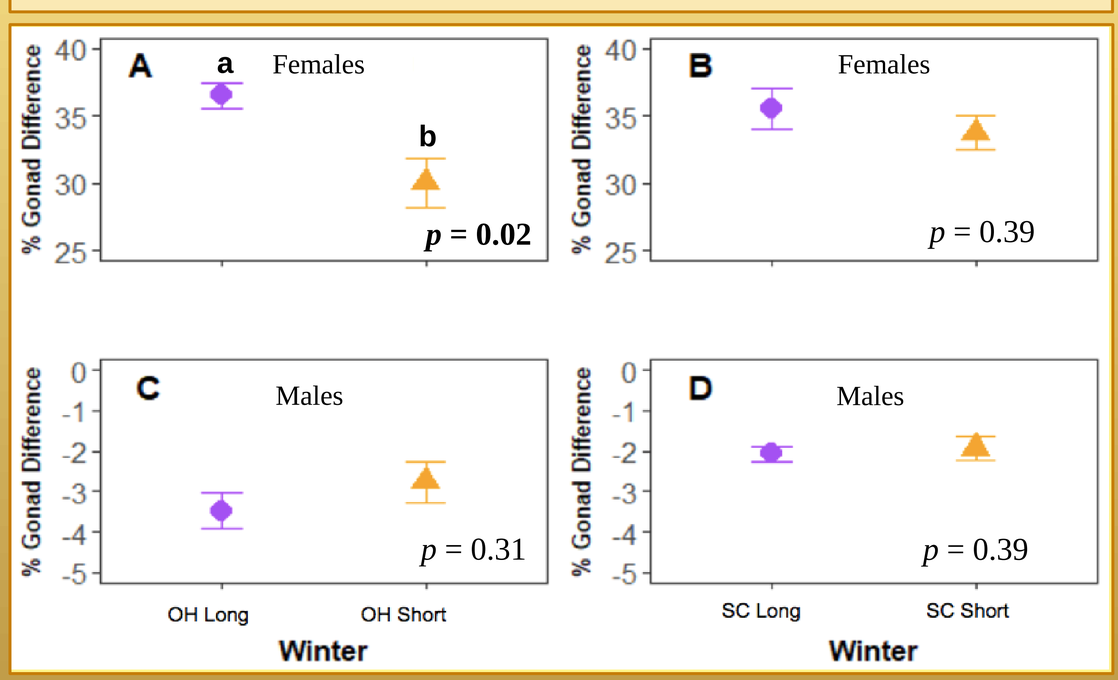


Figure 2. Mean (± SD) overwinter gonad growth (% of body mass) in short and long winter duration treatments for both females (A & B) and males (C & D) in OH and SC. Lowercase letters indicate treatment means that were significantly different from one another ($p < 0.05$).

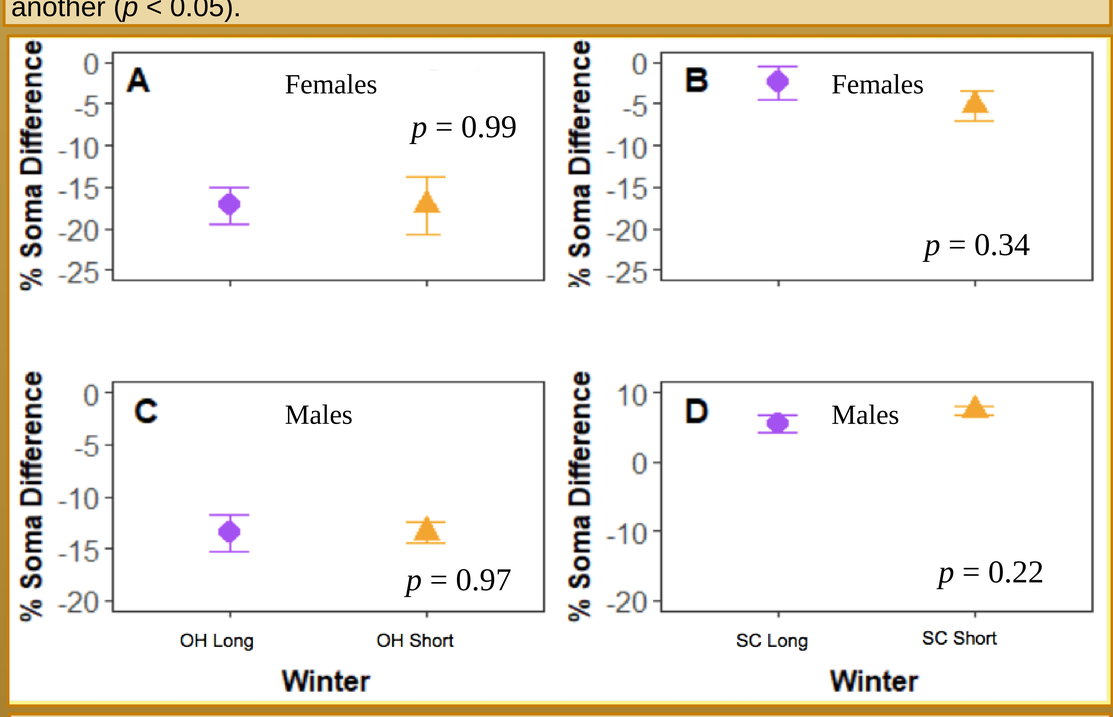


Figure 3. Mean (± SD) overwinter somatic growth (% of body mass) in short and long winter duration treatments for both females (A & B) and males (C & D) in OH and SC. Lowercase letters indicate treatment means that were significantly different from one another ($p < 0.05$).

Results

- Ohio female overwinter gonad growth was greater following the long winter duration (Figure 2).
- No significant difference was found between long and short treatments for either male or female somatic growth in Ohio and South Carolina (Figure 3).
- South Carolina male gonad growth and South Carolina male and female somatic growth was greater than Ohio growth (Figure 4).
- Ohio and South Carolina female overwinter gonad growth was similar, but South Carolina males had slightly larger gonads compared to Ohio males (Figure 4).

Figure 4. Mean (± SD) overwinter gonad and somatic growth (% of body mass) in South Carolina and Ohio for both females (A & C) and males (B & D). Lowercase letters indicate treatment means that were significantly different from one another ($p < 0.05$).

Discussion

- Warm winters do not disrupt reproductive development in South Carolina fish.
  - SC fish may have adaptations that allow them to successfully reproduce following short warm winters.
  - OH females allocated more energy to reproduction following long winters while SC females energy allocation to reproduction was not affected by winter duration.
  - Warm OH winters may increase metabolic cost, decreasing energy allocated to reproduction at northern latitudes.
- South Carolina fish actively grew during the winter, while Ohio fish lost mass during winter.
  - Different energy allocation strategies: driven by winter duration or local adaptations?
- Ohio fish may be building gonads from energy stored in the somatic tissue, known as “capital breeders”, while South Carolina fish may be building their gonads from their food intake during winter, making them “income breeders.”
- Somatic growth in both northern and southern populations was not affected by winter temperatures, suggesting non-reproductive growth during winter is minimal and not traded off against reproductive development.
- Our findings contradict other studies that have investigated latitudinal patterns in reproductive investment.
  - European perch gonad size decreased with increasing latitude.
- Future research should explore local adaptions of southern coolwater fish populations and the extent to which such adaptations represent genetic adaptations or phenotypic plasticity.

Acknowledgments

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