THE ECOLOGY OF BLACKTAIL REDHORSE *MOXOSTOMA POECILURUM* IN WEST FORK THOMPSON CREEK, LOUISIANA

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The School of Renewable Natural Resources

by
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B.S., Southeastern Oklahoma State University, 2004
December 2007

ACKNOWLEDGEMENTS

I would like to thank my advisor Dr. Allen Rutherford for bringing me to Louisiana and allowing me the ability to design my own project. Dr. Rutherford gave me tremendous support and encouragement throughout my research project. I would also like to thank my committee members Dr. William E. Kelso and Dr. Michael D. Kaller for their assistance and guidance.

This project would have been extremely difficult or impossible without the help of Lauren Hart, Angela Williamson, Johnny Meche, Chris Bonvillain, Matt Bahm, Richard Williams, Thorpe Halloran, Robyn Sellers, Jenny Bodin, Alison Martin, Rachel Smith, Kayla Dibenedetto, Anne Commagere, Aaron Podey, Raynie Bambarger, Adam Piehler, Rachel Walley, Jonathan West, Alex Perret, Bryan Ward, and many others that assisted in the field and provided me with support. I would also like to thank Mike Wampold for allowing me access to his property. I am also grateful that Burnice Jones was the land manager of this property and was willing to help in any way he could.

Most of all I would like to thank my wife Sarah and son Elijah for putting up with me and for being extremely supportive when I needed it the most. They were always happy to see me. Without the help and support of these people I would not have been able to accomplish this task.

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ABSTRACT

This study was designed to examine home range sizes and habitat use of blacktail redhorse *Moxostoma poecilurum* in West Fork Thompson Creek, Louisiana. Blacktail redhorse are a common non-game species found in Louisiana and other southeastern states. Adult blacktail redhorse (N=40; 187-273 mm total length) were implanted with radio transmitters and tracked twice weekly from February to September 2006 and from February to July 2007. To assess blacktail redhorse diet I analyzed 32 stomachs from fish collected by backpack electrofishing. I also conducted mark-recapture surveys of fish sampled monthly from May 2006 until July 2007. To assess homing ability in blacktail redhorse, I radio-tagged 10 individuals in 2007 and relocated them downstream (0.8 or 1.6 km) from their capture location. Results showed that implanted fish exhibited extremely high mortality or expulsion rates with 70% of all implanted transmitters being lost, even though retention rates in the laboratory were very high. On numerous occasions, I directly and indirectly observed avian and mammalian predators foraging in the study area, which likely explains high transmitter loss. Individual 95% linear home range sizes varied from 25 to 3,900 meters, with several fish having multiple home ranges, while others remained in the same pool throughout the study. Blacktail redhorse were observed foraging throughout the diel period, and their diet was primarily composed of chironomid (55%) and heptageniid larvae (17%). Similar to other redhorse species, blacktail redhorse were benthic feeders and foraging behaviors appear very similar to that of black redhorse *Moxostoma duquesnei*. Few marked individuals were recaptured (6 of 130) as indicated by mark-recapture sampling. The homing study showed only one individual moved back to its capture location. Small sample sizes and short study times limited both the mark-recapture and homing studies. Overall, blacktail redhorse exhibited a preference for pools with clay boulders, complex habitat,

and undercut banks. The high levels of predation observed throughout this study and its impact on blacktail redhorse abundance suggest that local predation pressures structure this portion of the population and may be a driving force in structuring the entire headwater stream fish community in this area.

INTRODUCTION

The ecology of freshwater fishes has been investigated thoroughly for most game species (Bjornn 1971; Chisholm et al. 1987; Todd and Rabeni 1989; Schaffler et al. 2002; Young and Winn 2003; Gunderson et al. 2004). However, there has recently been an increased interest in the life histories of common non-game species as well (Matheney and Rabeni 1995; Snedden et al. 1999; Sakaris et al. 2005; Jeffres et al. 2006). Blacktail redhorse *Moxostoma poecilurum* (Catostomidae) are a common non-game sucker, ranging from eastern Texas to Florida and as far north as Kentucky (Burr and Cashner 1984; Ross et al. 2001). In Louisiana, blacktail redhorse have been collected throughout the state in small streams to large rivers, but tend to occupy slower moving waters than other redhorse species (Ross et al. 2001). Throughout the southeastern U.S., blacktail redhorse are known to spawn in aggregations from late April to May as water temperatures approach 20°C (Gunning and Shoop 1964; Kilgen 1974; Ross et al. 2001).

Studies of other closely related sucker species have described crepuscular feeding habits (black redhorse *Moxostoma duquesni*; Bowman 1970), diurnal (northern hog suckers *Hypentelium nigricans*; Matheney and Rabeni 1995), and nocturnal movement patterns (salish suckers *Catostomus* spp.; Pearson and Healey 2003), and various levels of site fidelity and movements related to reproduction (Bowman 1970; Pearson and Healy 2003), but little is known about blacktail redhorse. These types of data (home range, seasonal movement, and mortality) can be determined effectively with telemetry, which allows investigators to follow individual fish movements. Telemetry research requires a substantial time commitment and is relatively expensive (Winter 1996), which has likely restricted telemetry-based research of common non-game species. Technology has improved substantially since the first telemetry studies (e.g., Henderson et al. 1966), particularly in the areas of extended transmitter life and decreased transmitter size. Researchers are now able to follow the movement of smaller fishes for longer periods, which allows examination of short-term fish movements and determination of fish activity periods (e.g., forage, rest, reproduction, etc). Many studies have used radiotelemetry to determine fish movement throughout the diel period (Guy et al. 1994; Matheney and Rabeni 1995; Snedden et al. 1999).

Problems associated with telemetry include transmitter expulsion, infection and mortality, and reduced fish mobility (Summerfelt and Mosier 1984; Brown et al. 1999; Walsh et al. 2000). Several fish species have been shown to expel transmitters, and some only weeks after surgery. Channel catfish *Ictalurus punctatus* have been shown to expel 52% of implanted transmitters within a 23 day period (Summerfelt and Mosier 1984; Marty and Summerfelt 1986). Rainbow trout *Oncorhynchus mykiss* have also been shown to expel transmitters at a relatively high rate (Chisholm and Hubert 1985; Helm and Tyus 1992). However, hybrid striped bass *Morone saxatilis* x *chrysops* expulsion rates have been reported to be low (Walsh et al. 2000). To minimize negative effects of transmitter implantation on fish behavior and movement, Winter (1983) concluded that transmitter weight should be ≤ 2% of the fish's body weight. However, Brown et al. (1999) viewed this as a conservative estimate after reporting that fishes with transmitters 12% of body weight showed no loss in swimming performance.

To complement telemetry data, information from mark-recapture studies have been used to determine fish movement, migration, abundance, and mortality (Bowman 1970; Guy et al. 1996). Mark-recapture is relatively inexpensive, thus a larger number of fishes can be marked (Guy et al. 1996), but the low recapture rates typical of these studies often result in insufficient data to assess fish movements (Winter 1977).

A good understanding of fish movement patterns and the stream area used by fishes is critical to managing game and non-game fish populations (Guy et al. 1994; Gunderson-VanArnum et al. 2004). Further, when fish stocks decline and reintroduction is needed, it becomes important to understand their ecology (Johnson 2001; Pearson and Healy 2003). Many fishes exhibit homing behaviors and have been shown to use chemical and physical cues to return to their home range after relocation (Stabell 1987; Hert 1992; Dukes et al. 2004; Nordeng and Bratland 2006). Atlantic salmon *Salmo salar* have been shown to return to their rearing hatchery after reintroduction even though suitable spawning habitat was available at the translocation site (Carr et al. 2004). After relocation largemouth bass *Micropterus salmoides* initially moved to local habitats and assumed similar compass orientations to their original home range, however, they typically returned to their home range (3-69 days; Mesing and Wicker 1986). Fishes that do not exhibit homing behavior would be better candidates for reintroduction because of the increased predation risks associated with homing-related movements.

For a complete understanding of a fish's ecology, it is also important to determine their dietary requirements. Pond-raised blacktail redhorse have been shown to prey on detritus, macrophytes, caddisfly larvae, ostracods, midge larvae, cladocerans, copepods, and protozoans, however this information has not been determined for fish in natural settings (Kilgen 1972). Other closely related suckers (black redhorse, golden redhorse *Moxostoma erythrurum*, northern redhorse *Moxostoma macrolepidotum*, silver redhorse *Moxostoma anisurum*, and northern hog suckers) have been shown to forage predominately on benthic invertebrates (Meyer 1962; Bowman 1970; Matheney and Rabeni 1995), and based on taxonomic and structural similarities between these fishes and blacktail redhorse, it is likely these fish forage in a similar manner.

This study was undertaken to clarify some of the basic ecology of blacktail redhorse in a coastal plain stream. More specifically, my objectives were to determine seasonal and diel movement patterns, habitat use, homing ability, and diet for blacktail redhorse. Further, I compared diets of pond-raised blacktail redhorse to those in a natural stream watershed. Finally, I compared blacktail redhorse feeding and spawning behavioral patterns to other taxonomically and structurally similar catastomid species.

METHODS

Study Site

The study stream, West Fork Thompson Creek (hereafter WFT), was located in West Feliciana Parish about 1.6 kilometers east of Chapel Hill, Louisiana and approximately 24 kilometers north of St. Francisville, Louisiana (Figure 1). WFT begins in southern Mississippi and flows downstream into Thompson Creek, which is the southern-most tributary of the Mississippi River in Louisiana. All property surrounding WFT is private, which makes access to the stream limited. Within WFT, my study reach was approximately a five kilometers long (straight-line distance) and was characterized by sand substrates, which resulted in considerable changes in benthic morphology with each major rain event (Figure 2). The riparian area was composed primarily of hardwoods *Quercus* spp. with interspersed pines *Pinus* spp. and willows *Salix* spp. The canopy along the stream is relatively open throughout the study reach.

Telemetry

Thirty-one blacktail redhorse captured with backpack electrofishing were implanted with radio transmitters in 2006, and nine in 2007. During each sampling event all blacktail redhorse were collected, but only fish that weighed more than 80 grams (transmitter $\leq$ 5% of body weight) were implanted. Length and weight were taken for all fish and those within the proper size range were implanted with a 3.7 g transmitter (Advanced Telemetry Systems Model # F1585) that was 13-mm wide, 27-mm long, and 7-mm high. Transmitters were coded by frequency, and their reported life expectancy was 262 days.

Surgical techniques were similar to that of Hart and Summerfelt (1975), where an incision was made between the pectoral and pelvic fins approximately 1.5 times the width of the

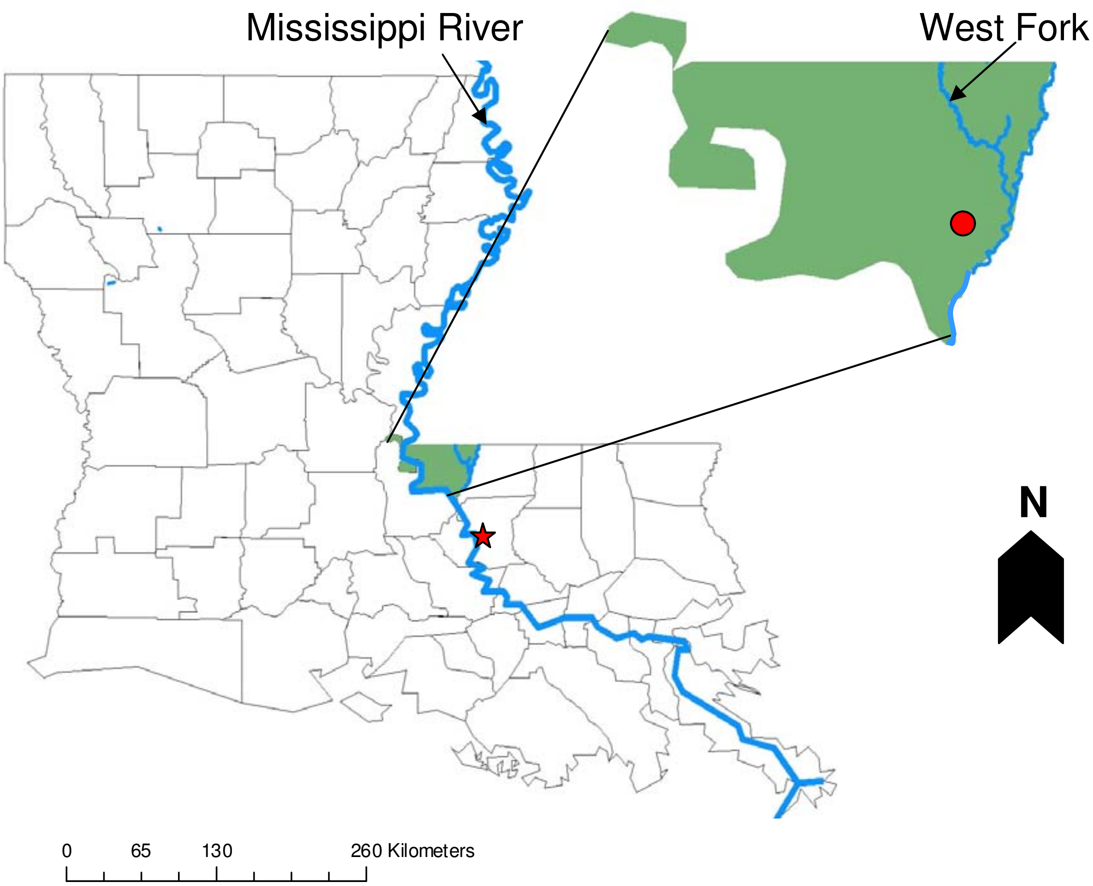

Figure 1. The study stream, West Fork Thompson Creek, located in West Feliciana Parish, Louisiana (Red Star represents Baton Rouge the state capital and circle is for St. Francisville).

Figure 2. Stream changes in West Fork Thompson creek over an 8 month period during 2006 and 2007 (top picture of stream channel in 2006 looking upstream and bottom picture of same channel in 2007 looking down stream).

transmitter. The incision was closed with three interrupted, 4/0 non-absorbable sutures (Oasis). Before the surgical procedure, fish were anesthetized with 1.2 mg/L of clove oil and placed in a water-bath, which irrigated the gills with a 0.6 mg/L clove oil solution. Clove oil concentrations were determined through pre-study laboratory experimentation and appeared to maintain complete anesthesia. Upon completion of surgery, fish were placed in a holding pen for a minimum of 30 minutes to ensure successful recovery. After recovery all fish were released at their capture location. In addition, five blacktail redhorse were surgically implanted prior to the start of the study with radio transmitters in a laboratory setting. Over a three-month period, all fish retained transmitters and remained healthy.

I located fish with a portable receiver (Lotek SRX 400) fitted with a three-element folding yagi antennae. Fish were monitored 1-3 times per week from February through September 2006 and from January through June 2007. Fish monitoring ended 1 October 2006 based on a landowner request that no activity be conducted during hunting season. During each tracking session, fish were monitored on foot up to 3 km upstream and 2 km downstream of the access bridge on Pump Station Road. Monitoring distances were somewhat restricted because of limited stream access.

Once a fish was located within a specific habitat type, its exact location was determined by "dialing off" the transmitter frequency and reducing the gain. This procedure was extremely accurate at locating transmitters to an area of one meter or less of the transmitters' actual location. After fish were located, I measured and recorded habitat characteristics such as habitat type (pool, riffle, run), percent canopy cover, substrate and cover type [limbs/roots, log, complex (rootwad and log), undercut bank, clay boulders] (Figure 3), and water velocity (FlowTracker® Handheld Acoustic Doppler Velocimeter SonTek, YSI, Inc., Yellow Springs, OH, USA).

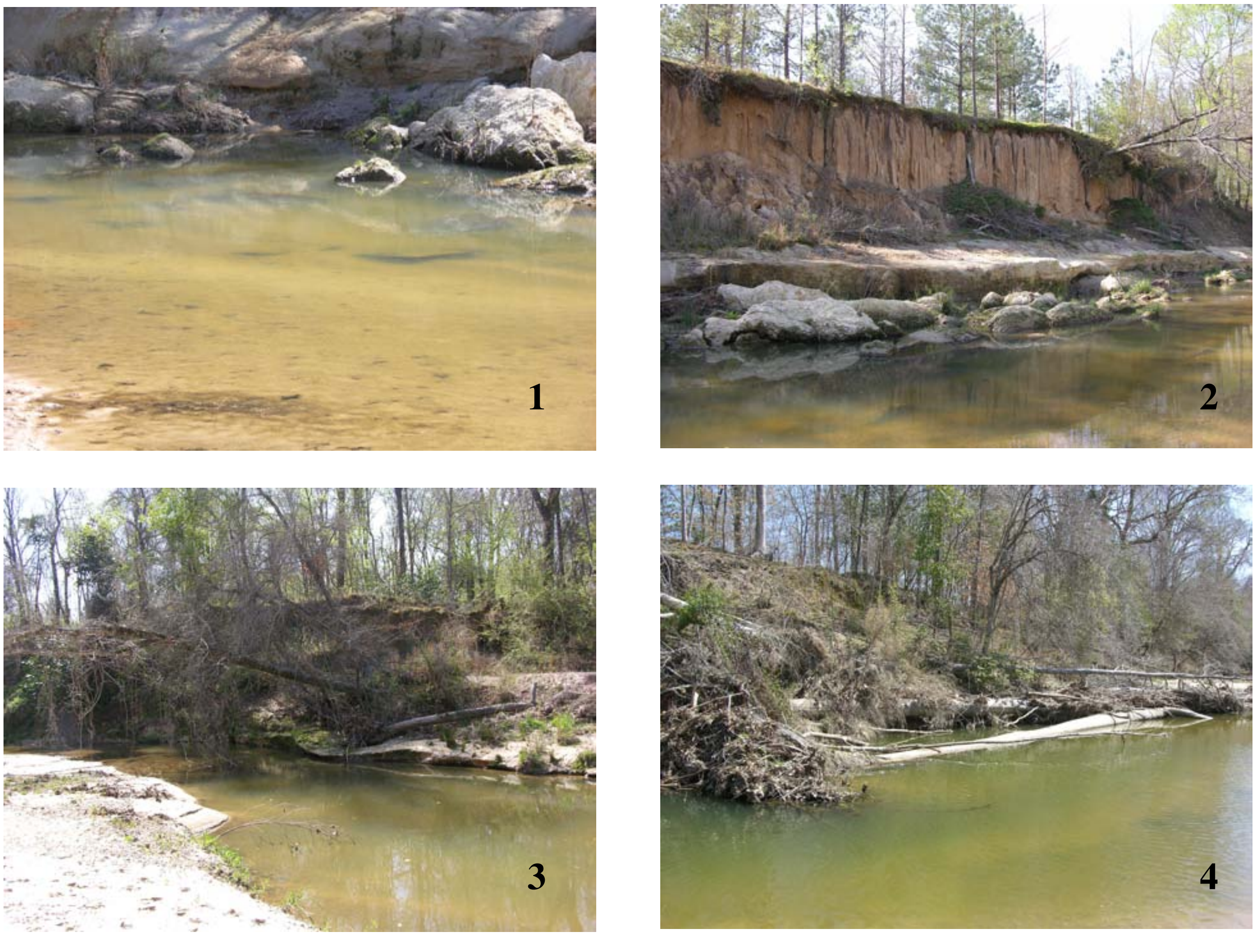

Figure 3. Habitat types found in West Fork Thompson creek (Pictures 1 and 2 are of clay boulder habitat, 3 is undercut bank, and 4 is complex habitat).

At each fish location I recorded dissolved oxygen (mg/L), pH, temperature (°C), turbidity (NTU), salinity (PSS), and specific conductance (mS/cm) with a handheld Hydrolab Quanta® water quality monitor (Hydrolab, Inc., Austin, TX, USA). Stream discharge was taken from the Comite River near Olive Branch, LA from the U.S. Geological Survey gauging station (USGS Gauging Station 07377500). The Comite River stage data was similar to a gauge placed in WFT, which was monitored a month before being displaced by a local flooding event (J. L. West and W. E. Kelso, personal communication). When several fish were located within the same reach, all location data were recorded before environmental data collection to prevent disturbance of fish caused by entering the stream.

When fish moved from the study location, an intensive search effort was attempted if fish had not returned to study site over a two-week period. This search extended from an access bridge located in Mississippi to the washout bridge on LA Hwy 421, which is approximately 24 stream kilometers. The 12 km of upstream habitat extends from Turnbull Road just across the Mississippi state line to Pump Station Road, and the 12 km downstream extends from Pump Station Road to LA Hwy 421. If the fish were found in the initial search area, the remaining portion of the stream was not searched. In 2007, searches were extended to cover approximately 45 km of stream from the headwaters into the mainstem of Thompson Creek. Due to restricted stream access, searches were infrequent but were attempted once per month after a fish was located outside the study reach.

Habitat availability was determined by sampling pools and the riffle downstream from the pool where blacktail redhorse were collected. At each of these sites, I measured cover, depth, water velocity and substrate availability at one-meter intervals across stream and at five-meter transects along the length of the stream channel. These data were then used to determine percent availability of habitat variables within the selected pools.

Population Estimation

Backpack electrofishing surveys were attempted once per month beginning May 2006 and ending July 2007 with an interruption due to access limitations (October 2006 – January 2007 and April 2007). Three pass electrofishing was used to sample each target pool (100 m section of stream). Target pools were chosen if blacktail redhorse and river otter *Lutra canadensis* activity were present in and around the pool. In August 2006, blacktail redhorse were sampled from within a 50-m stream section where fish were in extremely high concentrations. This sample was included in subsequent analysis but the abundance value was not extrapolated from the 50-m area to the 100-m section typically used, to avoid over estimation. All fish were marked with fin clips and blacktail redhorse were marked with visible implant elastomer and alpha-numeric tags to distinguish among sites and dates. Marking was done to complement the telemetry data in an effort to determine if these fish would reside in the same pool throughout the year.

Home Range Analysis

Home ranges were calculated with 95% Minimum Convex Polygons (Winter 1977) and 95% linear home range. These calculations were performed with ArcMap version 9 (ArcMap, Environmental Systems Research Institute, Inc., Redlands, CA, USA). Modified polygon shapefiles were constructed to fit all data and only encompassed the stream channel. These modified polygons greatly enhanced the accuracy of home range estimates and were constructed with only 95% of the data to reduce the impact of outliers on home range size.

12-Hour Monitoring

Diel monitoring was limited to summer 2006 primarily on the upstream end of the study reach because of restricted stream access. Fish were monitored throughout a 12-hour period at 30-minute intervals from April through June 2006. Thirty-minute time intervals between relocations were selected to allow fish to settle after being disturbed by human activity along the stream bank. At each 30-minute location, a flag was placed along the shoreline with the fish's transmitter number and time of location, and straight-line distance measurements from these points was used to determine instream fish movement. Water depth, water velocity, habitat type (run, riffle, pool) and substrate were taken at locations where fish were located four or more times or when fish moved into a new habitat type. These measurements were taken after monitoring was complete to prevent fish disturbance.

Diet and Age

A total of 32 blacktail redhorse collected by backpack electrofishing were used to assess diet. Fish weight and length were taken, stomachs were removed and placed in 95% ethanol, and otoliths and scales were collected for analysis of age and growth. Stomach contents were then sorted in the laboratory and identified to family (Smith 2001; Merritt et al. 2007). Instream benthic invertebrates from WFT were collected by sampling three areas near fish capture locations with a modified Hess sampler (Kaller and Kelso 2007). Otoliths were aged after remaining in glycerin for one month by viewing them under a microscope set at 20x power. I did not grind otoliths because of their small size.

Relocation and Homing

Twelve blacktail redhorse were captured from the same pool and implanted with transmitters; two fish were released in the capture pool, five were relocated to an area 0.8 km downstream and five fish were moved 1.6 km downstream. Implantation techniques, habitat availability and water quality methods were identical to those described above (see Telemetry section). If fish were not relocated within two weeks, I began an extensive search from the WFT headwaters at the Mississippi state line downstream to Highway 421. If fish were not located within this area, I extended the search further downstream to Thompson Creek (45-stream km).

Statistical Analysis

Chi-square analysis was used to test for relationships between fish habitat availability and habitat use to examine the associations (+ or -) between fish and habitat type. Analysis of Variance (ANOVA) was used to analyze differences in daily, monthly, and directional movement. A log+1 transformation was used to more closely approximate normality for all movement data. A simple linear regression weighted by the number of times a fish was observed was used to determine the relationship between fish length and linear home range size. All analyses were performed with Statistical Analysis System software (SAS, version 9.1.2, Cary, North Carolina, USA).

RESULTS

Fish Fates

During the periods of February 24 – September 1, 2006 and from February 6 – June 26, 2007 a total of 496 locations were taken on 40 fish ($\overline{X}$ = 12 location per fish). Tagged blacktail redhorse ranged in size from 187-273 mm total length with a transmitter weight that ranged between 2-5% of overall body weight. Twenty-eight (70%) of these fish had transmitters that were either expelled or displaced from a fish that died. Of these transmitters, 14 (35%) were found in the stream channel, 12 (30%) were located on land and 2 (5%) were found in a heron and a snake (Table 1). Similar results were found with the 2007 relocation study with 4 (33%) of the 12 fish losing transmitters; 3 (25%) of which were in the stream and 1 that was on land (Table 2). Most of the transmitters were recovered, but some were never found. Several fish were never located after release, which could have been due to mortality or transmitter failure (Table 1 and 2).

Habitat Use and Blacktail Redhorse Abundance

Blacktail redhorse abundance was positively associated with complex habitat, clay boulders, and undercut banks and was negatively associated with open water ($X^2 = 346.64$, df = 6, $p < 0.0001$, Figure 4). During the 12-hour night and day telemetry study, fish typically used the same habitat and rarely moved over 100 m. Blacktail redhorse abundance was highest in August 2006 and remained unchanged until February 2007. Redhorses less than 200 mm were common in 2006, but in February 2007 abundance of these fish began to decline. Individuals greater than 200 mm had their highest abundance in February 2007 and their lowest documented abundance in July 2006 and July 2007 (Figure 5). Fish abundance declined in March 2007 and continued to decline in the summer and appears unrelated to stream discharge (Figure 5).

Table 1. Transmitter numbers for 2006-2007 sampling season with fish length, weight, sex, surgery date, date last found alive, number of locations (N), location of transmitter, 95% minimum convex polygon, and 95% linear home range for blacktail redhorse. An asterisk (*) indicates a fish had multiple home ranges and letters (a, b, c) represent transmitters that were reused.

Trans #	Length (mm)	Weight (g)	Sex	Date Tagged	Last Found Alive	N	Location of Transmitter	Home Range 95% m^2	Linear Home Range 95% (m)
23	221	111	N/A	2/24/2006	3/7/2006	2	Unknown	N/A	15
45	210	91	N/A	2/24/2006	3/17/2006	6	Land	1332	87
45*	210	91	N/A	5/17/2006	8/21/2006	6	Land	357	25
62	252	180	N/A	2/24/2006	4/6/2006	10	Water	735	60
79	247	165	N/A	2/24/2006	4/6/2006	9	Land	970	58
102	187	101	F	2/24/2006	5/22/2006	21	Water	1074	54
124	236	141	M	2/24/2006	3/17/2006	6	Unknown	19118	1186
144	219	102	F	2/27/2006	5/2/2006	16	Water	1950	84
164	209	90	N/A	2/27/2006	4/7/2006	10	Unknown	65110	965
185	218	110	M	2/27/2006	4/7/2006	6	Unknown	85179	3370
203	230	120	N/A	2/27/2006	5/31/2006	22	Water	1715	81
244	219	108	F	3/2/2006	7/31/2006	33	Land	2150	133
262	203	75	M	3/2/2006	4/21/2006	12	Snake	2496	133
262*	203	75	M	3/2/2006	8/14/2006	21	Snake	2442	110
223	221	117	M	3/3/2006	8/2/2006	32	Water	5859	260
223*	221	117	M	3/3/2006	8/2/2006	32	Water	820	46
283	221	119	F	3/3/2006	N/A	0	Unknown	N/A	N/A
304	212	94	F	3/3/2006	9/1/2006	31	Alive	890	41
324	225	116	M	3/3/2006	5/2/2006	13	Water	2929	79
344	233	146	M	3/3/2006	5/17/2006	6	Unknown	191816	2254
362a	206	91	M	3/3/2006	3/30/2006	7	Water	51993	1326
385	201	84	M	3/3/2006	8/2/2006	35	Water	5084	262
402	200	90	M	3/3/2006	3/17/2006	4	Water	2988	116
442a	221	121	N/A	5/23/2006	6/30/2006	6	Land	222	22
424a	209	83	N/A	5/23/2006	6/27/2006	5	Water	21297	685
462	254	162	N/A	5/23/2006	N/A	0	Unknown	N/A	N/A
484a	226	119	M	5/23/2006	6/30/2006	6	Water	556	22
502	200	84	F	5/23/2006	6/30/2006	6	Land	136	21
521a	215	102	M	5/23/2006	6/15/2006	4	Land	51	33
543a	221	114	M	5/23/2006	6/30/2006	6	Land	136	22
562a	219	111	M	5/23/2006	6/27/2006	5	Water	70	20
582a	222	110	M	7/7/2006	7/21/2006	4	Water	22667	607
484b	230	108	M	7/12/2006	7/25/2006	3	Land	N/A	54
521b	220	120	M	7/12/2006	8/2/2006	5	Land	N/A	79

Table 1. Continued.

543b	250	163	M	2/6/2007	2/27/2007	4	Land	2905	850
484c	273	204	M	2/6/2007	4/10/2007	4	Unknown	13072	773
484c*	273	204	M	3/20/2007	5/11/2007	9	Unknown	1874	96
362b	260	177	M	2/6/2007	2/16/2007	1	Land	N/A	N/A
562b	249	163	M	2/6/2007	4/10/2007	13	Unknown	6126	431
562b*	249	163	M	4/13/2007	5/11/2007	6	Unknown	90	14
582b	231	115	M	2/6/2007	6/13/2007	34	Quit	1108	102
424b	226	111	M	2/6/2007	6/26/2007	36	Alive	2352	171
602	229	118	M	2/6/2007	3/29/2007	13	Water	775	61
362c	253	166	F	3/8/2007	3/27/2007	8	Heron	16862	1019

Table 2. Transmitter number, length, weight, sex, surgery date, date last found, number of locations, and location of transmitter of fish used in relocation study.

Trans #	Length (mm)	Weight (g)	Sex	Date Tagged	Last Found Alive	N	Location of Transmitter
623	195	78	M	5/21/2007	6/26/2007	10	Alive
681	205	91	M	5/21/2007	5/22/2007	1	Found dying
644	207	97	M	5/21/2007	6/4/2007	5	Water
694	230	117	M	5/21/2007	5/22/2007	1	Unknown
663	221	108	M	5/21/2007	5/23/2007	2	Unknown
762	279	223	M	5/21/2007	6/26/2007	10	Alive
824	236	144	M	5/21/2007	6/13/2007	7	Water
802	217	91	M	5/21/2007	5/25/2007	3	Land
743	215	96	M	5/21/2007	6/13/2007	7	Water
723	218	113	M	5/21/2007	N/A	0	Quit
783	210	88	M	5/21/2007	N/A	0	Quit
602	218	102	M	5/21/2007	N/A	0	Quit

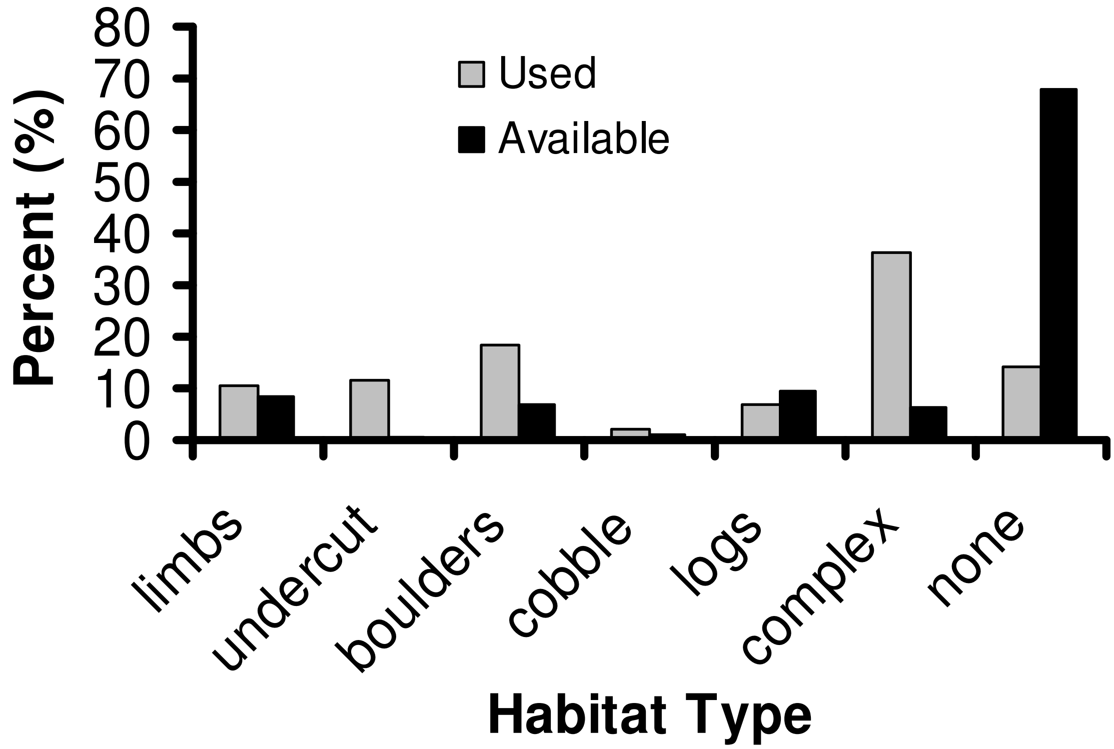

Figure 4. Blacktail redhorse habitat use and habitat availability during the 2006 - 2007 field seasons in West Fork Thompson Creek, Louisiana.

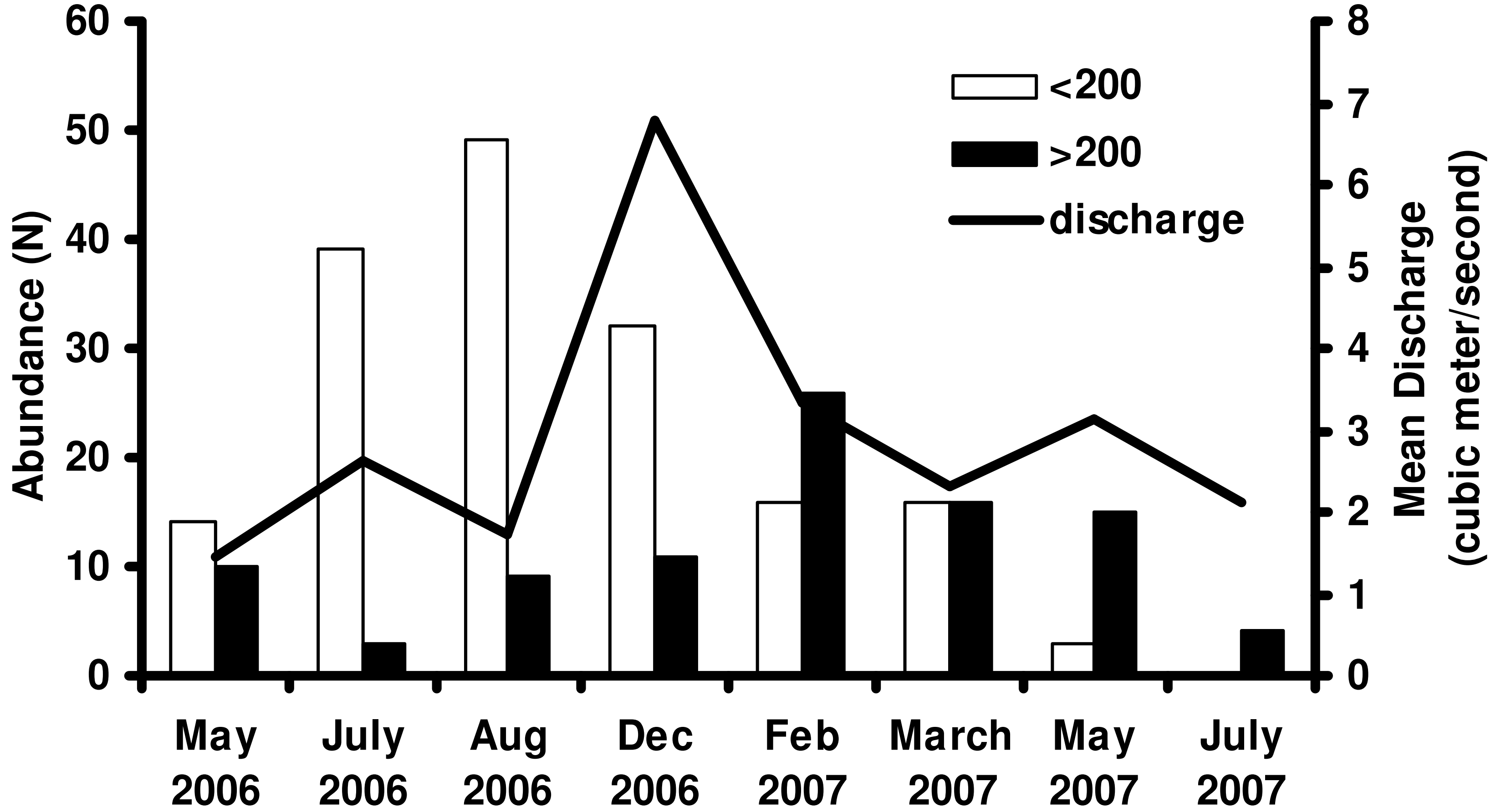

Figure 5. Blacktail redhorse abundance (represented in two size classes fish less than 200 mm total length and fish greater than 200 mm) and discharge from May 2006 through July 2007 in West Fork Thompson Creek, Louisiana.

Home Range and Movement

Linear home range size varied from 15 to > 3,900 m for blacktail redhorse (N=40) with the majority being less than 150 m (Figure 6). The largest linear home range was 3,900 m (484c; Table 1), and this fish had one of the largest 95% minimum convex polygons (111,500 m^2). Minimum convex polygons were influenced greatly by the number of locations per individual transmitter and ranged from 51 – 192,000 m^2 (Table 1). Most linear home ranges comprised less than 250 m of stream channel (Table 1). Five fish had two separate home ranges throughout the tracking periods in 2006 and 2007 (Table 1). Seventy-five percent of fish daily movement in 2006 was less than 10 m/day, while in 2007, it accounted for nearly 55% of their total daily movement (Figure 7).

In 2006, fish movement peaked in March and was lowest in August (Figure 8). During this time, mean monthly stream discharge was highest in March and July with the lowest discharge occurring in June (Figure 8). During the 2007 field season, fish movement peaked in February and declined steadily with the lowest recorded fish movement in June, which coincided with stream discharge during this sampling period (Figure 9). During both years movement was significantly different among months (2006 $F = 5.37$, $p = 0.0008$) (2007 $F = 3.98$, $p = 0.0092$). Ninety percent of all hourly movement rates were between 0 and 30 m/hour, and fish most frequently moved between 5 to 10 m/hour and 25 to 30 m/hour (Figure 10).

Linear home range size was not related to fish length, i.e., larger individuals did not have larger home ranges than smaller individuals. Linear home range size during the summer months (April – study end) were significantly smaller than home ranges during February and March. Thirteen fish (46%) had home ranges smaller than 60 m and 19 (68%) had home ranges smaller than 120 m, while only three (11%) individuals had home ranges consisting of more than 600 m.

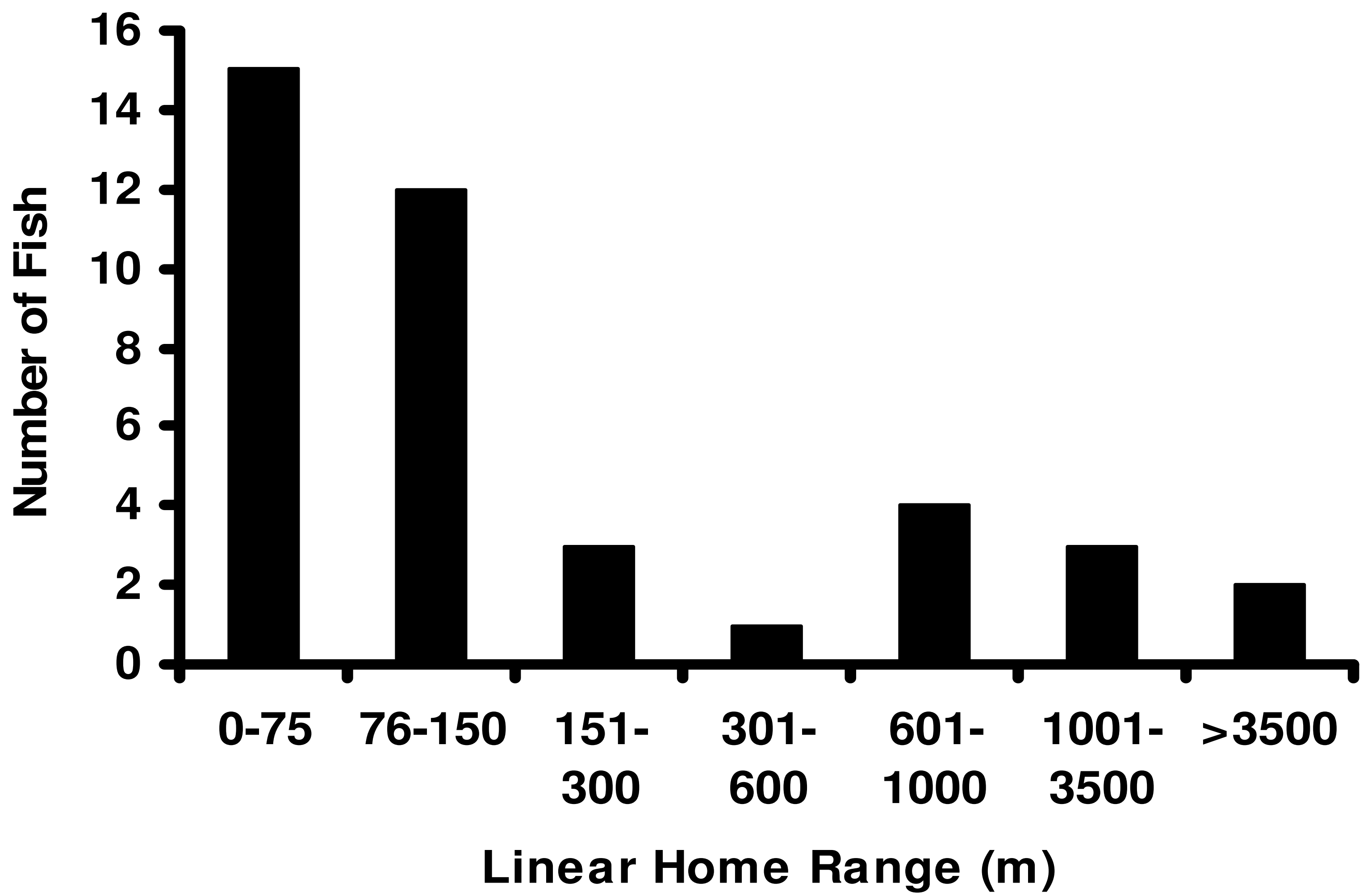

Figure 6. Linear home range of blacktail redhorse in West Fork Thompson Creek, Louisiana for the 2006 (March - September) and 2007 (February - June) sampling seasons.

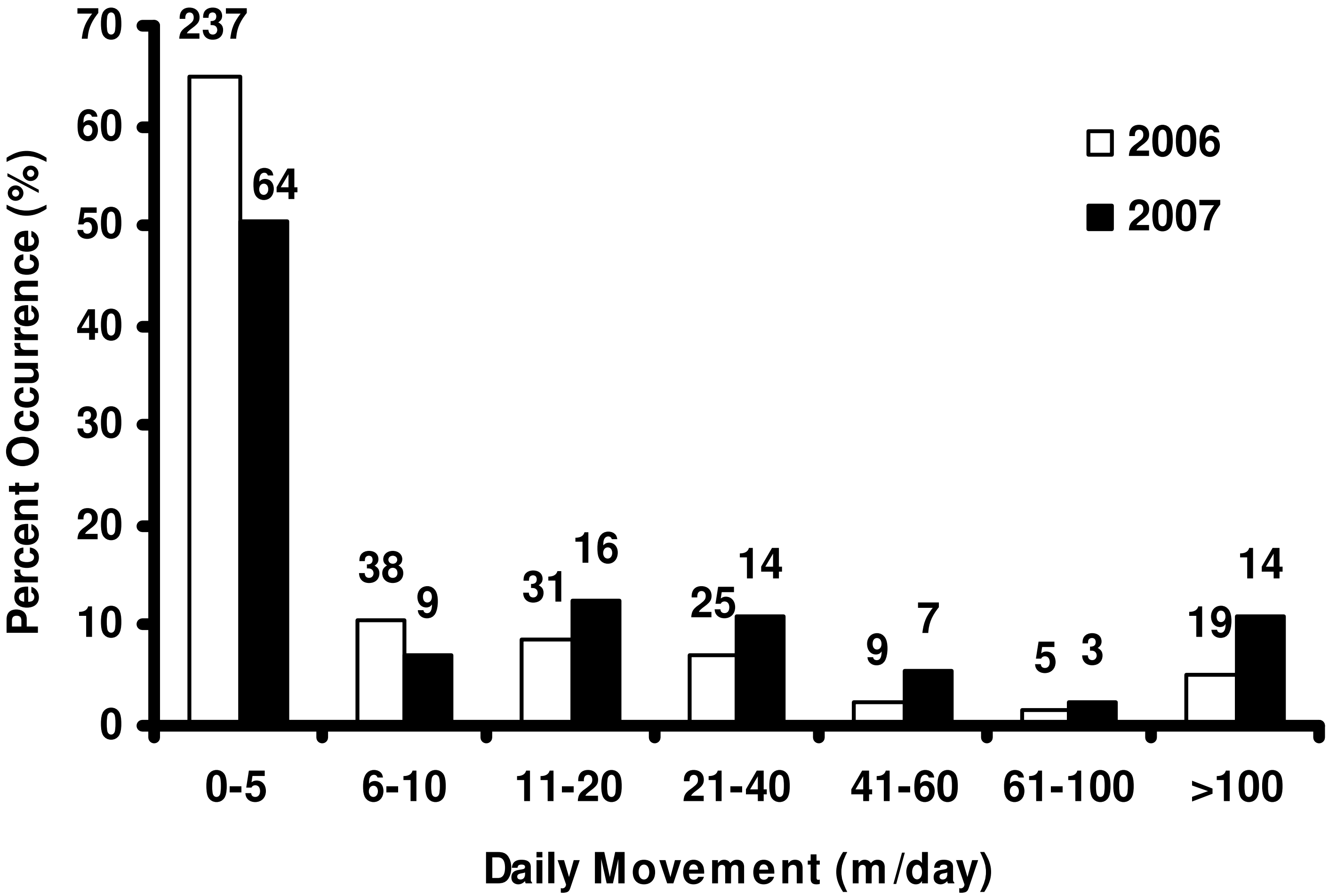

Figure 7. Daily fish movement and percent occurrence of blacktail redhorse tracked during 2006 (March - September) through 2007 (February - June) in West Fork Thompson Creek, Louisiana.

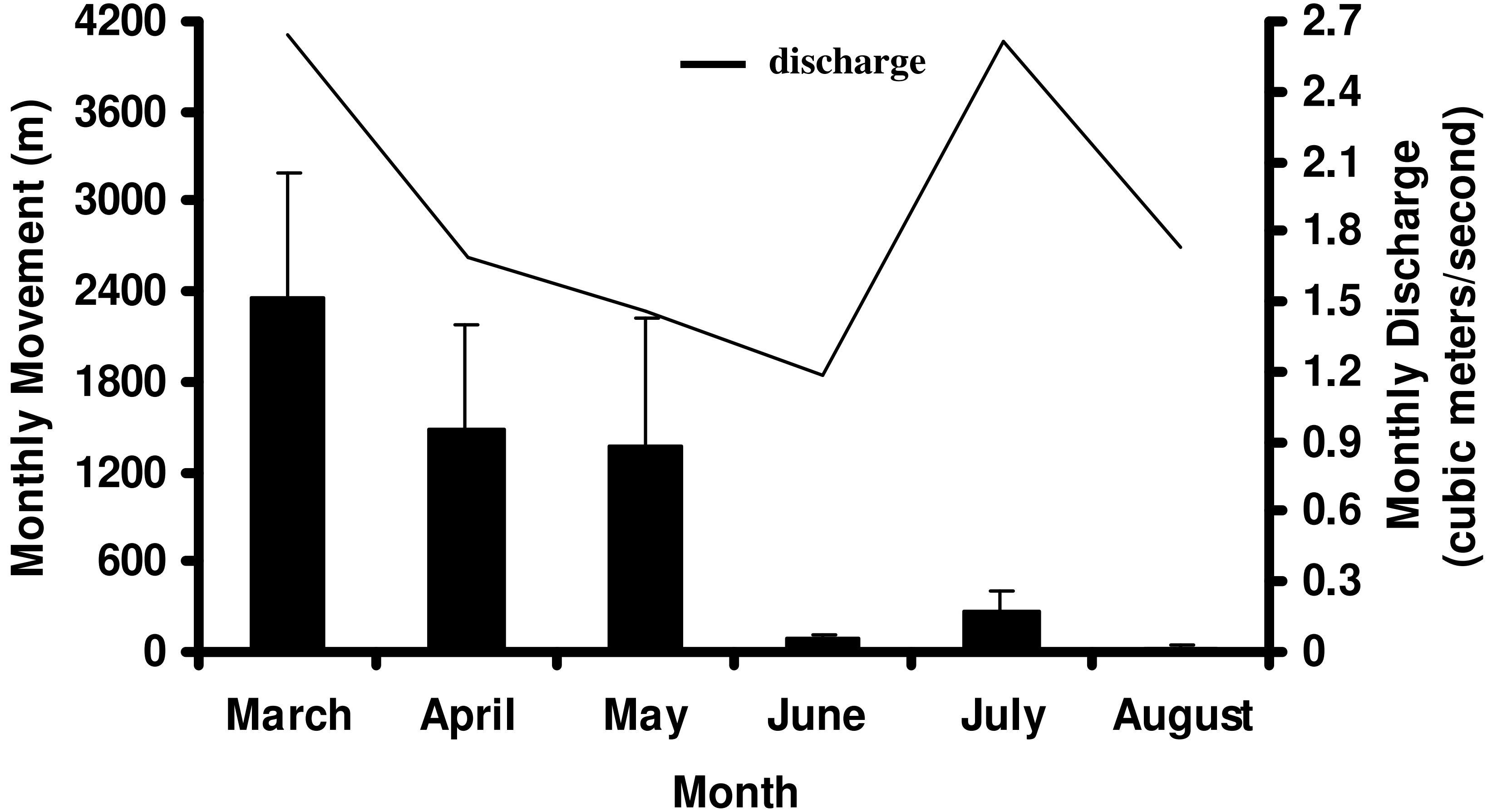

Figure 8. Blacktail redhorse mean monthly movement (+ SE) and monthly discharge in West Fork Thompson Creek, Louisiana during 2006 field season.

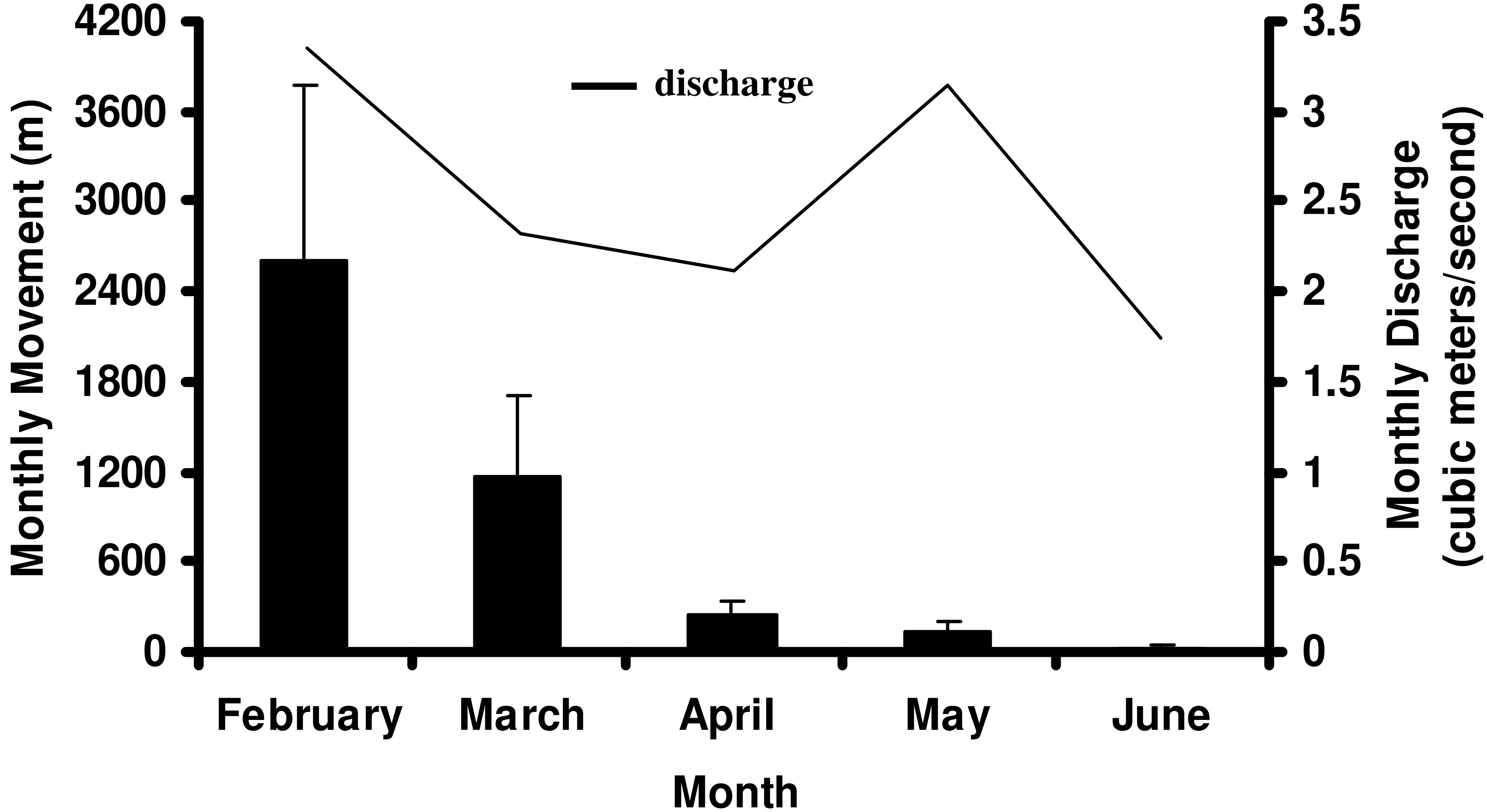

Figure 9. Blacktail redhorse mean monthly movement (+ SE) and discharge in West Fork Thompson Creek, Louisiana during 2007 field season.

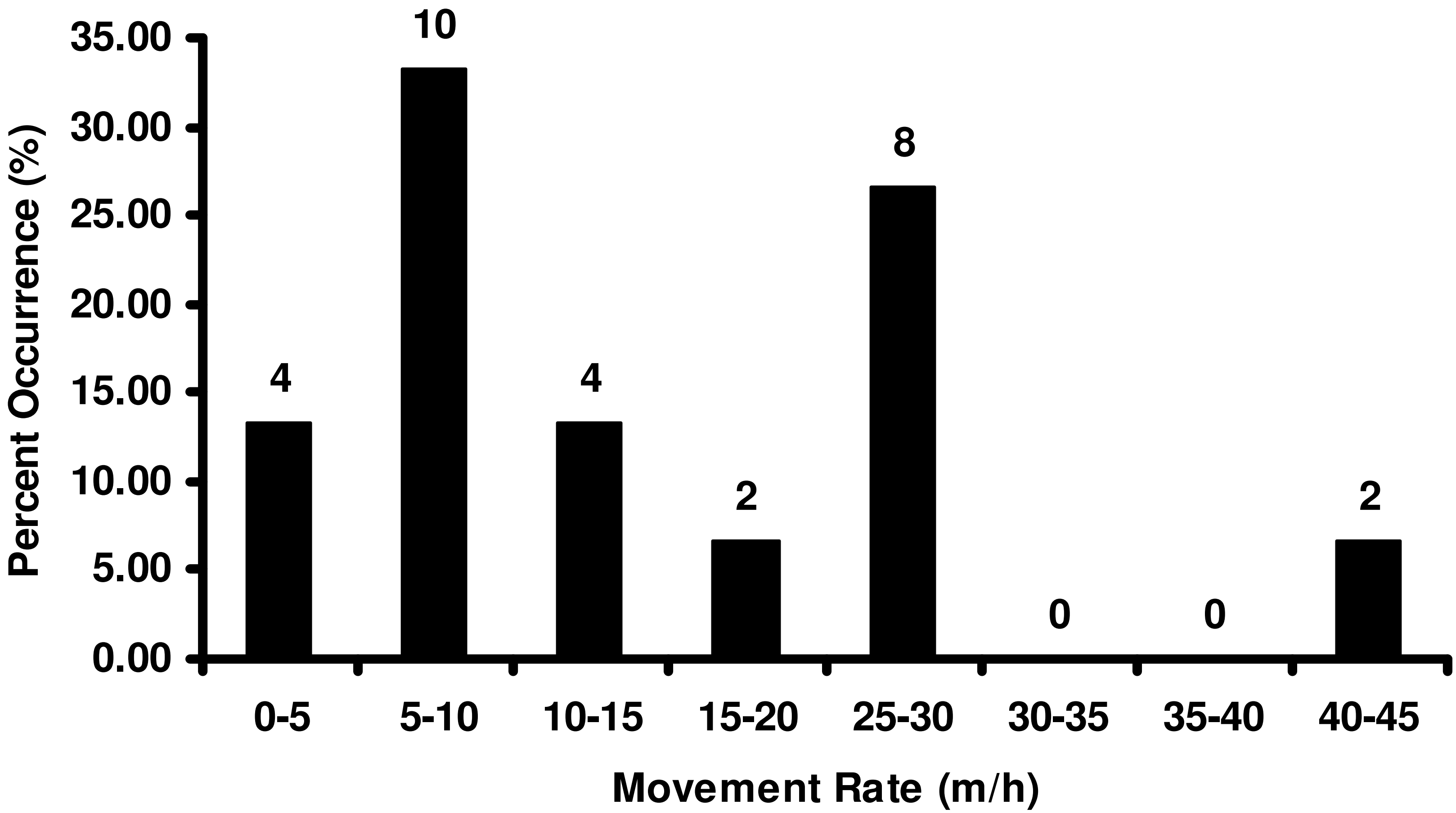

Figure 10. Blacktail redhorse movement rate (m/h) and percent occurrence of different hourly movement rates observed in West Fork Thompson Creek, Louisiana. Numbers above bars indicate the number of individuals in each movement category.

Mark-Recapture

A total of 130 blacktail redhorse were marked from December 2006 through May 2007. Among the marked fish only three fish were recaptured in February (7%), and three fish were recaptured in March (9%) (Table 3).

Diet and Age

A total of 21 (65%) fish had prey items in their stomachs, and the diet was primarily composed of chironomid and heptageniid larvae, which comprised 55 and 17 percent, respectively (Table 4). Of the 52 blacktail redhorse I aged, 40 were age 1+ (132-178-mm TL) and 12 were age 2+ (184–238-mm TL) fish. All fish greater than 184-mm TL were age 2+.

Relocation and Homing

After relocation of ten fish six, fish remained at or near their relocation site over the next eight days. The day after relocation I found nine fish, but two fish disappeared by the following field day. One of the two fish that was released remained at the capture site, while the other was never relocated. Fish 681 returned to its initial point of capture within one day after being relocated 0.8 km downstream, but was subsequently found dead (Table 5). Fishes 644, 824, and 743 made small movements (~50-75 m) upstream but either died or expelled their transmitters after moving. Fish 802 moved 180 m downstream and away from its release site into a shallow pool and later died, with the transmitter being recovered on land. Fish 762 made a 1000-m downstream movement away from its translocation site and remained in this area until the end of the study (Table 5).

Table 3. Mark recapture data from December 2006 – July 2007 with number captured, number recaptured, and total percent.

Month &Year	Number Captured	Number Recaptured	Total Percent (%)
Dec 2006	44	N/A	N/A
Feb 2007	42	3	7
Mar 2007	32	3	9
May 2007	18	0	0
Jul 2007	4	0	0

Table 4. Blacktail redhorse diet of fish collected with electrofishing equipment on August 21, 2006. (A=Adult, L=Larvae, P=Pupae)

	Total Sampled (N)	**% Total**
# Fish Sampled	32	
# Containing Prey Items	21	65
Prey Items		
Diptera		
Chironomidae (L)	74	55.2
Diptera (P)	4	3.0
Heptageniidae (L)	23	17.2
Coleoptera (A)	11	8.2
Cheumatopsyche	9	6.7
Ostracoda (A)	5	3.7
Odonata		
Gomphidae (L)	2	1.5
Zygoptera (L)	2	1.5
Elmidae (L)	2	1.5
Scritidae (L)	1	0.75
Hydracarina (A)	1	0.75

Table 5. Transmitter number, surgery date, date last found, number of locations (N), distance relocated, movement, and direction of movement for blacktail redhorse relocation study (2007). An asterisk (*) means fish moved back to initial capture location.

Trans #	Date Tagged	Date Last Found	N	Distance Relocated (m)	Movement Distance (m)	Movement Direction
783	5/21/2007	N/A	0	0	N/A	N/A
623	5/21/2007	6/26/2007	10	0	0	Same pool
681	5/21/2007	5/22/2007	1	800	750*	up
644	5/21/2007	6/4/2007	5	800	75	up
694	5/21/2007	5/22/2007	1	800	N/A	N/A
663	5/21/2007	5/23/2007	2	800	N/A	N/A
762	5/21/2007	6/26/2007	10	1600	1000	down
824	5/21/2007	6/13/2007	7	1600	55	up
802	5/21/2007	5/25/2007	3	1600	180	down
743	5/21/2007	6/13/2007	7	1600	55	up
723	5/21/2007	N/A	0	1600	N/A	N/A
602	5/21/2007	N/A	0	1600	N/A	N/A

DISCUSSION

Fish Fates

Poor recapture rates, lost transmitters, and physical evidence suggests that blacktail redhorse seemed to suffer significant mortality in WFT, which appears to be a major driving force in the size and abundance of this population. This may also be the reason that larger individuals (age 3+) are seldom encountered. WFT is possibly a "sink" population where fish move into the system from downstream to spawn and individuals that remain in WFT suffer significant predator-related mortality from snakes, herons, and otters. It has been well documented that river otters are efficient predators on many fish species such as cutthroat trout *Oncorhynchus clarki* , Atlantic salmon, longnose sucker *Catostomus catostomus*, eels *Anguila* spp., sunfishes *Lepomis* spp., and cyprinids (Greer 1955; Jenkins and Harper 1980; Magalhaes et al. 2002; Crait and Ben-David 2006). However, otters have been shown to have a preference for benthic fishes due to their reduced swimming performance (Greer 1955; Rui Beja 1996; Crait and Ben-David 2006). In WFT, blacktail redhorse were most commonly found in pool environments, where otter activity has most frequently been documented (Magalhaes et al. 2002). Bowman (1970) found that black redhorse within their winter home range pool would not leave the area even though they were under heavy spear fishing pressure. My data suggests the same site fidelity among individuals under natural predation pressure during the summer months. Blacktail redhorse were observed in schools of more than 100 individuals prior to the increase of otter activity in 2006. These schools became smaller throughout the field season, which likely was due to predation from the otters. Otter presence was observed when the stream levels began to drop in May 2006, and predation increased throughout the field season. During the 2007 field season, otter presence was observed in January and latrine sites were scattered throughout the study reach in higher abundances than during 2006. Otter density was not estimated during sampling because of the difficulty to determine accurate estimates.

Habitat Use

Blacktail redhorse habitat use has received limited study, but fish in WFT were strongly associated with cover and preferred specific cover types. Although open water was most common in the stream, fish avoided these areas, which is likely due to increased exposure to predation from terrestrial and aquatic predators. It was extremely difficult to induce fish to move from areas with instream cover. On several occasions radio-tagged fish were located in pools after documented predation events had occurred and I attempted to stimulate their movement. One individual stayed in the same area and would not move from under a large boulder for over a week. Subsequently, this individual made a movement of over 1,000 m upstream of their previous location into an area without cover and remained alive for eight more days. Fish were capable of avoiding predators if cover was readily available, and these fish were often observed foraging close to cover or in deep water. When fish were disturbed, they would immediately move back to the safety of instream cover or into deeper water. Blacktail redhorse preferred pools with slow moving water, and cover such as undercut banks, clay boulders, and complex habitat. Similarly, adult silver redhorse have been shown to prefer long, deep pools with slower current, whereas young golden and silver redhorses have been shown to inhabited slow-moving waters near overhanging river banks (Meyer 1962).

Mark-Recapture

Blacktail redhorse were only recaptured in February and March, and over time fewer individuals were captured, with larger fish (>200 mm) being the most abundant. Capture rates among months for all blacktail redhorse remained stable from December through March and declined in May. New individuals were being captured throughout these time periods but very few marked individuals were found. The low number of recaptures (5%) in my study may indicate that fish in WFT exhibited high mortality or had home ranges larger than 100 meters. Conversely, Gunning (1963) reported a significant number of blacktail redhorse recaptures with 91 percent (61/67) of marked fish being recaptured within a 137 m area. He also reported that a high percent (74%) of blacktail redhorse remained in a 30 m stream section, with only a few individuals traveling distances up to 137 m. Larger individuals (>200 mm) have also been shown to have restricted home ranges from early spring to late fall of about 30 m (Gunning 1963). I found no relationship between home range size and fish length, which has also been reported in bluegill sunfish *Lepomis macrohirus* (Paukert 2004). Closely related species, golden redhorse, northern redhorse, and silver redhorse have been shown to have restricted summer movements, which was reflected in the relatively high recapture rates (55%) reported by Meyer (1962). Unlike the WFT blacktail redhorse population, these studies were based on populations that were stable and apparently not under extreme predation pressure as in WFT.

The limited recapture of fish in WFT was not likely related to marking loss because fish were double marked with a fin clip and alpha-numeric tags and/or visual implant elastomer. The mark-recapture stream section was a permanent pool that was approximately 100 m in length, which was comparable to the study area reported by Gunning (1963). During the July sampling period the low recapture rates in WFT may have been due to fish removal for the relocation study and reduced water clarity in the study area that affected sampling efficiency.

Telemetry

Analysis of telemetry data showed that during the April to November time period nearly 50% of the fish in WFT had home ranges between 0 - 60 m and 68% had home ranges less than 120 m. Differences between home ranges reported by Gunning (1963; see above) based on mark-recapture data and my study were likely due to my increased ability to detect excursions outside of the mark-recapture stream reach with telemetry. In addition, telemetry allowed me to sample more frequently and over a much larger area than possible with a mark-recapture study, which resulted in the larger home range sizes. I found that some individuals would make extensive movements and move back to home areas in as little as 24 hours, and these fish typically had very large home ranges. To avoid exaggerated home ranges I used only 95% of the locations of the fish to determine home range size, however because I tagged only large, more mobile fish (>200 mm) my measured home range sizes may have been larger, than the population average.

Home range sizes varied among individual blacktail redhorse, which suggests that individual fish exhibit differing movement patterns, with some fish being sedentary and some being mobile. This type of alternative activity pattern has been reported for many species such as largemouth bass, rainbow trout, cutthroat trout, and many others (Funk 1957; James and Kelso 1995; Hilderbrand and Kershner 2000; Richardson-Heft et al 2000). The relatively low recapture rates shown in WFT suggest either fish move substantial distances or are suffering significant instream mortality. During the two years of telemetry, I found that blacktail redhorse moved large distances during spring months (February – April), likely in association with spawning. The closely related black redhorse have also been shown to make extensive movements associated with spawning, moving up to 9.6 km upstream to spawning riffles. Surprisingly, several of these individuals were relocated in spawning condition three years after initial tagging and up to 24 km away (Bowman 1970). In WFT several blacktail redhorse made substantial spawning-associated movements, with one individual moving 7.6 km upstream. More significant upstream movements were observed in 2007, which was likely due to fish being tagged nearly a month earlier than in 2006. In 2007, I tagged fish at the beginning of February and immediately observed significant movements upstream.

Blacktail redhorse home ranges appeared to contract after the spawning period in late April to early May with the majority of these individuals remaining in the same 100 m stream reach. The contraction in home range size observed during the summer months could be explained by the few individuals being tracked during each tracking session. Also, some individuals were tagged later in the sampling season (May and July) after spawning and spring peak in discharge occurred. However, the number of times individuals were tracked did not have a significant impact on home range size, and fish did not have significantly different home range sizes. Therefore, sampling effort does not explain the observed changes in home range size, and I believe that my home range estimates were good representations of actual stream use.

Diet and Foraging

The dominant stomach contents found in blacktail redhorse were similar in composition to dominant Louisiana stream benthic invertebrates in these coastal plain, sandy substrate streams (Kaller and Kelso 2007), and this suggests indiscriminant, opportunistic feeding. Blacktail redhorse are bottom feeders like other redhorse species and exhibited foraging behaviors similar to that of black redhorse (Bowman 1970). The diet of stream blacktail redhorse is predominately insects, whereas pond raised blacktail redhorse feed predominantly on non-insects (Kilgen 1972). I often observed blacktail redhorse foraging in large groups of up to

40 individuals feeding in pools. It was not uncommon to see individuals feeding alone along the pool bottom over sandy substrate, but I never observed foraging in riffles. Single feeding individuals would often forage in shallow water along the pool edge and a trail of "drift" would be observed behind them. These individuals were often followed by other fishes such as longear sunfish *Lepomis megalotis* and minnows that were likely foraging on organisms stirred up by the blacktail redhorse.

Homing/Relocation

The only individual that exhibited homing in WFT moved back to the capture pool within 24 hours. Unfortunately, I was unable to determine the fate of many of the other fish tagged for relocation. The homing data is extremely limited by the time of year, brevity of study, and our inability to determine if fish tagged were known to be residents of the sampled pool. Other homing studies have shown that largemouth bass took up to two years to return to their capture location (Richardson-Heft et al. 2000). White suckers have been shown to return to spawning sites from previous years (Olson and Scidmore 1963) and this behavior may also be exhibited by blacktail redhorse. Determination of homing may be more adequately assessed if fish had been tagged prior to spawning and I had used known residents. Despite my limited data, homing of blacktail redhorse may be very important in this system because fish may be traveling substantial distances to reproduce in upstream reaches. If a catastrophic event occurred that decimated the downstream portion of the blacktail redhorse population, fish abundance in the upstream portion of the population would be greatly reduced.

Blacktail Redhorse Spawning

Spawning was observed on at two occasions in March 26, 2007 and April 14, 2006. Three tagged individuals were observed spawning over a shallow riffle with seven other blacktail redhorse. One of the tagged fish was a female and the other two were males. The group of fish gathered around the female clearing gravel and creating multiple nests. The spawning aggregation would stay over the nest for about 15 seconds, swim upstream, and then return to the riffle within a few minutes to clear out another gravel area. This activity continued for nearly 15 minutes and then all fish returned to the upstream pool. It was unclear, but our presence along the bank may have disturbed the fish enough to inhibit continued spawning activity. During spawning activity, northern hog suckers and other minnows were observed foraging just downstream of the spawning fish. The observed spawning activity in April 2006 occurred in slightly deeper (~0.5 m deep) water, and because of poor visibility spawning behavior was less clear. Black redhorse males have been shown to defend territories during spawning and spawn in water that is 0.1 – 0.6 m deep (Bowman 1970). However, because I only observed spawning on a few occasions in 2007, I am unsure whether, male blacktail redhorse were defending territories. However, in 2006 I did observe multiple individuals that seemed to be guarding territories. On these occasions blacktail redhorse exhibited similar activities to those described by Bowman (1970) for black redhorse.

Summary

Blacktail redhorse population abundance in WFT seems to be significantly influenced by aquatic, semi-aquatic, and terrestrial predators. Most blacktail redhorse used a relatively small area of the stream. Blacktail redhorse were often present in significant numbers. This behavior makes these fish extremely vulnerable to predation. During the study, I documented 8 of 9 tagged individuals from the same 100 m stream reach that had suffered mortality within a week. Although these fish are not economically important, they are ecologically important, as they constitute a substantial prey base in WFT and likely have similar ecological roles throughout their range. Blacktail redhorse are benthivores that preferred pools with complex cover, clay boulders and undercut banks, which likely serve as their major protection from predators. WFT has a substantial floodplain area that is inundated during storm events, where flood waters typically rise and recede quickly. This makes WFT an extremely flashy and hostile environment for resident fishes. Other Louisiana streams have been shown to have larger blacktail redhorse than those present in WFT (W. E. Kelso and D. A., Rutherford unpublished data), and this may be due to the stochastic stream environment and the high predation pressure in WFT.

Blacktail redhorse are subjected to an extremely harsh environment throughout their short life. WFT has limited cover for fishes especially during high flow events. These fish are also under tremendous pressure in the summer drying period because of their vulnerability to predators. They often reside in small stream sections in dense concentrations, which attract predators. These fish have extremely high site fidelity and they often stay in suitable habitat until they suffer mortality. Blacktail redhorse are also very vulnerable to predation during their extensive search for suitable spawning grounds.

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APPENDIX A: FISH TOTAL MOVEMENT

Date	Total Daily Movement (m)	Minimum Movement (m)	Maximum Movement (m)
3/4/2006	77	0	27
3/7/2006	144	0	56
3/10/2006	6193	0	1800
3/14/2006	753	0	106
3/17/2006	4621	0	2207
3/23/2006	2825	0	2478
3/24/2006	304	0	57
3/30/2006	3604	0	3394
4/6/2006	2239	0	1983
4/7/2006	3726	0	3274
4/13/2006	50	0	50
4/14/2006	222	0	114
4/21/2006	76	0	48
4/27/2006	309	0	251
5/2/2006	96	0	40
5/16/2006	69	0	49
5/17/2006	8498	0	5164
5/19/2006	40	0	21
5/21/2006	1581	0	1322
5/22/2006	2329	0	2072
5/23/2006	0	0	0
5/24/2006	44	13	31
5/25/2006	130	0	130
5/31/2006	425	18	217
6/6/2006	177	0	34
6/9/2006	0	0	0
6/14/2006	140	0	21
6/15/2006	0	0	0
6/27/2006	163	14	33
6/28/2006	0	0	0
6/30/2006	20	0	20
7/5/2006	26	0	13
7/11/2006	0	0	0
7/12/2006	0	0	0
7/14/2006	381	0	381
7/21/2006	281	0	218
7/24/2006	204	0	112
7/25/2006	48	0	23
7/31/2006	163	0	50
8/2/2006	0	0	0
8/7/2006	104	0	104
8/11/2006	0	0	0
8/14/2006	71	0	71
8/18/2006	0	0	0
8/21/2006	0	0	0

APPENDIX A: CONTINUED

2/13/2007	7780	530	3338
2/16/2007	2114	2114	2114
2/19/2007	3418	0	2884
2/23/2007	0	0	0
2/27/2007	2340	0	2340
3/8/2007	0	0	0
3/9/2007	4559	13	4472
3/12/2007	47	0	47
3/15/2007	47	47	47
3/19/2007	2492	0	1344
3/20/2007	211	0	60
3/22/2007	239	0	60
3/26/2007	3355	0	3133
3/27/2007	615	0	520
3/29/2007	202	0	70
4/2/2007	151	24	41
4/5/2007	452	24	335
4/10/2007	196	19	92
4/13/2007	800	800	800
4/17/2007	140	0	73
4/19/2007	157	0	157
4/23/2007	0	0	0
4/24/2007	156	0	156
5/1/2007	167	0	167
5/11/2007	619	77	454
5/16/2007	38	19	19
5/17/2007	53	0	53
5/21/2007	53	0	53
5/22/2007	51	0	51
5/23/2007	0	0	0
5/25/2007	53	0	53
6/1/2007	125	62	63
6/4/2007	0	0	0
6/6/2007	62	0	62
6/8/2007	0	0	0
6/13/2007	0	0	0
6/19/2007	0	0	0
6/22/2007	0	0	0
6/26/2007	0	0	0

APPENDIX B: BLACKTAIL REDHORSE AGE

Species	Length	Weight	Age	Species	Length	Weight	Age
BR	152	35	1+	BR	154	37	1+
BR	151	33	1+	BR	161	41	1+
BR	152	34	1+	BR	156	36	1+
BR	153	33	1+	BR	152	32	1+
BR	178	57	1+	BR	153	33	1+
BR	156	35	1+	BR	160	40	1+
BR	157	38	1+	BR	156	40	1+
BR	140	26	1+	BR	163	42	1+
BR	141	31	1+	BR	168	46	1+
BR	152	35	1+	BR	217	97	2+
BR	155	33	1+	BR	227	123	2+
BR	156	38	1+	BR	213	86	2+
BR	155	38	1+	BR	217	104	2+
BR	151	37	1+	BR	187	66	2+
BR	162	40	1+	BR	184	42	2+
BR	151	32	1+	BR	238	134	2+
BR	165	42	1+	BR	224	N/A	2+
BR	168	46	1+	BR	199	80	2+
BR	161	42	1+	BR	228	N/A	2+
BR	166	41	1+	BR	219	94	2+
BR	168	47	1+	BR	202	77	2+
BR	162	40	1+	NH	152	35	1+
BR	151	34	1+	NH	146	33	1+
BR	154	35	1+	NH	136	29	1+
BR	153	33	1+	NH	142	29	1+
BR	158	37	1+	NH	132	25	1+
BR	157	39	1+	NH	146	35	1+
BR	158	41	1+	NH	150	34	1+
BR	150	32	1+	BR = blacktail redhorse NH = northern hog sucker			

VITA

Jesse Adam Bahm was born in Ponca City, Oklahoma, on December 1979. He attended Tonkawa High School in Kay County, Oklahoma, and graduated in 1998. In 2004, he obtained a Bachelor of Science in Fisheries and Wildlife Conservation from Southeastern Oklahoma State University in Durant, Oklahoma. He then worked as a research assistant for one year at the University of Arkansas and is currently a candidate for the Master of Science degree in fisheries at Louisiana State University, Baton Rouge, Louisiana.