Transactions of the American Fisheries Society 135:1145–1155, 2006

DOI: 10.1577/T05-230.1

[Article]

Seasonal and Diel Movements and Habitat Use of Robust Redhorses in the Lower Savannah River, Georgia and South Carolina

TIMOTHY B. GRABOWSKI*[1]

Department of Biological Sciences, Clemson University, Clemson, South Carolina, 29634-0326, USA

J. JEFFERY ISELY

U.S. Geological Survey, South Carolina Cooperative Fish and Wildlife Research Unit, Clemson University, Clemson, South Carolina, 29634-0372, USA

Abstract.—The robust redhorse *Moxostoma robustum* is a large riverine catostomid whose distribution is restricted to three Atlantic Slope drainages. Once presumed extinct, this species was rediscovered in 1991. Despite being the focus of conservation and recovery efforts, the robust redhorse's movements and habitat use are virtually unknown. We surgically implanted pulse-coded radio transmitters into 17 wild adults (460–690 mm total length) below the downstream-most dam on the Savannah River and into 2 fish above this dam. Individuals were located every 2 weeks from June 2002 to September 2003 and monthly thereafter to May 2005. Additionally, we located 5–10 individuals every 2 h over a 48-h period during each season. Study fish moved at least 24.7 ± 8.4 river kilometers (rkm; mean ± SE) per season. This movement was generally downstream except during spring. Some individuals moved downstream by as much as 195 rkm from their release sites. Seasonal migrations were correlated to seasonal changes in water temperature. Robust redhorses initiated spring upstream migrations when water temperature reached approximately 12°C. Our diel tracking suggests that robust redhorses occupy small reaches of river (~1.0 rkm) and are mainly active diurnally. Robust redhorses were consistently found in association with woody debris and gravel streambed sediments along the outer edge of river bends. Fish exhibited a high degree of fidelity to both overwintering and spawning areas. Our observations of long-distance seasonal migrations suggest that successful robust redhorse conservation efforts may require an ecosystem management approach.

The robust redhorse *Moxostoma robustum* is a large-bodied riverine catostomid whose known native distribution is currently restricted to three Atlantic Slope drainages in the southeastern United States. This species was originally described from the Yadkin River within the Pee Dee River basin in North Carolina (Cope 1870) but subsequently was effectively lost to science for over a century (Bryant et al. 1996). Its rediscovery in 1991 prompted conservation efforts to prevent further population decline and prompted listing under the Endangered Species Act (Bryant et al. 1996; Cooke et al. 2005). Populations have been discovered in the lower Piedmont and upper coastal plain regions of the Oconee and Ocmulgee rivers in the Altamaha River system (Georgia); the Savannah River (Georgia and South Carolina); and the Pee Dee River system (North Carolina and South Carolina). Robust redhorses probably occurred in river systems between the Pee Dee and Altamaha rivers, such as the Santee River basin (Bryant et al. 1996); however, populations have yet to be identified from these other rivers and are presumed to be extirpated. The decline of robust redhorses, like that of other catostomid species, has been blamed on numerous factors, including introduced predators (flathead catfish *Pylodictus olivaris*: Bart et al. 1994) and competitors (buffalo *Ictiobus* spp.: Moyle 1976); habitat degradation and fragmentation (Jennings 1998; Weyers et al. 2003); and recruitment failure (Jennings 1998; Weyers et al. 2003). However, the exact causes of decline and the current status of robust redhorse populations are currently uncertain.

Despite being the focus of conservation and restoration efforts, virtually nothing was known about the movement or habitat use of adult robust redhorses before this study. Adult fishes have been observed to form spawning aggregations on shallow main-channel gravel bars in the Oconee and Savannah rivers during May and June, when the water temperature is 18–22°C (Freeman and Freeman 2001). Anecdotal reports suggest that adults are generally collected in association with woody debris and swift current throughout much of the year. To date, there have been few

* Corresponding author: tgrabow@uga.edu
[1] Present address: Warnell School of Forestry and Natural Resources, Georgia Cooperative Fish and Wildlife Research Unit, University of Georgia, Athens, Georgia 30602-2152, USA.

Received September 21, 2005; accepted March 6, 2006
Published online August 31, 2006

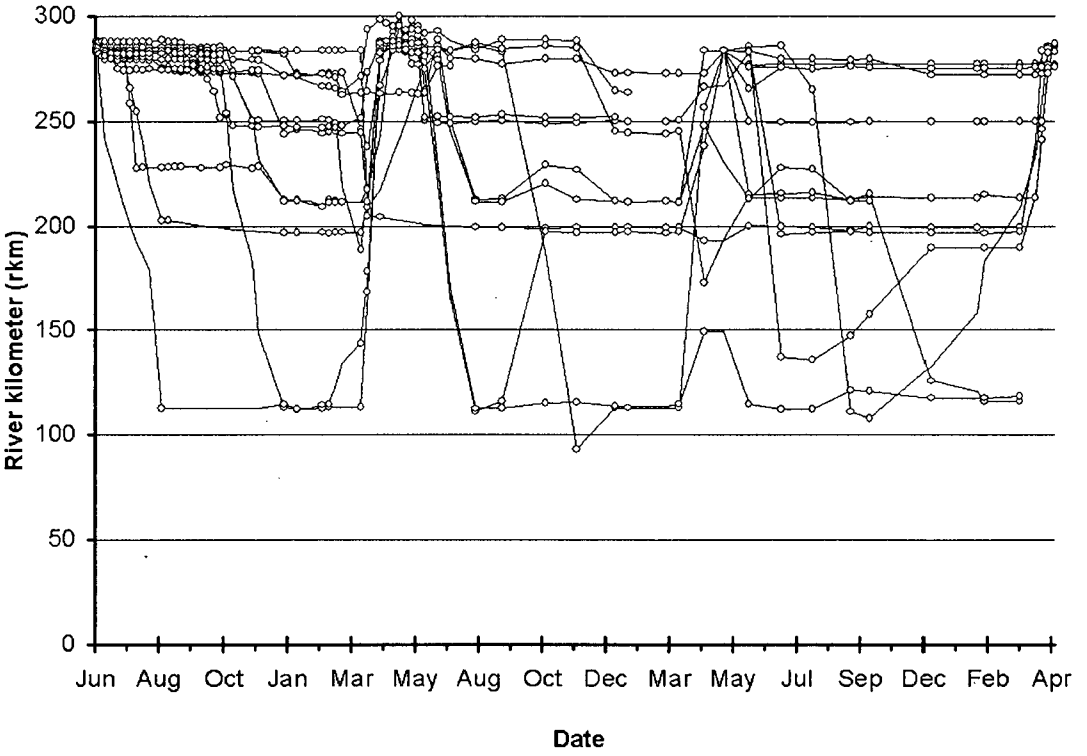

FIGURE 2.—River kilometer (rkm) positions of individual radio-tagged robust redhorses in the lower Savannah River below New Savannah Bluff Lock and Dam from June 2002 to April 2005. The solid lines connecting points indicate the movements of individual fish.

Results

We captured a total of 19 adult robust redhorses that ranged in size from 460 to 690 mm TL during June 2002. Two males were captured immediately below Savannah Rapids at rkm 324.2. Another 17 individuals (12 males, 5 females) were captured below NSBL&D from a main-channel gravel bar at rkm 283.7. The individuals captured from this gravel bar were presumably part of a spawning aggregation. Captured fish exhibited characteristics consistent with those described for breeding *Moxostoma* spp., such as fully formed nuptial tubercles, a loss of mucus, and cornified scales (Jenkins and Burkhead 1993). In addition, most of these individuals expressed gametes with mild abdominal pressure. Four robust redhorses died or shed their transmitters within the first 2 weeks after release, and one female died or shed the transmitter after 21 months. An additional five individuals (4 males, 1 female) were captured at the same gravel bar in May 2004. Two of these fish died or shed transmitters within 2 weeks of release.

Between June 2002 and April 2005, we relocated radio-tagged robust redhorses 1,182 times. Diel tracking accounted for 515 of these observations. Individuals were relocated from 10 to 165 times. Individual females were relocated an average (±SE) of 71.6 ± 15.59 times, and males were relocated an average of 73.1 ± 14.93 times. The two individuals captured above NSBL&D were relocated a combined 60 times. These two fish, along with fish captured in 2004 and fish number 48, were not incorporated in at least one of the diel tracking transects.

Most of the robust redhorses remained near (within 6.5 rkm of) their release sites throughout summer 2002 (Figure 2). However, one individual moved 172.8 rkm downstream within 1 week of release and remained there throughout the fall and winter before moving upstream in spring 2003. The remaining fish below NSBL&D began downstream migrations to overwintering areas in early to mid-fall 2002 (Figure 2). Overwintering fish dispersed along the length of the river down to rkm 90 (Figure 2). The majority of radio-tagged robust redhorses showed a high degree of overwintering-site fidelity (Figure 2), returning to the same 100–200-m lengths of shoreline each year. These

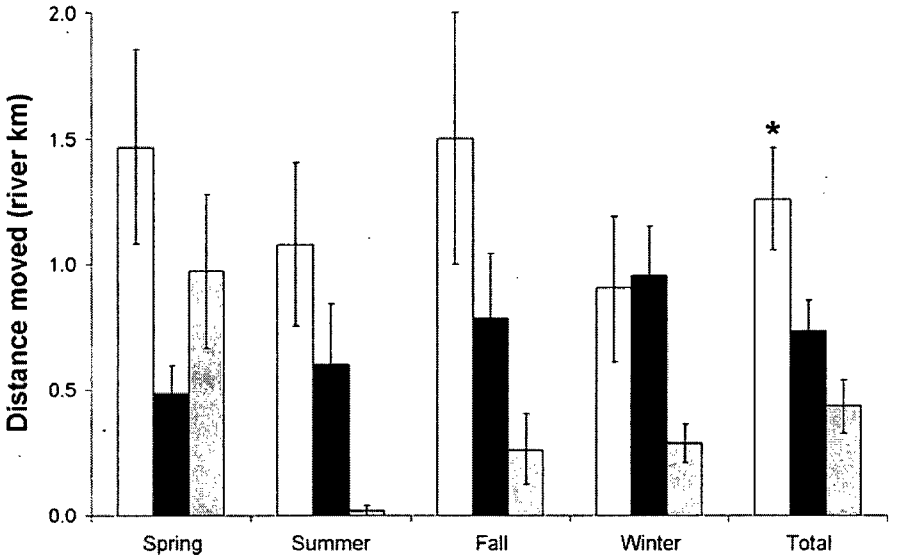

FIGURE 6.—Mean (±SE) absolute movement between 2-h tracking periods for robust redhorses in the lower Savannah River below New Savannah Bluff Lock and Dam from June 2002 to May 2005. The white, black, and gray bars represent daylight, nighttime, and twilight periods, respectively.

Colorado pikeminnow *Ptychocheilus lucius* (Tyus 1990), razorback suckers (Mueller et al. 2000), and paddlefish (Stancill et al. 2002). However, unlike most of the abovementioned species and the majority of catostomid species (Curry and Spacie 1984; Page and Johnston 1990), our radio-tagged robust redhorses did not ascend tributaries to spawn. Instead, they used main-channel gravel bars similar to other large riverine redhorses, such as the river redhorse (Hackney et al. 1968), greater redhorse (Jenkins and Jenkins 1980; Cooke and Bunt 1999), and copper redhorse *Moxostoma hubbsi* (R. Dumas, Société de la Faune et des Parcs du Québec, personal communication). Therefore, fidelity to spawning habitat in the lower Savannah River may be overestimated, as there are only two main-channel gravel bars to choose from. For example, individuals exhibited a high degree of site fidelity when conditions were suitable for spawning in 2004 and 2005. However, individuals visited both gravel bars in May and June 2003, when high water rendered depth and current velocities on both bars unsuitable for robust redhorse spawning (Freeman and Freeman 2001). This pattern of wandering among a few sites within a relatively small area during the spawning season has been observed in razorback sucker (Tyus and Karp 1990; Modde and Irving 1998; Mueller et al. 2000) and paddlefish (Paukert and Fisher 2001; Stancill et al. 2002) and suggests some assessment of habitat quality and suitability occurs before committing to a spawning site, regardless of past use.

The degree of fidelity displayed for staging and overwintering areas by radio-tagged robust redhorses was unexpected. Radio-tagged robust redhorses often migrated more than 100 rkm to spawning habitats and then returned a few weeks later to the same fallen tree where they spent much of the previous winter. In many cases, this site specificity was on the order of 0.1 rkm for overwintering areas. Other telemetry studies of riverine fishes have not noted this level of specificity of individuals to overwintering and staging areas. However, fidelity to overwintering or oversummering areas has been identified on coarser scales in reservoir populations of striped bass *Morone saxatilis* (Jackson and Hightower 2001; Young and Isely 2002), razorback sucker (Mueller et al. 2000), and Gulf sturgeon *Acipenser oxyrinchus desotoi* (Wooley and Crateau 1985; Clugston et al. 1995; Heise et al. 2005). It is not clear why robust redhorse would display such a high degree of fidelity to overwintering and staging habitats. Reports on the behavior of other catostomids offer no clear patterns. Some studies suggest these fishes are generally more active and wide ranging (Dauble 1986; Chart and Bergersen 1992), while others hint at a similar behavior pattern (Matheney and Rabeni 1995; Bunt and Cooke 2001). It is important to note that these studies were conducted on populations in smaller streams, were short-duration telemetry studies, or relied upon mark–recapture, making direct comparisons to this study difficult.

A possible reason for the high degree of site fidelity