SUCKERS, STUDENTS, AND SCIENCE: STUDYING THE SICKLEFIN REDHORSE IN GEORGIA

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INTRODUCTION

In the southern Appalachian Mountains of north Georgia, the arrival of spring is advertised by the blooms of the Redbuds, Dogwoods, Cherries, Forsythias and, for me, the return of five different species of redhorses, large-bodied suckers of the genus *Moxostoma* to Brasstown Creek, a moderately-sized coolwater stream flowing through Young Harris, Georgia. By the hundreds, these redhorses migrate in an orderly succession from the larger Hiwassee River near Murphy, North Carolina, across state lines and become temporary residents of north Georgia.

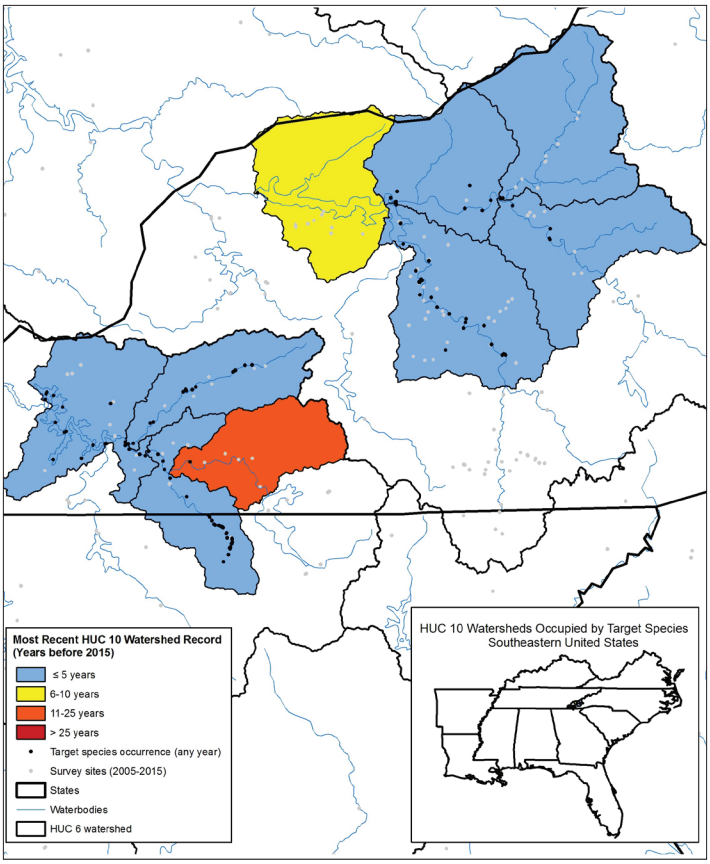
Few watersheds in the US can compare to Hiwassee River in terms of redhorse diversity. Beginning in late March, Silver Redhorses (*M. anisurum*) are the first to make the annual pilgrimage to the upstream spawning grounds, but they are quickly followed by the Sicklefin Redhorse (*M.* new species), which takes up residence at spawning sites in mid-April. As May approaches, the most abundant redhorse, the Golden Redhorse (*M. erythrurum*), appears, followed closely by the similar Black Redhorse (*M. duquesnei*). It is only in the latter stages of the month of May that the River Redhorse (*M. carinatum*), the plodding straggler but largest of the group, finally arrives to complete the redhorse migration cycle.

However, it is the Sicklefin Redhorse that has recently received much attention from citizens, fish enthusiasts, researchers, and state and federal natural resource agencies. For many years the Sicklefin Redhorse went unnoticed among the redhorses, identified either as River Redhorse based upon the similarly red caudal fin or Shorthead Redhorse (*M. macrolepidotum*) due to its somewhat falcate dorsal fin, or a hybrid between the two. But it was in 1992 that Dr. Robert Jenkins of Roanoke College would record and recognize the Sicklefin Redhorse, named for its characteristic falcate or concave dorsal fin, from collections and drawings of individuals from the Little Tennessee River in North Carolina. In 1993 the Tennessee Valley Authority (TVA) would document the Sicklefin Redhorse in the Hiwassee River system in Brasstown Creek. Investigations of museum records would turn up collections from as early as 1937, and discussions with the Cherokee would reveal a reference to Sicklefin Redhorse as "junigihtla" or "wearing a red feather" in English. The Sicklefin Redhorse and other redhorses were vital to the Cherokee of the southern Appalachians as tribe members would travel en masse to the tributaries of the Hiwassee and Little Tennessee rivers in the springtime to collect redhorses from constructed fish weirs. Dr. Jenkins made several more collections and produced the first report of the Sicklefin Redhorse to the US Fish and Wildlife Service in 1999. Dr. Jenkins continued to study distributional and life history aspects of Sicklefin Redhorse, recording extensive field notes, videos, and capture information from hundreds of released individuals. He also collected anatomical data on more than 50 internal and external characters of approximately 230 preserved specimens and, with help from several of his students from Roanoke College, studied food habits, feeding behavior, age at maturation, fecundity, and spawning behavior and habitat. What became apparent through Dr. Jenkins' work and the work of many others is that this species was likely surviving in only a small area of its native range due to the historic construction of dams within the Hiwassee and Little Tennessee watersheds.

Successive research focused on further describing life history traits, range, behavior, and habitat use of the Sicklefin Redhorse. The most comprehensive research to date of Sicklefin in the Hiwassee River watershed was conducted by Scott Favrot, a graduate student at North Carolina State University, from 2006 to 2007. Favrot refined the description of habitat use of the Sicklefin Redhorse originally reported by Jenkins, mapped the distribution of the Sicklefin Redhorse population, and tracked movements of individu-

Figure 1. Male Sicklefin Redhorse from Brasstown Creek, Georgia displaying spawning tubercles on lower lobe of caudal fin and on anal fin and with prominent falcate dorsal fin. (Photo by J.G. Davis)

als between Brasstown Creek, Hiwassee Reservoir, and the Valley River. Adults generally occupied flowing runs in rivers and large tributaries, generally upstream of reservoirs and sometimes occupied shallow, near-shore areas.



Conservation Status Assessment Map for Sicklefin Redhorse. (Map by Georgia Department of Natural Resources and Tennessee Aquarium Conservation Institute)

Juveniles preferred slower currents and deeper pools in downstream reaches of rivers near and within downstream reservoirs. Larvae were likely carried downstream into the upper reaches of the reservoir. Favrot's research initiated a subsequent study of Sicklefin in the Hiwassee drainage by Tomas Ivasauskas (North Carolina State University), who has investigated larval life history of the Sicklefin Redhorse and assessed predation on redhorse eggs and larvae by recently introduced Blueback Herring (*Alosa aestivalis*) in the Hiwassee River. Recently, the US Fish and Wildlife Service has conducted a genetic analysis to develop an estimate of effective population size, initiated propagation and reintroduction work, and has carried out cryopreservation of male gametes.

A number of individuals and entities have made recent contributions including the Eastern Band of the Cherokee, North Carolina Wildlife Resources Commission, Western Carolina University, North Carolina State University, Duke Energy, Georgia Department of Natural Resources, and Young Harris College. Together, these partners have established a Candidate Conservation Agreement, a sort-of proactive approach to conservation of a candidate species that designates dollars for monitoring, restoration, and research to prevent listing on the Endangered Species Act. In particular, Georgia Department of Natural Resources has contributed funding to support research by myself and students at Young Harris College over the past three years to study the only known spawning population of Sicklefin Redhorse in Georgia. Recently, NANFA awarded the NANFA Conservation Research Grant to contribute additional funding.

Figure 2. Young Harris College student researchers William Leatherwood and Austin Farley use the downstream seining technique to capture Sicklefin Redhorse in Brasstown Creek, Georgia. (Photo by J.G. Davis)

RESEARCH AND PURSUIT OF THE SICKLEFIN REDHORSE

My family and I moved to Young Harris, Georgia, from middle Tennessee as I began my appointment as an assistant professor at Young Harris College. I was lured to north Georgia by its incredible aquatic diversity with designs on continuing my research on rare and imperiled native aquatic species and introducing students to the aquatic diversity in southern Appalachia. Upon meeting Dr. Brett Albanese of Georgia DNR's Nongame Section, it became apparent that there was a need to better understand Georgia's population of Sicklefin Redhorse but also a lack of manpower to do so. As a wide-eyed scholar with a doctorate degree in which the ink was barely dry, I had found my research project. Thus, my journey with the Sicklefin began.

Figure 3. Use of a passive integrated transponder (PIT) tag reader to detect a PIT-tag inserted near the dorsal fin of a Sicklefin Redhorse captured in Brasstown Creek, Georgia. (Photo by J.G. Davis)

In April 2013 I began to tentatively explore Brasstown Creek with snorkel and seine and my first full-time undergraduate researcher and volunteer, David Atwood. Donning dry suits, hoods, gloves, and binoculars, we sought the Sicklefin in the still cold, springtime waters of Brasstown Creek. Our specific objective was to evaluate various sampling methods for Sicklefin. We'd heard countering arguments from biologists that you could catch them in a seine and that you couldn't catch them in a seine. We'd heard fascinating tales of snorkeling and of massive shoals in deep pools visible from the stream bank. But how could biologists reliably detect these suckers under normal conditions so that they could begin to quantify the population? With all of the available literature on quantitative sampling of fishes, could it be as simple of spotting and counting Sicklefin from the stream bank?

That first spring we learned several important things. Yes, we could simply spot and count Sicklefin reliably. We improved our seining technique, settling on a downstream method that would require nimble feet and no fear of a forward flop into the water, perhaps because of an unseen boulder. We graduated to wider and deeper seines and larger mesh sizes but mostly developed the technique for maintaining the properly curved bag while simultaneously looking for spooked Sicklefin in front of the seine. We learned how Sicklefins respond to a seine, backing up out of the pool or run toward the head of the shallower riffle just downstream and, then, in a seemingly defiant act to the approaching seine, bolting forward into the seine for capture. Snorkeling proved more challenging as these wily suckers would often maintain a distance just out of visual range, waiting for you to look left as it swam past on the right. However, on the rare occasion that a large boulder or piece of woody debris was properly positioned, I could find myself perched just behind the object and peering slightly over and around it to spy "the red flag waving" of the Sicklefin. As I struggled to hold onto a boulder in heavy current of a gravelly run, the Sicklefin would appear to almost leisurely stroll around the heavy current feeding or occasionally warding off a wandering Black or Golden Redhorse. Visual surveys resulted in the greatest detection of Sicklefin presence, and canoe surveys that provided a visual census seemed like a reliable method to estimate the number of spawning Sicklefin in Brasstown Creek. Probably our most important finding was the capture of a Sicklefin Redhorse approximately two river miles farther upstream in Brasstown Creek than had previously been reported. Indeed, we had our own record to add to the distinctive history of the Sicklefin.

With a greater understanding and familiarity of Sicklefin and its favored locations, I headed confidently into the

spring of 2014 to repeat the findings from the previous year with two new undergraduate researchers, William Leatherwood and Austin Farley, who had agreed to take on what was quickly becoming known at the college as "Dr. Davis's Sicklefin Challenge." Equipped with new gear, redhorse seining expertise, and a young, athletic seining crew, we surveyed additional sites, tested out sampling methods, and for the first time, collected pectoral-fin rays to analyze age and growth of Sicklefin Redhorse. Jenkins (1999) had published the only known growth estimates for Sicklefin Redhorse, describing them as relatively slow-growing and long-lived with a maximum observed age of 21. Our efforts resulted in the collection of more than 25 Sicklefin Redhorse and successful processing and aging of pectoral-fin rays. Perhaps with more samples, we could establish pectoral-fin rays as a non-lethal method for aging Sicklefin Redhorse, which, given the designation of Sicklefin as a candidate species, would be necessary for study of population dynamics of Sicklefin in the future. We began to implant passive integrated transponder (PIT) tags into Sicklefin as well as to track future growth, survival, and movement. We also took tissue samples for genetic analysis and collected milt for cryopreservation to assist the US Fish and Wildlife Service in fulfilling objectives for conservation of Sicklefin.

Our results indicated that Sicklefin are indeed slow-growing, long-lived fish as Jenkins had described and that pectoral-fin rays were an acceptable non-lethal alternative for aging Sicklefin. In spring 2015 my mission was to continue our tagging program and collect more samples for age and growth analysis. Because of an epidemic of graduating Sicklefin researchers, a new student, Fernando Serrano, stepped up to take on the Sicklefin Challenge. Fernando and I would catch more than 25 Sicklefin and recapture our first Sicklefin Redhorse from the previous year approximately 100 meters from its point of capture the year before. We also investigated the role of stream discharge in influencing annual growth of Sicklefin. Results indicated that discharge did not significantly impact Sicklefin growth although discharge during the spring and annual spawning migration appears to impact growth more than discharges at other times of the year. While the results were similar from the previous year, the exciting aspect was the number of students who were now volunteering and for the first time venturing into the waters of Brasstown Creek. Several freshmen were now sampling for Sicklefin and seeing this fish for the first time.

In spring 2016 our goals changed slightly. In consultation with Brett Albanese and members of the newly formed Sicklefin Redhorse Conservation Committee, we would continue our focus on collecting Sicklefin Redhorse for assessing age structure of the population and individual growth rates but also attempt to implant as many PIT tags as possible to

Figure 4. Male Sicklefin Redhorse held by William Leatherwood for collection of sperm to be cryopreserved by the USFWS for future propagation and hatchery rearing of genetically diverse Sicklefin Redhorse. (Photo by J.G. Davis)

begin a movement and telemetry study of Sicklefin Redhorse in Brasstown Creek. For this year, Fernando would return to continue pursuing his developing passion for Sicklefin and other native fishes of Appalachia along with the next generation of student Sicklefin researchers, Kaylyn Crossley and Josh Goeltz. They would receive the similar indoctrination to Sicklefin sampling as previous students, including the slips, trips, and falls familiar to any downstream seiner. Although seining had been moderately successful in the previous two years (>50 Sicklefin captured), a new technique was recommended by Dr. Albanese for capturing greater numbers of Sicklefin, which was a modified fyke net that would be placed in the stream during the height of the Sicklefin migration. However, determining the height of migration would prove more difficult. Due to a warmer spring than usual and quickly warming stream water temperatures, I decided to begin sampling sooner than usual with the first seine haul pulling through the water in the last week of March. This was much earlier than the scientific literature reports for spawning migration although we had captured a Sicklefin on April 8th in the previous year.

But there we were, plying those cool waters with our Sicklefin seining tactics with the hopes of catching Sicklefin in March. I had begun scouting survey sites visually from the road on the way home in the evenings and observed my first March Sicklefin. The next day, March 31st, we captured our first Sicklefin Redhorse of the season with our seine. Indeed, it appeared that spawning might happen early this year.

A warm front over the next week and sightings of many redhorses caused us to quickly move up our fyke-net sampling days. Brett and his team of DNR personnel arrived with the net in the second week of April and expertly set up

this "contraption" with the hopes and anxiety that accompanies all fish biologists when attempting a new sampling technique. This would be either boom or bust. After setting up the net on the first day and enjoying a dinner on the Young Harris College campus, Brett and his DNR crew would return to find more than 100 redhorses in the holding cage of the fyke net. Success! Over the next two days, each morning and evening would be welcomed with the prospect of sorting through more than 100 redhorses. Over two days, 66 Sicklefin Redhorse would be captured, exceeding our total number of captures over the past two years. Now, with over 100 pectoral-fin rays collected from Sicklefin Redhorses, we had enough samples for our age and growth study of Sicklefin Redhorse and enough tagged Sicklefin Redhorse to begin the next phase of our research.

FUTURE RESEARCH ON THE SICKLEFIN REDHORSE IN GEORGIA

As spring sampling concludes, the next immediate step involves the processing and sectioning of pectoral-fin rays, age assignment for individuals, and calculation of growth curves. Looking forward to the annual return of Sicklefin Redhorse in spring 2017, we hope to welcome the return of many of our tagged Sicklefin Redhorses. Previous research has suggested that Sicklefin may exhibit some fidelity to the stream and even the sites that they choose for spawning. Upon their return, we plan on having a series of PIT-tag detection arrays positioned along the stream bottom at various locations in Brasstown Creek. As tagged Sicklefin Redhorse pass by these underwater arrays, their unique tag number as well as the date and time should be recorded. The information gathered from this should be powerful and substantial. We will be able to determine the exact time in which migration into Georgia occurs, the number of individuals that return to spawn, the rate at which Sicklefin proceed upstream to spawn and downstream after spawning, and the time in which outmigration occurs. Furthermore, "recaptures" of tagged individuals detected by the array will allow for development of population models that will help us more accurately estimate population size and other population parameters such as recruitment and mortality. With this data, we will be able to develop population models to assess how Sicklefin Redhorse populations may respond under certain scenarios, enhancing the ability to make data-driven and informed conservation decisions and construct appropriate actions for conservation.

The Sicklefin Redhorse is a distinct cultural treasure of north Georgia. For individuals wanting to catch a glance of the Sicklefin, I recommend taking a trip to the Enchanted Valley in Young Harris, Georgia around mid-April. Start by surveying around bridges and pull-offs along local Highway

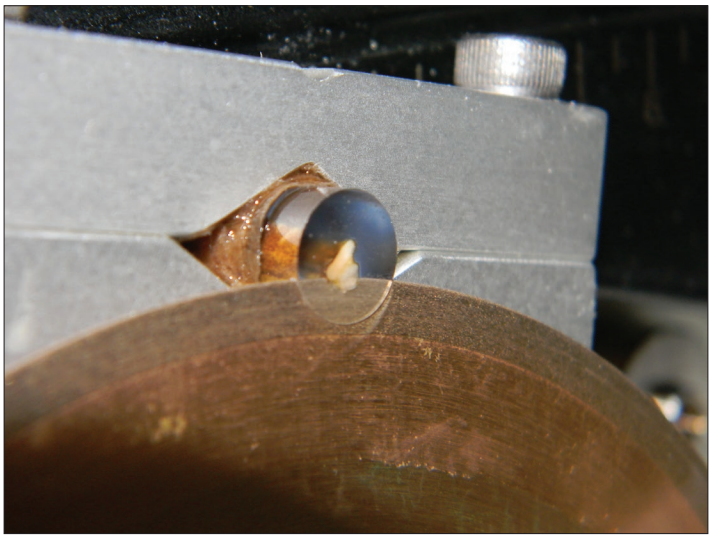


Figure 5. Top: Clear epoxy mounts of pectoral fin rays collected non-lethally from Sicklefin Redhorse in Brasstown Creek, Georgia. Bottom: An epoxy-mounted pectoral fin ray section being cut using a diamond wafering blade and isomet sectioning saw. (Photos by J.G. Davis)

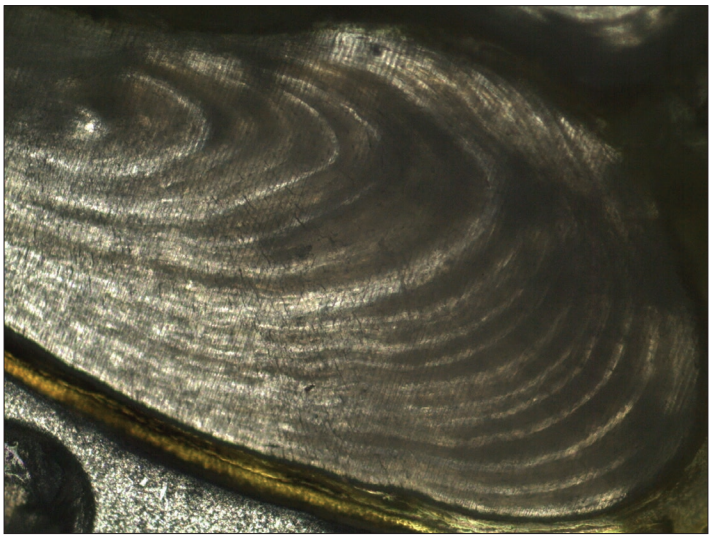


Figure 6. A sectioned pectoral fin ray of a Sicklefin Redhorse viewed under 100x magnification showing many annuli that represent one year of the fish's life. (Photo by J.G. Davis)

66. A good pair of polarized sunglasses is a necessity. Many redhorse species can be observed, but the Sicklefin Redhorse will stand out with its red caudal fin. But be careful as the River Redhorse also has a red caudal fin. The distinguishing characteristic is the concave dorsal fin that is so distinct that it can be observed from the stream bank. If you want to snorkel to see this fish up close, I recommend a dry suit or thick wetsuit as Brasstown Creek may be as cool as 13°C at this time of year. Because Sicklefin may be rare and patchily distributed in the stream, start by observing one from the bank and then entering the water from downstream, moving slowly upstream as stealthily as possible and taking shelter along any obstruction if present. You will likely observe other redhorses but also lampreys, Tennessee Shiner (*Notropis leuciodus*), Warpaint Shiner (*Luxilus coccogenis*), River Chub (*Nocomis micropogon*), Central Stoneroller (*Campostoma anomalum*), Northern Hog Sucker (*Hypentelium nigricans*), Redline Darter (*Etheostoma rufilineatum*) Greenside Darter (*E. blennioides*), Banded Darter (*E. zonale*), Gilt Darter (*Percina evides*), and two species of crayfish.

Like many of the suckers of the family Catostomidae, the Sicklefin Redhorse is threatened by deteriorating water quality and land-use practices that increase siltation in streams. Because of its migratory nature and stream fidelity, damming of watersheds has isolated and even eliminated genetically distinct populations, necessitating dam removal, and propagation of hatchery-raised Sicklefin in recent years. Continued monitoring and research of existing populations highlights these issues and works toward addressing conservation needs of this species. When the Sicklefin Redhorse returns to Georgia again next year, I will be there to greet them, and there will be another team of Young Harris College students with me, ready to work, and to discover new information about one of the rarest of Georgia's native fishes.

ACKNOWLEDGEMENTS

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