Ontogenetic and Geographic Variability in Epidermal Club Cell Densities in White Suckers (Catostomus commersoni)

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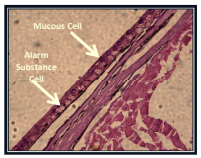
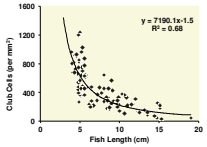
Introduction

Fish species from the superorder Ostariophysi (minnows, catfish, suckers etc) possess specialized epidermal club cells (ECCs), which are associated with pheromones that trigger alarm responses when damaged[1]. The density of these cells has been linked to a variety of ecological factors including health, predation risk, pathogens, and exposure to UV radiation[2]. All of these factors are likely to vary geographically, across different bodies of water (lakes, rivers, streams). However, research in this topic is very limited to one paper[3]. Another research direction has originated from our labs; and that is an association between ECC densities (cells/mm^2 of tissue) and fish length, revealed in several minnow species. Trying to better understand this link, we set out to investigate factors that contribute to the variation in ECC density within the Ostariophysi superorder.





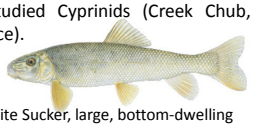
Objectives

For this study, we investigated the White Sucker (Catostomidae Family), as compared to previous UWEC studies, which used minnows (Cyprinidae Family).

Examine the variation of ECC density of White Sucker specimens from different bodies of water (lakes, streams, and rivers).

Determine if a relationship exists between ECC density and length within the White Sucker species.

Analyze ECC density in the White Sucker species and compare them to ECC densities in previously studied Cyprinids (Creek Chub, Hornyhead Chub, and Blacknose Dace).



White Sucker, large, bottom-dwelling omnivore, common in many aquatic environments

Creek Chub, moderately large bodied water-column, predator, common in small cold and cool water streams

Hornyhead Chub, medium sized, water-column, insectivore, common in small cool and warm water streams

Blacknose Dace, small bodied, bottom-dwelling, insectivore, common in small cold, cool and warm water streams

Materials and Methods

Fish specimens were obtained from UW-Stevens Point, which included ten different bodies of water (lakes, rivers, and streams). Approximately ten specimens from each body of water were examined. (N=73). First, each fish was photographed and total length was recorded (mm). Subsequently, one square centimeter was extracted from dorsal surface of the fish (behind the head). This tissue was then prepared for histological examination using standard procedures.

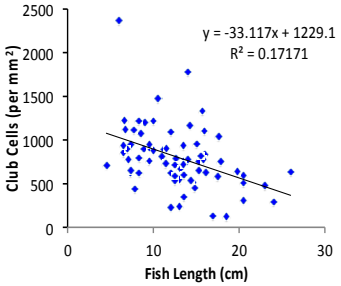
Staining

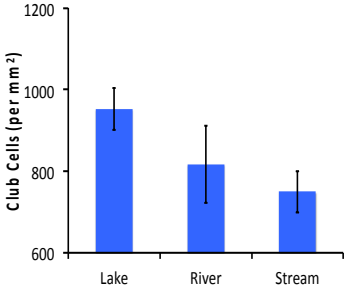
Paraffin embedded specimens were then stained with Periodic acid and Schiff's reagent in combination with Mayer's hematoxylin and Eosin Y. This staining protocol yielded contrasting staining patterns for the different target cells (ECCs and Mucus cells).

Microscopy Analysis

Bright field microscopy was used to capture images of epidermal tissue for analysis. All ECCs and mucus cells within the epidermis were counted and recorded within a specified area of the cross section to obtain density. Thickness, area, and length measurements of the section also were recorded to generate these estimates (mm^2).

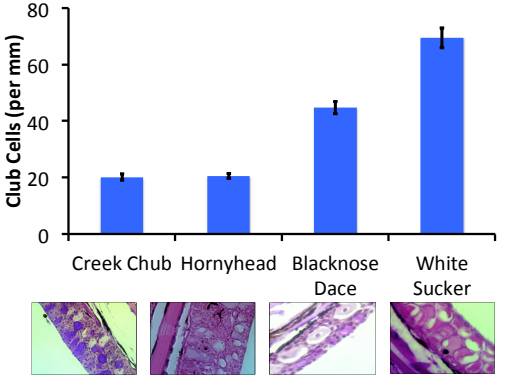
Although the relationship was weak, epidermal club cell densities in White Sucker declined with increasing body size ($p = 0.003$)





Lake-dwelling White Sucker had higher club cell densities than suckers from rivers and streams, but these differences were not statistically significant (One-way ANOVA, $F = 1.41$, $P = 0.25$)

Club Cell densities in White Sucker were as much as three times greater than densities in three cyprinid species. In most suckers examined, club cells comprised nearly 100% of skin cross-sections. Mucus cells (another common cell type in fish epidermal tissue) tended to be small and restricted to the outer epidermal surface. By contrast, mucus cells in other species were large and often dispersed throughout the epidermis



Interpretations

THE WHY?

Why do fish produce ECCs? Surprisingly, this issue remains unresolved despite nearly a century of scientific investigation. A long list of explanations have been proposed and rejected. Recent research has focused on the hypothesis that the primary role of ECCs is to provide protection against pathogens and environmental stressors. Under this scenario, the alarm response would have been secondarily evolved. Evidence supporting this hypothesis is mixed, and so the search for an answer to the origins of ECCs continues.

Ultimately, one goal of our work – to describe species, geographic and developmental patterns of variability in ECC production – is to answer this "why" question.

THE HOW?

Even more elusive than the "why" question is the "how" question. How is the production of ECCs regulated within ostariophysian fishes? Specifically, we refer to the molecular and cellular triggers affecting cell growth and propagation. Some experimental evidence has indirectly implicated hormones (both stress and sex), and others have suggested an energetic role, but this about all that is known about the controls over the production of ECCs. Our work, which has revealed a taxonomic and developmental link to ECC production, suggests that there must be a strong genetic component to the regulation of these cells.

References

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3) Manek, A. K., et al. "Within and between Population Variation in Epidermal Club Cell Investment in a Freshwater Prey Fish: A Cautionary Tale for Evolutionary Ecologists." *Plos One* 8.3 (2013): 8. Print.

Acknowledgments

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