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Habitat Preferences of Reintroduced Sicklefin Redhorse (*Moxostoma* sp.) in the Oconaluftee River near Cherokee, NC

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Abstract

The Sicklefin Redhorse (*Moxostoma* sp.) is an imperiled species whose range is restricted to Blue Ridge portions of the Hiwassee and Little Tennessee River systems in North Carolina and Georgia. The Sicklefin Redhorse population is threatened by habitat degradation, stream impediments, and restriction of their native home range that isolates and limits their population potential. In order to determine if individuals had habitat preferences when selecting habitat, we translocated 10 individuals from the Tuckasegee River into Oconaluftee River and tracked them via radio telemetry. Once occupied areas were established, we performed a visual habitat analysis adapted from the Environmental Protection Agency (EPA). Individuals reintroduced above the Ela dam in Cherokee, NC exhibited specific preferences when selecting areas of the Oconaluftee River to occupy. The fish exerted a strong preferences for habitats with cobble, bedrock, and boulders as the dominant substrate, and a heavy presence of macrophytes. Sicklefin Redhorse were more likely to be in areas with a variety of in-stream habitat options and were at least 1 meter in depth. The Oconaluftee River contains aspects of habitat necessary for the species to thrive, and could be essential in establishing the Sicklefin Redhorse back to part of its historic range.

1. Introduction

The Sicklefin Redhorse (*Moxostoma* sp.) is a medium size sucker fish that belongs to the order Cypriniformes. They have relatively long life cycles of approximately 20 years and can grow to a length of 650 millimeters[1]. They have an elongated and compressed body with a distinct sickle shaped dorsal fin, and a red caudal fin. The body is olive covered, with a copper sheen and dark lower fins, often with an orange sheen. The Sicklefin Redhorse was originally thought to be a hybrid of the Smallmouth Redhorse (*M. breviceps*) and a River Redhorse (*M. carintum*), until behavior and morphological studies led to them being recognized as a distinct species in 1992[1].

Collection records of the Sicklefin Redhorse, as well as other characteristics known about the species, suggest it once inhabited the vast majority of rivers and large creeks in the Southern Appalachian portion of the Hiwassee and Little Tennessee River Systems of North Carolina, Tennessee, and Georgia[2] .The Sicklefin Redhorse is currently a candidate for a federally threatened species with plans to be listed as endangered within the coming year. Presently, only two populations of the Sicklefin Redhorse are known to exist, one in the Hiwassee River system and one in the Little Tennessee River systems, since being eliminated from approximately 50% of its former range[2].

The majority of populations were weakened when suitable habitat was destroyed because of impoundments[2]. The construction of dams is the greatest factor contributing the downfall of the species from its historical range. The dams caused the flowing, cool, highly oxygenated habitats with coarse, sandy, gravel, and rocky bottoms to become modified into habitats that are no longer suitable for supporting the Sicklefin Redhorse. The existence of these impoundments continue to limit the species from reestablishing into the historical reaches it is once occupied. The impoundments restrict the natural spawning and foraging behavior of the adult, due to the increasingly still water,

increased water depths, and accumulating silts and sediments on the bottom[3]. The quality of downstream reaches are negatively affected due to a change in flow regimes, velocities, temperature, and nutrient cycles[4,5,6,7]. The release of water from dams changes the downstream temperature, causing negative effects for native inhabitants, changing the historical compositions of native fish and macroinvertebrates[8]. The range reduction and isolation of a species that used to migrate unimpeded significantly increases the vulnerability of extinction. These isolated populations lack the ability to respond and adapt to changes within its environment with the same efficiency as a widely dispersed, interconnected healthy population[9].

In addition to the threats of impoundments, inadequate erosion and sediment control, runoff of organic and inorganic pollutants, habitat alterations such as channelization also negatively modify the aquatic environment, and threaten the surviving populations[1]. Nutrient and chemical pollutants from waste water discharges and storm water runoff from row crops and livestock, roads and parking lots, lawns, and other nonpoint sources also threaten the species in addition the siltation. In addition to being poisoned by the runoff, changes in water chemistry can also adversely affect aquatic organisms[10]. The nutrients from residential lawns and livestock can also lead to eutrophication and reduced oxygen levels, which would prove to be unsuitable for the Sicklefin Redhorse[11,12].

The Sicklefin Redhorse is specially adapted, similar to other *Moxostoma* sp., to occupy large reservoirs in the early part of its life, and to occupy cool to warm medium gradient rivers and streams during its adult life.[2,13] The adults are associated with moderate to fast flow and are usually found in riffles, runs, or high flow pools[2,14], and juveniles are found in deep, slower moving pools with adequate boulder cover[13]. The substrate of adult habitats usually consists of a gravel, cobble, boulder, and bedrock substrates with little or no silt overlay which allow successful feeding and spawning behavior[2,14]. The species shows a well-developed preference for more coarse substrates with an abundance of macrophytes when feeding[14].

The diet of a species is important in predicting habitat preferences and assessing threats. Diet analysis of the Sicklefin Redhorse indicates that they feed mostly on benthic macroinvertebrates, whose numbers are greatly enhanced in the presence of the macrophyte Riverweed (*Podostemum ceratophyllum*)[14]. The stream reach occupation areas following spawning typically support high densities of Riverweed, where individuals feed almost entirely over beds of River Weed[14], while spawning occurs in reaches with no Riverweed and exclusively over coarse substrates in fast slowing, open areas[2,14]. The Sicklefin Redhorse appears to be relatively sedentary, and outside of its migrations between spawning and wintering sites, it travels only short distances within an occupied stream reach[13].

The objective of our study was to determine the habitat preferences of the Sicklefin Redhorse once it has been translocated into the Oconaluftee River. Based on previous findings and what is known about the behavior of the Sicklefin Redhorse, our hypothesis was that the reintroduced fish would show preferences among the habitat available to them in the Oconaluftee River. We predicted there would be noticeable distinguishing features among the occupied and unoccupied areas that would help us determine the Sicklefin Redhorse's habitat preferences that would aid management. Our null hypothesis was that there were no differences between occupied and unoccupied habitats, and fish are simply choosing randomly.

2. Methods

2.1 Study site:

The Oconaluftee River is a tributary of the Tuckasegee River that arises in the Great Smoky Mountain National Park. It consists mostly of shallow depths with low levels of sedimentation, with a relatively steep slope and a coarse substrate. It has a headwater elevation of 1,611 m and drainage area of 477, and is approximately 30 km long. In portions running through downtown Cherokee, NC the stream has been channelized. The river is also impounded below the town of Cherokee by the Ela hydroelectric dam, causing some sedimentation and increasing depths as the river approaches the dam.

2.2 Methods:

Ten adult Sicklefin Redhorse were captured by boat electrofishers in the Tuckasegee River in Swain County, NC on August 26th, 2014. On site, they were surgically implanted with Lotek radio transmitters and passive integrative transponder tags with a minimum life span of 12 months. Each individual's transmitter had a unique pulsation code that allowed for identification of individuals when locating. The weight, sex, and health of each individual were

recorded. The fish were allowed a post op recovery period, and were then released in groups of five into two separate sites on the Oconaluftee River in Cherokee, NC. The fish were tracked from release until March, 2015.

The fish were tracked initially from the roadside, once a broad location was determined we exited the vehicle in order to gain better access to the river. We were able to find a more exact position from access along the river, and on occasion were able to verify their location with visual confirmation. We marked their occupied location based on the highest signal value were able to achieve. On two separate occasions, we traversed the river via kayaks and were able to verify our previous points collected. The Global Positional Systems (GPS) coordinates were recorded and converted into decimal degrees and input into GoogleEarth software. Using Google Earth, we then were able to classify certain reaches as occupied. We defined an occupied reach as an area of the stream where an individual Sicklefin Redhorse had been present for a period of at least 8 weeks.

We determined that five pools of the Oconaluftee River were occupied by Sicklefin Redhorse. In order to analyze the habitat choice of the individuals, pools were numbered beginning at release site #1 downstream to the last occupied individual released (Pools #1-9), and numbering picked up again at release site#2 to the last occupied individual released at the second release site (Pools #10-22). We then performed visual stream and habitats assessments adapted from the Environmental Protection Agency's (EPA) Habitat Assessment Field Data sheets[15] for each pool separately. During the visual assessment, we categorized maximum depth observed across the channel into three different categories: <1meters, 1-2meters, >2meters. We documented the available natural in-stream habitat that occurred (occurred if >5% coverage) by five different categories: Little or no habitat, multiple aquatic macrophytes and mosses, multiple sticks and/or leaf packs, multiple snags and logs, and 5% undercut banks and/or root mats. Bedform and substrate we documented by size categories (bedrock, boulder(256-4096mm), cobble(64-256mm), gravel(2-64mm), sand(0.063-2mm)) and by occurrence categories(Not present, rare(<10%), common(10-40%), Abundant(40-70%), predominant(>70%)) We calculated the frequency of different depths, the relative abundance of different substrates, and the presence various of habitats.

3. Results

The occupied pools tended to be deeper, with most occupied pools >2meter in depth (Figure 1). In pools that were occupied bedrock, boulder, and cobble was common (Figure 2). The pools that were unoccupied rarely had a substantial amount of boulders or bedrock, while occupied pools were classified by the amount of bedrock and boulder available. In occupied pools if sand was present, it was found in smaller quantities, while unoccupied pools more commonly had a sand substrate available.

There were differences between habitat in occupied and unoccupied pools. Riverweed was found in 80% of occupied pools, and in less than 10% of unoccupied pools (Figure 3). Multiple snags and logs as well as the presence of leaf packets were also significantly higher in occupied over unoccupied pools. Undercut banks and root systems were found in abundance in both occupied and unoccupied pools. Occupied pools often had at least two different types of instream habitat available, and were never in an area that provided little to no habitat (Figure 4).

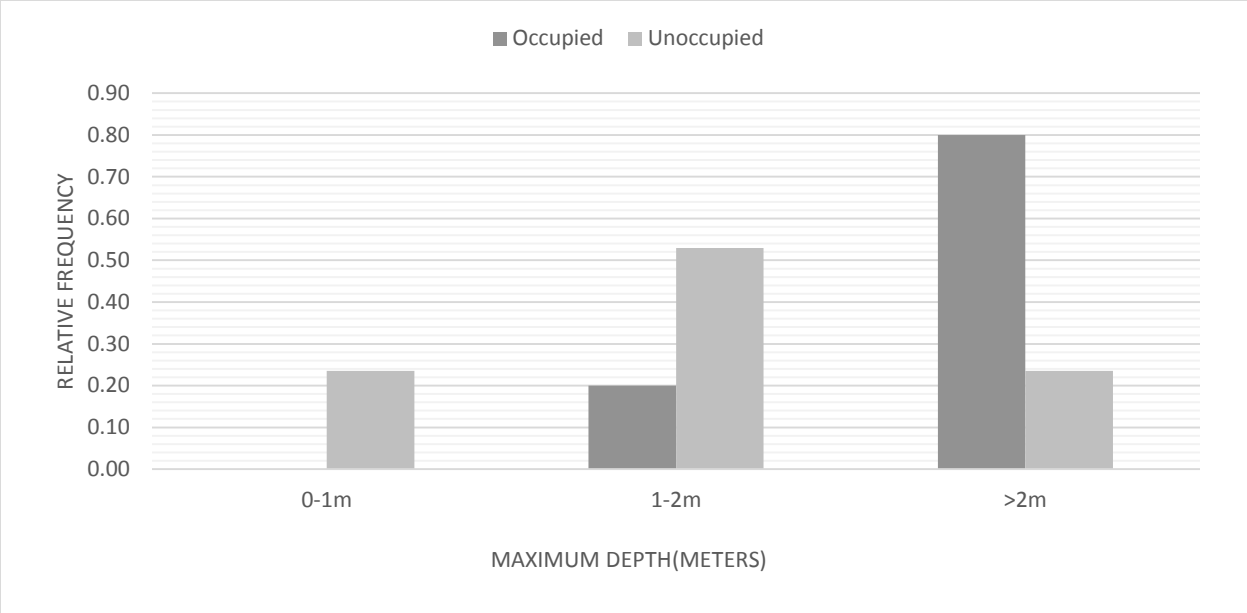

Figure 1. Maximum depth distributions between pools occupied by the Sicklefin Redhorse, and those that remained unoccupied.

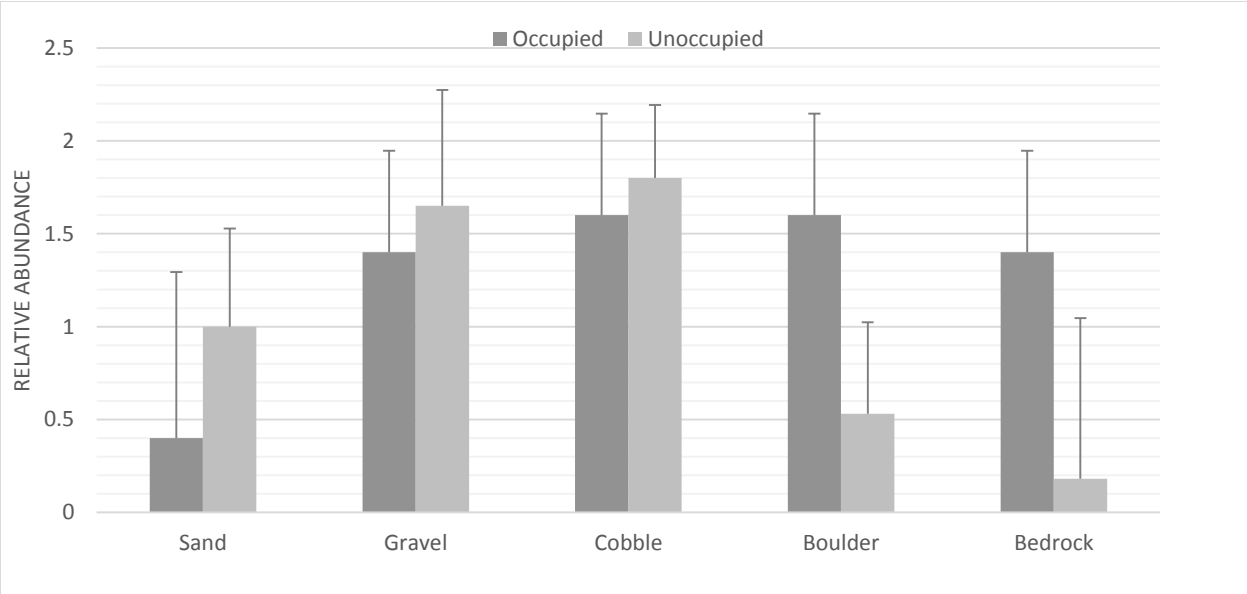

Figure 2. Abundance of substrates in occupied versus unoccupied pools based on assigning a number 0-1 depending on the frequency of occurrence within a pool, mean +/- standard deviation. (Boulder (256 – 4096 mm), Cobble (64 – 256 mm), Gravel (2 – 64 mm), Sand (.062 – 2 mm), Silt (< 0.062 mm))

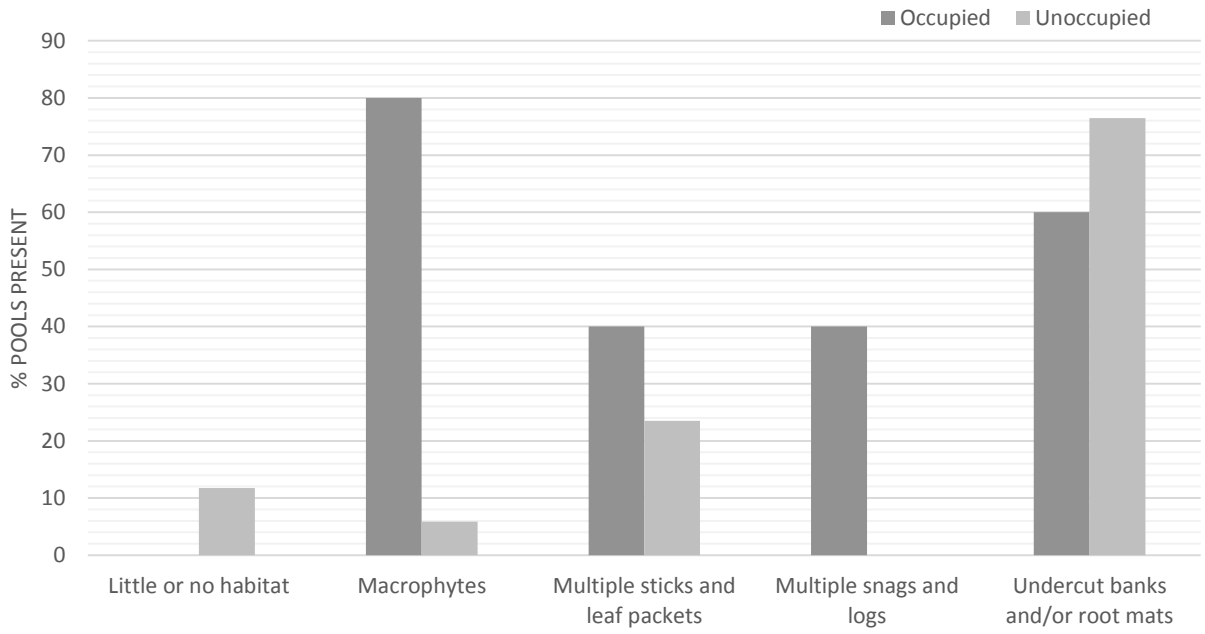

Figure 3. Distribution of in stream habitat available in occupied versus unoccupied pools. (Macrophytes=riverweed)

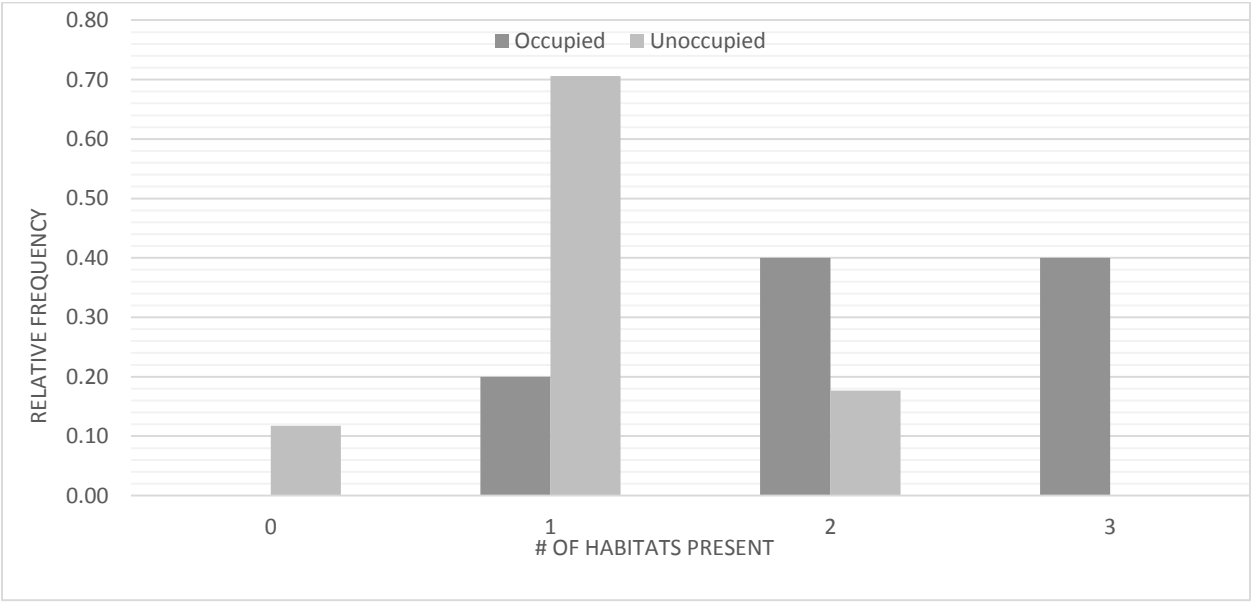

Figure 4.Frequency of the different number of available habitat present in occupied versus unoccupied pools.

4. Discussion

Our hypothesis was that there were noticeable differences in the pools that were occupied and those that were not. Based on our findings, we have evidence that backs the hypothesis that they are not picking habitat randomly. The depth of pools seemed to play a role in determining the suitability of individual pools. The radiotagged fish were not found in pools less than 1 meter deep, with most occurring in pools that were at least 2 meters deep. This is a trait that was not observed in previous studies of the adult fish, but is a quality more linked with juveniles[13]. The cause of

this distribution might be due to the relative size of the river, and the presence of a lot of deeper areas throughout the river, or could be attributed to another aspect of habitat preferences that somehow correlated with the depth of pools. The relationship could be due to bedrock within the Oconaluftee River only being found in the deeper reaches of the river.

Previous studies indicate that the substrate of pools is essential in determining suitable habitat for the Sicklefin Redhorse. Within our occupied pools, we observed the presence of gravel, cobble, and bedrock being the major contributors to the bedrock within the pools. Due to the feeding behavior of the Sicklefin Redhorse and their dependence on macroinvertebrates, the distribution of this substrate would maximize their feeding efficiency[14]. It would also explain why the occupied pools never occurred in areas that were subject to sedimentation, as this would interfere and lower their chances of feeding successfully[2,14]. It is likely that if we were observing their habitat preferences during their spawning behavior, the makeup of the substrate would change to favor spawning over feeding behavior. If the fish were spawning, we would likely see them in pools consisting of a sandy bottom with significantly more cobble than that observed during our study[2,14].

Perhaps the biggest difference between the occupied pools and unoccupied pools was the presence of the aquatic macrophyte, Podostemum (River Weed). This could be the most important aspect of habitat choice because the diet of the Sicklefin Redhorse is largely dependent on macroinvertebrates. In areas were river weed is available, the habitat would be more beneficial for macroinvertebrates and the abundance of them would increase[14]. The concentration and abundance of macroinvertebrates in the areas that contain river weed, would also make the habitat more favorable to the Sicklefin Redhorse because it would make locating food an easier process. These results align with the study done by Favrot, where the Sicklefin Redhorse were found with greater abundance in areas that contained macrophytes that could provide a stable food source[14].

In addition to the presence of macrophytes, other characteristics about in stream habitats were also observed as differing in unoccupied and occupied reaches of the river. The Sicklefin Redhorse were more often observed in areas that had multiple snags or logs or leaf packs. The number of habitats present also increased in occupied pools. These results could mean that in addition to substrate playing a substantial role in the suitability of habitat within a pool, the availability of other in stream habitats is also important.

While we were able to determine distinguishing factors between occupied and unoccupied pools, our sample size prevented us from achieving as conclusive of results as we would have been able to with a larger sample size. While we were able to collect ten fish to monitor, only five fish could be relocated enough times to classify a pool as occupied. With a larger sample size, our success in obtaining occupied pools would have been higher, and we would have had more accurate data. In addition, we could have improved our study by doing in stream habitat analysis in addition to the visual assessments. In stream habitat analysis would have allowed us to observe factors such as velocity that are simply unobtainable when doing visual assessments. In a river the size of the Oconaluftee, more complex stream analysis proves difficult. In addition to these improvements, statistical analysis could provide insight on to whether the observed differences in habitat were significant.

The habitat preferences we were able to observe and record in the stretch of the Oconaluftee above the Ela dam indicate that there is habitat available for the Sicklefin Redhorse. The availability of this habitat, and the survival of the fish above the dam could mean that reestablishment above the dam is possible for this fish. While, there is still significant work and monitoring to be done to ensure that the fish who have become established above the dam continue thrive, further reintroductions are essential to helping this species recolonize an area it once existed in before the presence of the Ela dam.

5. Conclusion

The Sicklefin Redhorse was first classified as its own species in 1992, though not formally described, and while currently listed as a threatened species, it is on its way to being listed as endangered. The alteration and modification of its historical habitat has led to the fragmentation and isolation of the remaining population. Reintroduction efforts are thus essential in assuring the survival of the species. With dams being listed as a major threat to current populations, the efforts to translocate and reintroduce them above dams has been a management focus.

In ten fish relocated above the Ela dam in Cherokee, NC, five of them become established. They showed habitat preferences in depth, substrate, and type and abundance of in stream habitat. The fish only occupied pools that had distinct characteristics in these categories, and thus reintroducing them into areas without these aspects would be unsuccessful. The reach of river above the Ela dam had significant habitat for at least some of the fish reintroduced. This study indicates that further efforts at reestablishment of the Sicklefin Redhorse in the Oconaluftee River could prove to be successful.

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