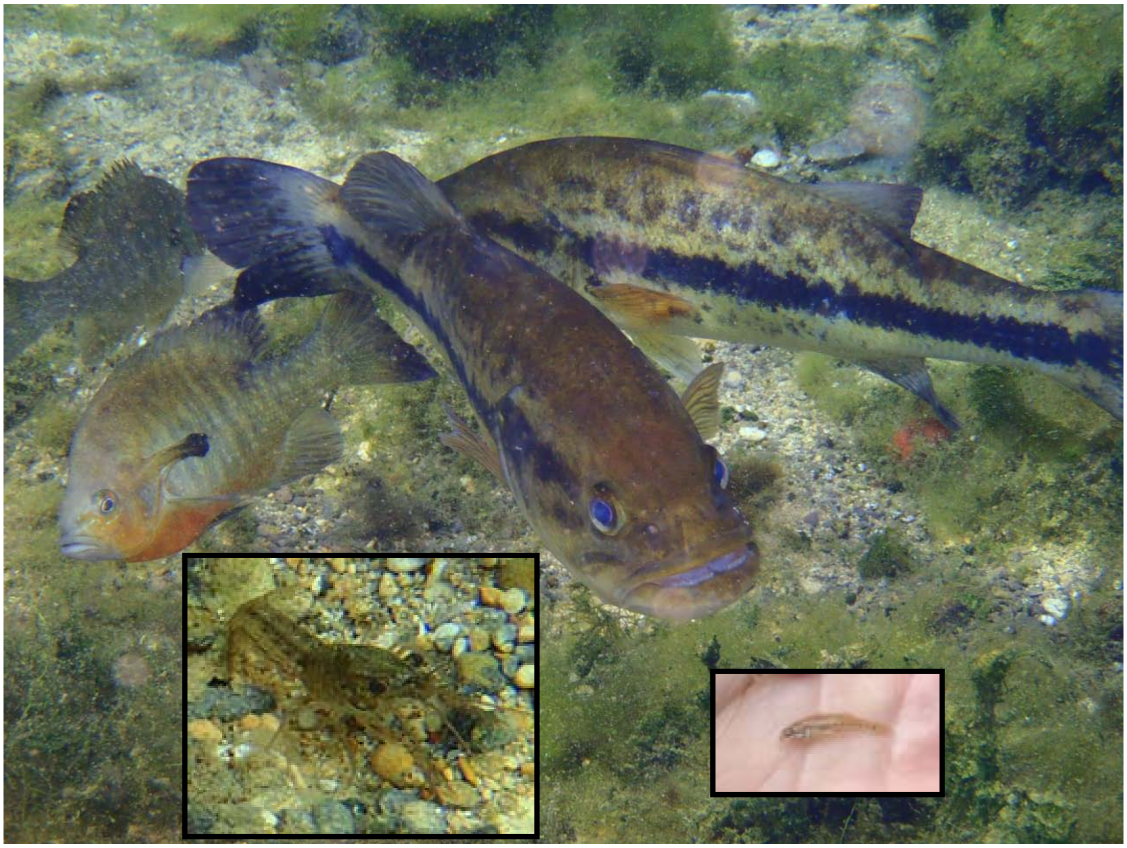

EFFECTS OF PREDATION ON FOUNTAIN DARTER POPULATION SIZE AT VARIOUS FLOW RATES STUDY

Literature Review and Proposed Methodology

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INTRODUCTION

Among spring systems of the Edwards Plateau, spring-associated fishes inhabit perennially flowing spring systems ranging in mean base flows from 2 to 125 cfs (Watson 2006, Bean et al. 2006, Shattuck 2009, Kollaus and Bonner 2012, Curtis 2012, Behen 2013). Relative abundances and densities of spring fishes within the spring system are related to magnitude of spring outflows (**Figure 1**), inferring that spring flow is the master variable of spring communities affecting abiotic (water temperature, water quality) and biotic (vegetation, predation, competition) conditions. With the use of non-linear models, relative abundances and densities (not shown) of spring fishes are predicted to decrease at flows <30 cfs. Mechanism for decreases in relative abundances and densities of spring associated fishes are speculative but likely includes a number of factors, including spring-associated fish physiology, habitat shifts, and increases in predation and competition from riverine fishes moving into the spring systems. At present, predation pressure along a gradient of low to high flows are largely unknown for the fountain darter in the Comal and San Marcos rivers.

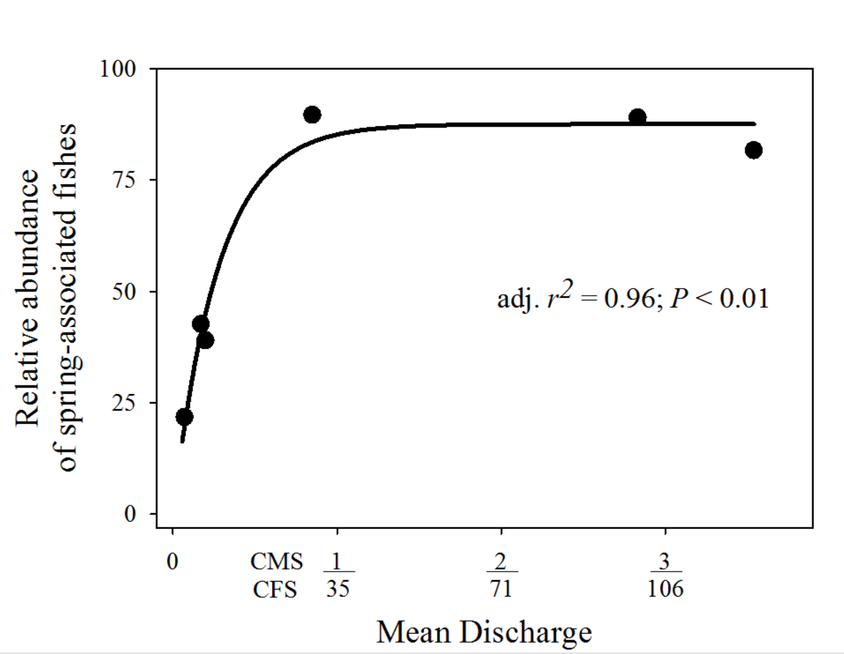

Figure 1. Relationship between relative abundances of spring associated fishes and flow among 6 spring-dominated streams within the Edwards Plateau (T. Bonner, unpublished data).

The purpose of this study is to begin the process of understanding complex predator-prey relationship in the San Marcos and Comal rivers. A series of laboratory experiments is proposed to assess the behavior of fountain darters with and without predators; quantify predation rates of fountain darters with invertebrate and vertebrate predators; and evaluate how aquatic vegetation and substrates might mediate predator consumption of fountain darters.

Benefits to HCP Ecological Model: Benefits of vegetation with respect to fountain darter predator avoidance will be tested in this study and can be used to justify importance of vegetation in the ecological model. In addition, findings of this study will establish the basis for assessing how changes in flow will affect predation of the fountain darter.

LITERATURE REVIEW

Predation of *Etheostoma*: Among simple predator-prey relationships (1 predator and 1 or more aquatic prey), bass (*Micropterus* and *Ambloplites*; < 130 mm in TL) alter habitat selection of *Etheostoma* (Magoulick 2004) and consume *Etheostoma* at an average rate of about 4.5 fish per 24 hours (Rahel and Stein 1988) with lower capture rates in shallow water (<10 cm in depth; Angermeier 1992). Application of these manipulative laboratory studies to natural systems is tenuous and likely do not adequately estimate predation risks of darters, given that the presence of additional predators (Sih et al. 1998; Thomas 2011) and additional prey (pelagic minnows, drifting invertebrates, terrestrial sources; Dahl and Greenberg 1996, Magoulick 2004, Sullivan et al. 2012) can synergistically increase or decrease predation rates on prey. As such, management recommendations based on an oversimplified understanding of predator-prey relationship can generate unintended consequences.

Darters in the presence of piscine predators move less, relying on chemical and visual cues to reduce movement (Becker and Gabor 2012) and cryptic coloration for concealment (Armbruster and Page 1996), or seek refuge in substrates (Rahel and Stein 1988; Matthews 1998). Crayfish, which only recently has been recognized as a formidable predator of benthic fishes (Taylor and Soucek 2010), prompt darters to move more and avoid refuge among available substrates because the refuge is also habitat for the crayfish (Rahel and Stein 1988, Thomas 2011). In fact, darter densities are inversely related to crayfish densities among 30 streams in Illinois, supporting Taylor and Soucek (2010) findings that crayfish consume, and therefore, directly or indirectly displace substantial numbers of benthic fish. Combining the two predators (bass and crayfish), predation risk on darters is difficult to quantify. Bass might consume more darters because darter movement has to increase to avoid predation by crayfish (Rahel and Stein 1988). Alternatively, bass might consume fewer darters, preferring to consume crayfish instead. Prey selection by the bass is likely subject to rules of Optimum Foraging Theory (MacArthur and Pianka 1966), which is influenced by densities of prey items and energy spent in search for prey (Stephens and Krebs 1986). Energy expenditures will be mediated by amounts of refuge provided by substrates and vegetation. Regardless of the prey selection by bass, a management option designed to reduce predation on threatened and endangered darters (i.e., fountain darters) might be to remove piscine prey, especially in modified habitats (Spring Lake, Landa Lake). However, an unintended consequence would be a trophic cascade where the removal of the piscine predator would increase crayfish populations that would, in turn, decrease fountain darter populations.

PROPOSED METHODS

Experiments will be conducted under laboratory conditions (i.e., Freeman Aquatic Biology Building). The series of experiments will be conducted in two phases. Fountain darters will be collected from the wild. Crayfish and centrarchid predators will be taken from the wild or purchased from a local vendor. In the event Freeman Aquatic Biology Building is not authorized to house fountain darters, the sister species Cypress Darter *Etheostoma proeliare* will be used as a surrogate for fountain darter.

<u>Phase 1</u> is to document and verify active consumption of fountain darters by crayfish and fish in the laboratory. Fountain darters are the smallest darter in North America and rely on immobility and cryptic coloration to minimize predation. Therefore, we'll conduct preliminary work to determine predation rates of fountain darter on natural substrates and in vegetation, to establish stocking rates of fountain darters, crayfish, and predatory fish in our experiments, and to determine which predatory fish to use

(Largemouth Bass, Warmouth, or Rock Bass) and size.

Phase 2 will be to unify predator/prey interactions under one experimental design. The experimental unit will be an aquarium with X fountain darters (exact numbers will be determined in Phase 1). The dependent variable will be numbers of darters partially or completely consumed. The control will be an experimental unit without a predator. Treatment 1 will be Predation (crayfish only, centrarchid only, crayfish and centrarchid; centrarchid predator to be determined in Phase 1), and Treatment 2 will be Vegetation (with vegetation and without; density and distribution to be determined in Phase 1). Control and treatments will be replicated at least three times. More replications might be added, depending on results (i.e., variability within the response variable) of Phase 1.

Experimental Design and Data Analysis

3 replications x Treatment 1 (control and 3 levels) x Treatment 2 (2 levels) = 24 experimental units.

Randomization rule: Treatments will be randomly assigned to an experimental unit.

A two-factor ANOVA will be used to test for differences (α=0.05) among treatments and a Fisher's LSD for post-hoc mean separation tests.

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