The Shape of Things to Come: Morphological Shifts in Juvenile Alewife Body Shape Preceding Emigration to Saltwater

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INTRODUCTION

Migration between fresh and salt water is a derived life history strategy associated with morphological, physiological, and behavioral shifts in juvenile fish. In order to capitalize on the benefits of migration, one would expect a body form specialized for prolonged steady swimming, showing divergence from populations of fish residing in a confined habitat, such as a lake or stream. With our anadromous (migratory) study population of juvenile Alewives (Bride Lake; East Lyme, CT), we are interested in observing morphological divergence that accompanies development as individuals prepare to leave their natal habitat.

The morphological shifts that separate the actively-migrating fish from those not yet mature enough to move into saltwater were examined through differences in body shape between the two groups. Specific characters that were investigated included body size, head size, body depth, and caudal peduncle width. We expect the migrant group to display a more fusiform shape, thus allowing for efficient sustained swimming and schooling.

PREDICTIONS

Migrants (actively-migrating)

vs

Residents (not yet migrating)

More fusiform: smaller head, thinner body, slimmer caudal peduncle, smaller eye; larger centroid size

More robust: larger head, deeper body, wider caudal peduncle, larger eye; smaller centroid size

METHODS

Field Collection and Preparation:

Migrants (weir trapped, Bride Brook) and residents (purse seined, Bride Lake) were collected in East Lyme, CT, on three dates in 2018. 30 fish were pinned and imaged (Figure 1) promptly after sampling (15 migrants and 15 residents).

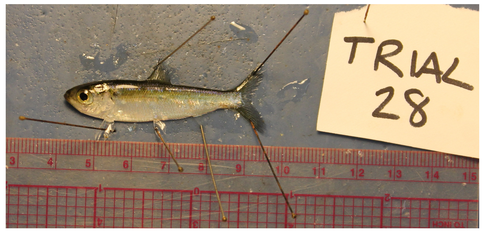

Figure 1 Example of a pinned specimen, prepared for plotting digital landmarks

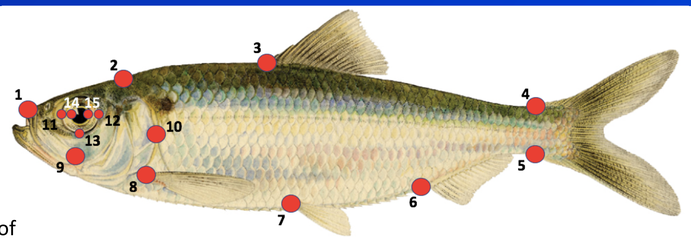

Figure 2A Landmark placement on model Alewife

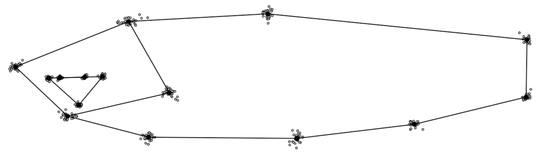

Figure 2B Landmarks of all 30 fish plotted in morpho space (small dots), overlaid with centroid (large dots) and wireframe

Landmark Setup:

15 landmarks were placed on clearly visible anatomical features (Figure 2A). Using MorphoJ software (Klingenberg 2011), a wireframe was created to visualize and detect changes in overall body shape, head shape, and eye/pupil diameter (Figure 2B).

Morphometric Analysis:

We utilized Procrustes aligned shape with and without size variables to performed an analysis of variance and canonical variate analysis tests. A model reduction approach was utilized to determine significant interactive effects of total length, centroid size, and group on shape.

RESULTS

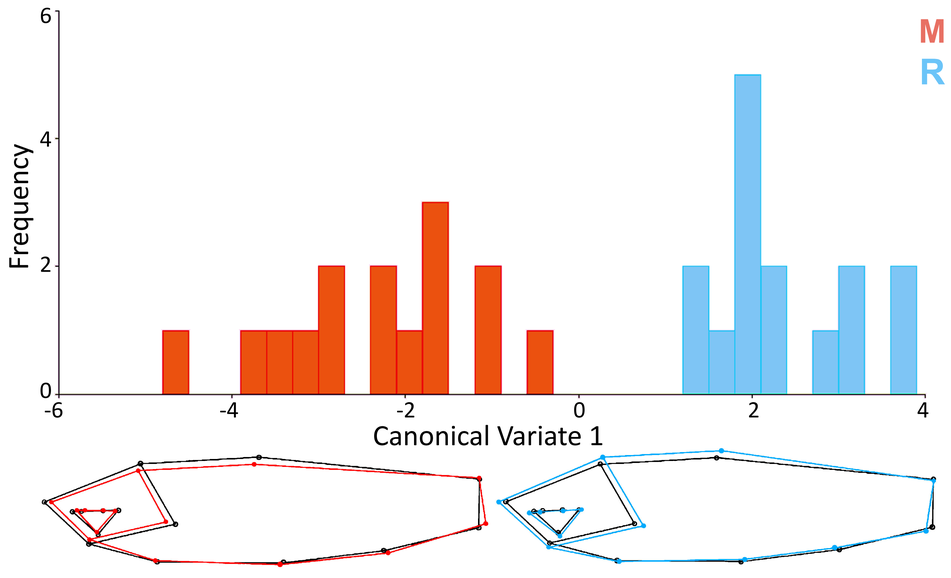

Figure 3 Canonical variate analysis in which shape change along the X-axis is visually represented by the wireframes below. Shape change is displayed as the change from the black wireframe (centroid) to the red (migrant) or blue (resident).

Shape Analysis:

Table 1 Canonical variate analysis associated with Figure 3. Shape was significantly different between migrants and residents (Mahalanobis distance)

	R	p-value
CV1	4.65	<0.001*

Modeling Morphometric Shifts:

Table 2 Total length had a significant influence on size-adjusted juvenile Alewife shape. Other factors such as centroid size and group did not significantly effect shape (model reduction; ANOVA).

	Df	F	p-value
Total Length	1	2.36	0.013*
Centroid Size	1	1.88	0.063
Group	1	1.00	0.419
Residuals	26		
Total	29		

DISCUSSION

Our predictions were supported and migrants showed a more fusiform body with characteristic features such as a smaller head and thinner body, while residents were more robust. We hypothesize that selective pressures favor this change in body shape in preparation for emigration, allowing for more efficient swimming and facilitating schooling behaviors in the saltwater environment.

A possible caveat is that total length and centroid size covary with group. Therefore, group could simply be a proxy for size of the fish, which is supported by our findings (median total length; migrants: 55mm, residents: 50mm). Alternatively, fish may adopt a more fusiform body as a potentially non-adaptive byproduct of rapid ontogenetic growth (growing longer before wider).

FINAL THOUGHTS

Does the morphological distinction between migrants and residents have biological significance? Does the small, yet distinct difference in shape amount to sizable benefits in swimming performance or energetics for oceangoing fish?

SHAPE ? **ADVANTAGE**

REFERENCES

1. C. P. Klingenberg. 2011. MorphoJ: an integrated software package for geometric morphometrics. *Molecular Ecology Resources* **11:** 353-357.
2. CT DEEP's Alewife Counter. 2015. Green Cities Blue Waters. CFE/Save the Sound.

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