HABITAT USE BY GROTTO SCULPIN (*COTTUS CAROLINAE*), A TROGLOMORPHIC FISH IN PERRY COUNTY, MISSOURI

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Abstract

Habitat studies in caves have been limited to qualitative studies providing general descriptions of the habitat utilized by fish populations. The lack of quantitative habitat use data for troglobitic species makes it difficult to examine important ecological traits such as the effects of habitat change or evidence of habitat specialization. This study quantitatively examined the habitat use of two grotto sculpin (*Cottus carolinae*) populations and corresponding resurgence populations in Perry County, Missouri. Study sites were divided into 10-meter sections and in-stream physical habitat was quantified for each section seasonally. Sculpin were captured using a variety of capture techniques (seining, dipnets, and electroshocking) from each section every 4-6 weeks. Weight, standard length, and eye length were recorded before individuals were released. Regression trees were constructed for analysis of our habitat data. Analyses showed that grotto sculpin on the surface disproportionately used shallower areas with high abundances of prey items. Grotto sculpin habitat use in the caves was best explained by depth, with sculpin favoring deeper habitats. Possible effects of altering land use in the porous Perry County karst region are discussed. The results from this study will help conservation officials make critical decisions regarding land use practices within the recharge area and provide baseline data on the habitat use of a benthic cave fish species.

Key words: *Cottus carolinae*, grotto sculpin, habitat use, troglomorphic, cavefish, silt, Missouri

Introduction

Cave environments are distinctive in many ways that make them fascinating settings for scientific studies (Poulson and White 1969). However, while the cave environment offers many unique research opportunities, the scarcity of organisms, the need for specialized gear, and the often treacherous surroundings associated with caves have historically limited research in this field (Trajano 2001). As a result, the knowledge of cave ecosystems is limited and most species have only been studied descriptively, if at all.

While the amount of cave research in general is limited, studies of habitat use for cave dwelling fishes are relatively non-existent. Habitat research in caves has been limited to qualitative studies providing general descriptions of the habitat utilized by fish populations. The lack of quantitative habitat use data for troglobitic species makes it difficult to examine important ecological traits such as the effects of habitat change or evidence of habitat specialization.

This study quantitatively examined the habitat use of two grotto sculpin (*Cottus carolinae*) populations and corresponding resurgence populations in Perry County, Missouri. Grotto sculpin (Figure 1) provide a unique opportunity to study

Figure 1 *The Grotto sculpin* (Cottus carolinae) *is a small fish from six caves in Perry County, Missouri. Photo by A.J. Hendershott.*

each sculpin before individuals were released. A total of 3,815 grotto sculpin were captured over 14 sampling periods from March 2006 until October 2007.

Overall grotto sculpin population densities from our study (0.04-0.06 sculpin/m^2) were similar to those of other cave fish populations (Trajano 2001). Among the grotto sculpin captured at each of our sites, 66% were juveniles (less than 60 mm) and 34% were adults. This age class disparity was largely explained by site location with adults forming a higher percentage of the overall grotto sculpin abundances at both cave sites while juveniles tended to account for a higher percentage of overall abundance on the surface.

Regression trees were constructed for analysis of our habitat data. Regression trees use the available data to determine a split for each node that best explains the variability of the dependent variable as it relates to the independent variable (Breiman et al. 1984, Andersen et al. 2000, De'ath and Fabricius 2000, Dzeroski and Drumm 2003). This splitting procedure continues for each group until an overlarge tree is grown. Overgrown trees will have higher error and attempt to explain differences that, in fact, may not be true (De'ath and Fabricius 2000, Usio et al. 2006). Trees of optimal size (measured as the sums of squares about the means) provide the most information. We used V-fold cross-validation to determine the optimal size of our regression trees.

a troglomorphic fish population that utilizes both epigean and hypogean ecosystems. Additionally, grotto sculpin are endemic to Perry County and their limited distribution elevates the possibility of a catastrophic event extirpating their entire population. As a result of this increased risk, the grotto sculpin is listed as an S2, G1-G2 "species of concern" in Missouri and as a candidate species under the Federal Endangered Species Act.

Methods

We quantitatively examined grotto sculpin habitat use in two caves, Mystery Cave and Running Bull Cave, and two corresponding resurgence sites, Cinque Hommes Creek and Thunder Hole Resurgence, respectively, in Perry County, Missouri. Study sites were divided into 10-meter sections and in-stream physical habitat was quantified for each section seasonally. Habitat measurements included stream width, water depth, maximum depth, substrate, silt cover and in-stream habitat. In addition, the porous karst landscape associated with Perry County karst may allow large amounts of runoff to enter directly into the caves. In order to quantify these effects, the presence and depth of silt was recorded at each of our locations.

Sculpin were captured every 4-6 weeks at each of our sites using a variety of capture techniques (seining, dipnets, and electroshocking). Weight, standard length, and eye length were recorded for

Results

Analyses showed that grotto sculpin habitat use was influenced by a variety of factors. On the surface, grotto sculpin favored areas with shallower habitats and high abundances of amphipods and isopods (Figure 2). Within these shallower habitats, grotto sculpin utilized areas where more than 23% of the substrate was clay. In the caves,

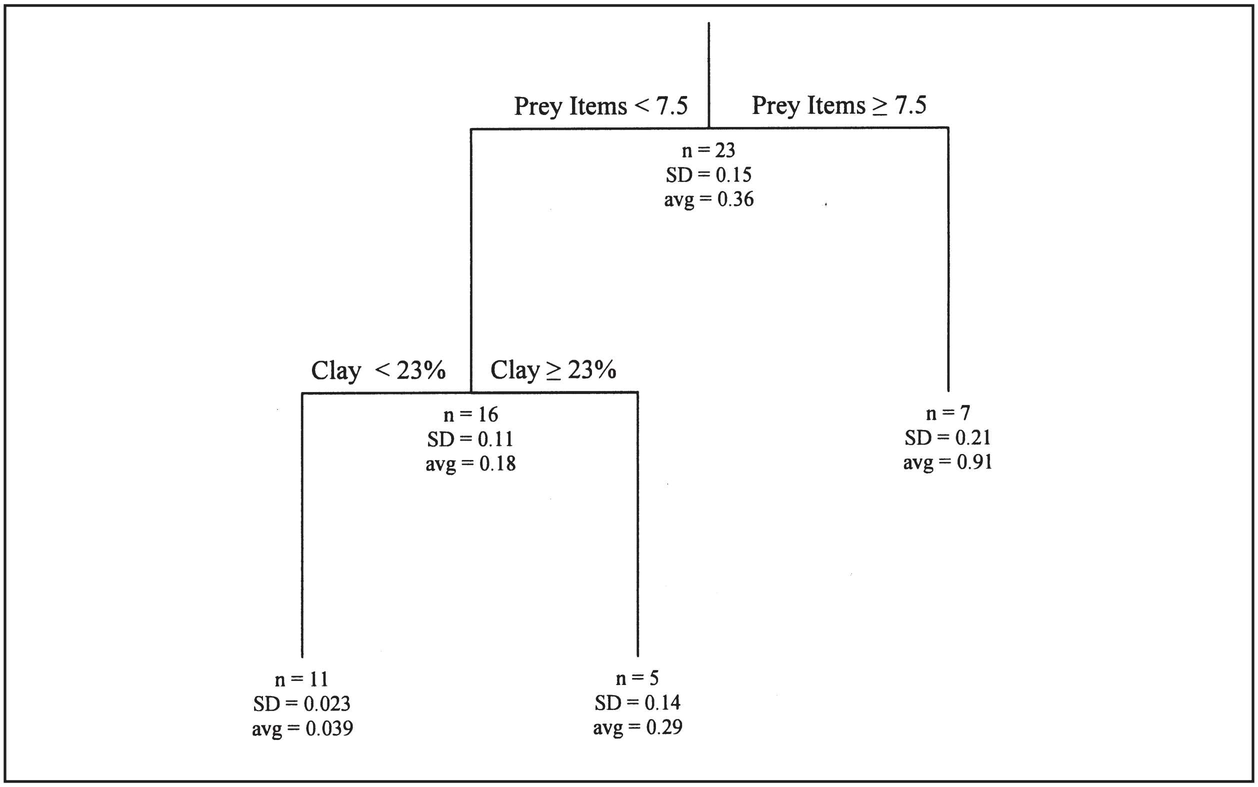

Figure 2 *Regression tree analysis for the habitat use of all grotto sculpin of both surface populations. Sample size (n), standard deviation (SD), and mean densities per node (avg) are given for each node. V-fold cross validation error was 0.43.*

grotto sculpin were found at highest abundances in deeper (greater than 16.3cm) habitats (Figure 3). Within deeper habitats, grotto sculpin disproportionately utilized areas where cobble represented at least 10% of the substrate. When grotto sculpin utilized shallower habitat (less than 16.3 cm), they were found in highest abundances in areas where silt was deeper than 1.9 cm.

The amount and composition of silt varied greatly among our sites. The substrate at both of our cave sites was covered by a significantly higher percentage of silt compared to the surface locations ($F_{3,156} = 121.2$, $p < 0.01$). The depth of the silt, when present, was also significantly higher at the cave sites compared to the surface (Table 1). While the average depth of silt on the surface was less than 0.1 cm, both cave sites had an average depth of >1 cm.

Discussion

Our results indicate that a wide variety of habitats are utilized and important to grotto sculpin populations. Because an overriding habitat variable was not found for the habitat use of all grotto sculpin, it is imperative that we preserve an assortment of habitat types for grotto sculpin populations to use. One of the biggest threats to the availability and quality of grotto sculpin habitat may be the increased siltation found throughout our study sites. Many of the habitats available to grotto sculpin have been covered in large amounts of silt indicating that ongoing siltation in the porous Perry County karst may limit the amount of desirable habitat available to the grotto sculpin. Silt has been shown to negatively impact the habitat use of many species and has been listed as the primary reason for decline in many surface-dwelling fish species (Judy et al. 1984, Berkman and Rabeni 1987, Wood and Armitage 1997, Rowe and Taumoepeau 2004). Because of their relatively small population sizes, this risk may be increased, and it is imperative that we protect the delicate environments they are found in. As such, efforts should be undertaken to limit and reduce the amount of silt and runoff entering the cave systems. The potential for negative impacts related to increased siltation are alarming and should be considered by conservation officials

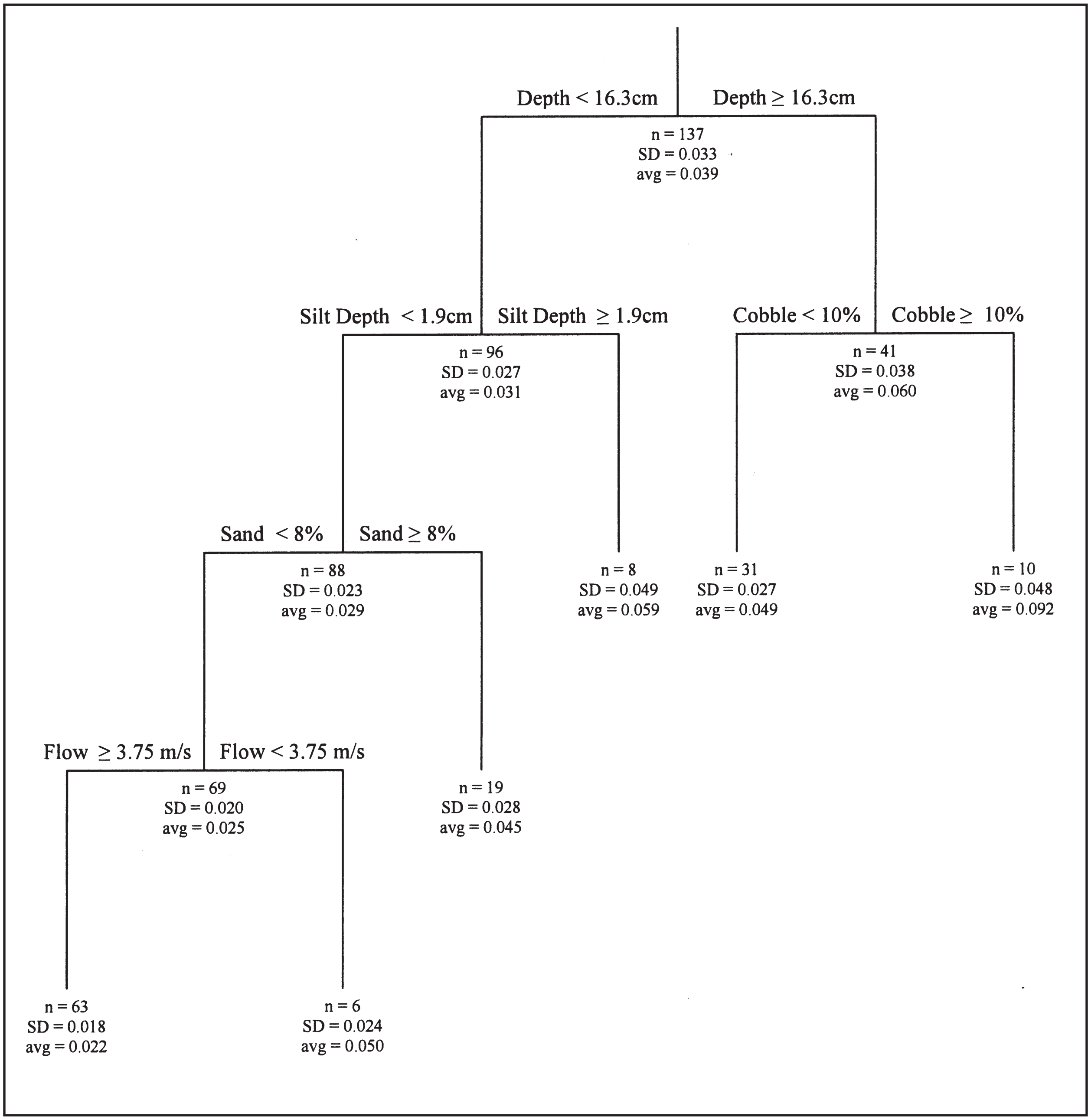

Figure 3 *Regression tree analysis for the habitat use of all grotto sculpin in both cave populations. Sample size (n), standard deviation (SD), and mean densities per node (avg) are given for each node. V-fold cross validation error was 0.69*

when making critical decisions regarding land use practices within the recharge area.

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Table 1. Mean values and standard error for silt cover and depth for Mystery Cave (n = 108), Running Bull Cave (n = 29), Thunder Hole Resurgence (n = 10), and Mystery Cave Resurgence (n = 13).

Variables	Mystery Cave	Running Bull Cave	Mystery Cave Resurgence	Thunder Hole Resurgence
Silt Presence	93.06%	62.26%	14.20%	0%
Percent Silt Cover*	65.76% ± 1.6%	28.30% ± 2.8%	6.12% ± 2.8%	0%
Silt Depth*	1.03 ± 0.06	1.20 ± 0.31	0.09 ± 1.44	0.00

* Indicates significant difference between cave and surface sites ($p < 0.01$)

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