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Pre-spawning Migration of Channel Catfish into Three Warmwater Tributaries–Effects of a Cold Trailwater

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Abstract

Spring migrations of channel catfish (*Ictalurus punctatus*) into the Kings, Mulberry and Buffalo rivers, Arkansas, were compared to determine adult catfish migration into a warmwater river that flows into a cold tailwater. The Buffalo River flows into a cold tailwater reach of the White River and supports a sparse channel catfish population compared to similar rivers in the region that do not flow into cold tailwaters. This is an important factor because many recent studies have demonstrated that channel catfish make pre-spawning migrations into tributary streams and may contribute significantly to tributary populations. To assess channel catfish migration, hoop nets were deployed at the confluence of the three rivers and fished continuously from 29 March to 22 April 1992, with total catches used as an index of the relative number of fish migrating into each river. Movements of channel catfish into the three rivers were observed throughout April; however, the relative number migrating into the Buffalo River (n=33) was significantly less than the Kings (n=169) or Mulberry (n=263) Rivers. Water temperature differed significantly between the White and Buffalo Rivers during the sampling period, but did not differ between the Kings or Mulberry, and their respective confluence. Although cold, White River tailwaters do not totally inhibit overwintering and migration of adult channel catfish into the Buffalo River, reduced numbers of migratory catfish may partially account for the river's low reproductive output and sparse adult population.

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Introduction

An increasing numer of tagging studies have shown that channel catfish (*Ictalurus punctatus*) exhibit extensive spring migrations from larger rivers or lakes into tributary streams. These spring migrations have been documented for river systems in a wide range of geographical locations. Humphries (1965) reported that channel catfish in the Savannah River, Georgia, made an upstream migration into a tributary stream during May and June, followed by downstream movement back into the river during July. In South Dakota, June (1977) reported that channel catfish in Lake Oahe moved into tributary rivers prior to spawning. Channel catfish movements into or out of tributaries have also been observed for river systems in Florida (Hale et al., 1986), Iowa (Welker 1967), Louisiana (Perry et al., 1985), Missouri (Newcomb, 1989; Dames et al., 1989), Wisconsin (Ranthum, 1971), and Wyoming-Montana (Smith and Hubert, 1989). These movements as well as channel catfish migrations reported from other investigations, are believed to be associated with spawning.

Annual migrations of channel catfish appear to be in response to either a lack of overwintering habitat in the tributary (Newcomb, 1989) or a lack of suitable spawning habitat in the confluence system (Gerhardt and Hubert, 1990). Channel catfish appear to require substantially different habitat areas for overwintering and spawning. Newcomb (1989) found that deep scour-holes in the Missouri River provide valuable overwintering habitats; during winter, channel catfish were only collected in depths greater than 3.7 m and water velocities less than 0.3 m/s. He reported a general pattern of channel catfish movement from these overwintering habitats into tributaries in spring, summer and fall. Use of deep-water (4.9 to 7.6 m) habitats by winter aggregations of channel catfish have also been reported for the Mississippi River (Hawkinson and Grunwald, 1979). Gerhardt and Hubert (1990) concluded that more abundant spawning habitat in a Wyoming tributary explained the substantial use by channel catfish during the spawning period.

Many small rivers may not provide both suitable spawning habitat and deep overwintering areas for channel catfish (Newcomb, 1989; Gerhardt and Hubert, 1990). Although tributary channel catfish populations may depend upon annual inputs from spring migrations of catfish which overwintered in other waters, information is not available on the importance of these annual migrations for maintaining tributary populations. In the Wisconsin River, it is estimated that greater than 75% of the channel catfish population migrates into overwintering habitats in the upper Mississippi River, and that an absence of migrating adults would result in a significantly reduced catfish population in the Wisconsin River (T.D. Pellett and D. Fago, Wisconsin Department of Natural Resources, unpublished data).

In Arkansas, a significantly lower abundance of young-of-year (YOY) channel catfish has been observed in the Buffalo River relative to similar, nearby warmwater, Ozark rivers (Siegwarth, 1992). The Buffalo River also supports a sparse natural adult catfish population; previously stocked, hatchery-reared catfish make up a significant (>93%) portion of the population (Siegwarth, 1994). One possible reason for the low reproductive output and recruitment observed in the Buffalo River is that, unlike other rivers examined, the Buffalo River flows into a cold tailwater. The sparse catfish population in the Buffalo River may result from these cold tailwaters if historic annual inputs of migrating adults have been reduced or eliminated.

The objective of this study was to determine if the cold tailwater reach of the White River has eliminated pre-spawning migration of channel catfish into the Buffalo River. This was tested by comparing relative numbers of catfish migrating into similar, nearby rivers which do not flow into cold tailwaters. Knowledge of cold tailwater effects on channel catfish migration will aid in assessing reasons for the lack of natural reproduction and sparse channel catfish populations observed in the Buffalo River.

Materials and Methods

Study Sites.--Pre-spawning migration of channel catfish was assessed for the Kings, Mulberry and Buffalo

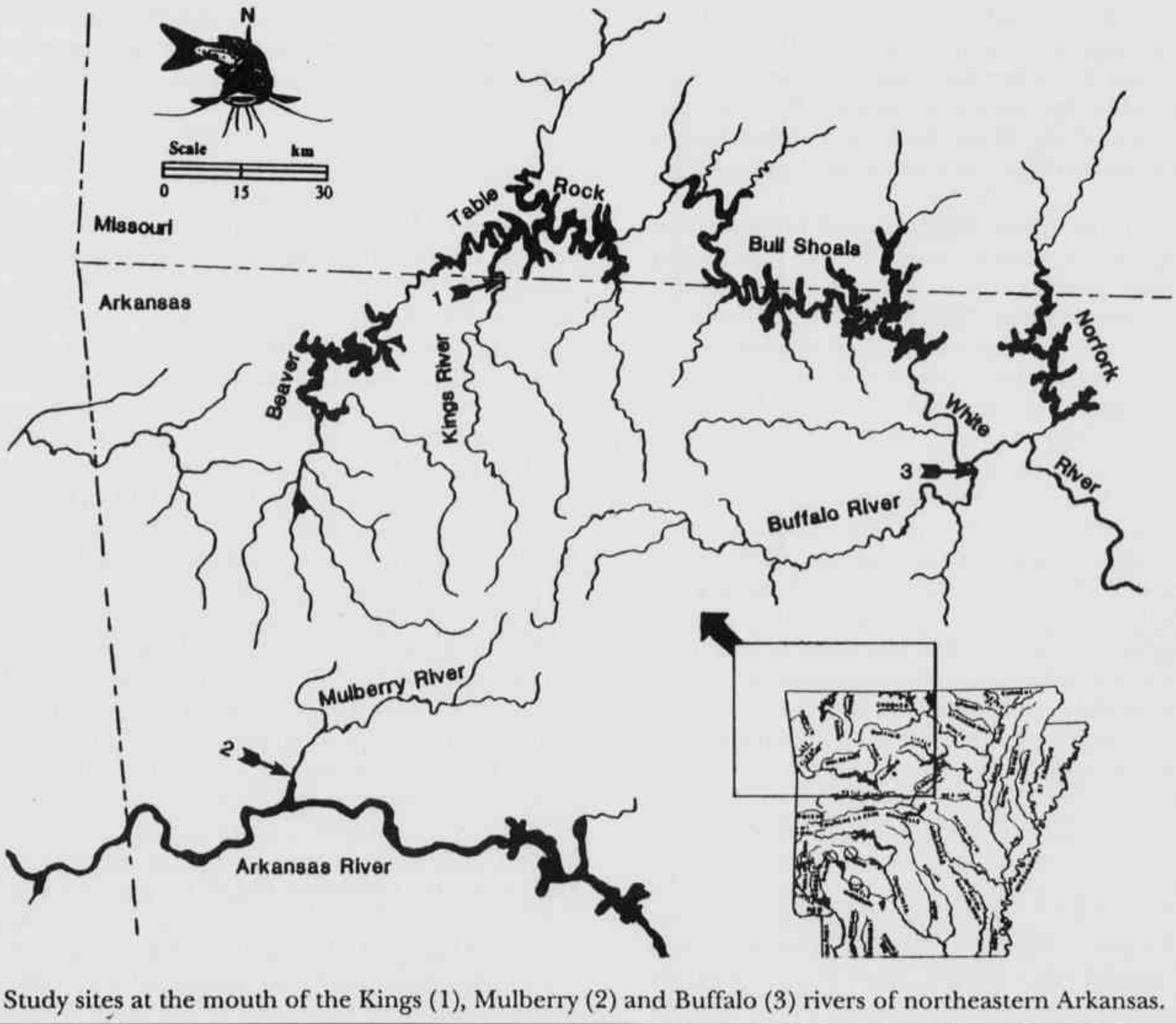

Fig. 1. Study sites at the mouth of the Kings (1), Mulberry (2) and Buffalo (3) rivers of northeastern Arkansas.

Rivers of northwestern Arkansas (Fig. 1). These three rivers originate in the Boston Mountains and are typical clear-water, Ozark streams characterized by long pools separated by short riffles. Substrate is primarily gravel and rubble in the headwater sections; rubble, boulder and bedrock in the middle reaches; with some deposits of sand and silt in the lower reaches. Land use in the Kings and Mulberry river watersheds is a combination of agriculture and forestry. The Buffalo river flows through U.S. Forest Service and National Park Service (NPS) lands and has been managed by NPS since 1972. The Kings, Mulberry and Buffalo rivers are free-flowing upstream from their confluence with Table Rock Reservoir, the Arkansas River, and the White River tailwater below Bull Shoals Dam, respectively (Fig. 1).

Cold tailwaters of the White River extend 160 km downstream from Bull Shoals Reservoir, including a second input of cold tailwater from the North Fork of the White River below Norfork Reservoir which joins the White River approximately 17 km below the confluence of the Buffalo River. Tailwaters created from these impoundments support an important put-and-take fishery for rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). Although warmwater streams flow into this coldwater stretch of the White River, the mainstream is not warmed sufficiently to eliminate trout (Aggus et al., 1977).

Discharges of the Kings, Mulberry and Buffalo rivers vary seasonally, with a general pattern of high flow during spring and early summer followed by relatively low flow in late summer and autumn. Local storm events, however, can produce flooding in any season. Low discharge during late summer and autumn results in intermittent flow in headwater reaches. Average annual discharge for Kings River is 12 m^3/s and ranges from 0.01 to 35.3 m^3/s (USGS 1988). The Mulberry River has a slightly higher gradient (4.3 m/km) than the other two rivers; average annual discharge is 15.3 m^3/s (USGS 1988). Average annual discharge reported for the middle reach of the Buffalo River is 25.8 m^3/s and ranges from 0.04 to 555.0 m^3/s (USGS 1988).

Assessment of Channel Catfish Migration.--One sampling site each was selected at the mouth of the Kings, Mulberry and Buffalo rivers (Sites 1, 2 and 3; Fig. 1). Four hoop nets were deployed within the main channel at each site. Hoop nets were of two designs; one large net (3.2 cm web, double finger throated, with seven 1.1 m diameter hoops) and one small net (1.9 cm web (bar measure, double finger throated, with six 0.6 m diameter hoops) were fished in tandem (one hoop net-set) continuously from 29 March through 22 April, after which sampling was terminated due to heavy rainfall and flooding. One net fished for a 24 h period represented one net-day of effort (CPUE). Nets were emptied and cleaned every three or four days (5 sampling dates x 4 nets = 20 net samples/river) and all channel catfish collected were enumerated, measured for total length (TL), marked (adipose fin clip), and a pectoral spine was removed before being returned alive to the river. Spine cross-sections of all catfish were examined to identify any hatchery-reared fish stocked in previous years (Siegwarth, 1994). Water temperature (°C) was measured for each river and its respective confluence on the dates nets were sampled.

Differences in catch rates of channel catfish and water temperature among rivers (and their confluences) were compared by analysis of variance (ANOVA) using the Statistical Analysis System (SAS Institute 1988). If a significant difference was found ($P < 0.05$), the ANOVA was followed by Bonferroni's Multiple Range Test to identify rivers that differed from one another. To satisfy the assumptions of the statistical analysis (i.e., constant variance of catches among rivers and normal distribution of residuals), total catch/net sample was transformed using a standard $\ln(x+1)$ transformation (Box and Cox 1964). Regression analysis was used to identify potential relationships between catch rates and water temperature within each river.

Results

A total of 465 channel catfish was collected from 276 net-days of effort from the three rivers during March and April 1992. The largest numbers were collected from the mouths of the Kings (n=169) and Mulberry rivers (n=263), while the fewest were collected from the Buffalo River (n=33). Of the 33 channel catfish collected from the Buffalo River, 25 were determined to hatchery origin. Mean catch per net sample among rivers was significantly ($P<0.5$) lower for Buffalo River than the Kings and Mulberry rivers (Table 1). Overall CPUE for the large nets was 4.3, 3.5 and 0.7 for the Mulberry, Kings and Buffalo rivers, respectively; CPUE for small nets was 1.4, 0.1 and <0.1 for the three rivers, respectively. No previously marked channel catfish were recaptured.

Water temperatures observed during the sampling period did not differ ($P>0.05$) among the Kings, Mulberry and Buffalo rivers. However, water temperatures differed significantly ($P<0.05$) between the White and Buffalo rivers, but not between the Kings River and Table Rock Reservoir or between the Mulberry and Arkansas rivers (Table 2). Water temperature among the Mulberry/Arkansas rivers, and Kings River/Table Rock Lake exhibited consistent trends throughout April, while the Buffalo and White rivers had increasingly larger differences (Fig. 2). Catch rates of channel catfish during March and April were not significantly correlated with water temperature within any of the three rivers ($r^2<0.80$

for each river).

Table 1. Comparison of mean (±SE) catch/hoop net-set of channel catfish migrating into the Kings, Mulberry and Buffalo rivers. Values in each row without a letter in common are significantly different (P<0.05)[a].

	River		
Variable	Buffalo[b]	Kings	Mulberry
Mean catch/net-set	3.3	16.9	26.3
	±1.5	±4.4	±8.2
Transformed ln(x+1) mean catch/net-set	0.8[Y]	2.2[Z]	2.2[Z]
	±0.3	±0.3	±0.4

[a]Comparisons were not made between mean catch/net-set due to violations of statistical assumptions (unequal variance among rivers).

[b]Includes 2.5 fish/net-set which were determined to have a hatchery origin.

Table 2. Comparison of mean (±SE) water temperatures (°C) among the Kings, Mulberry, and Buffalo rivers and their confluence.

River	Confluence	P-Value
Kings	Table Rock Lake	
13.9 (±1.8)	14.3 (±1.9)	P>0.05
Mulberry	Arkansas River	
13.6 (±1.9)	15.5 (±1.8)	P>0.05
Buffalo	White River	
14.8 (±1.6)	9.9 (±0.7)	P<0.05

Discussion

Although several factors can influence CPUE results (Ricker, 1975) and hoop net catches (Muncy, 1957; Mayhew, 1973; Hubert and Schmitt, 1982), comparative catches of channel catfish in the present study are believed to be reliable because of similar limnological and climatic conditions among the Kings, Mulberry and Buffalo rivers during the sampling period, and because of the restricted channel widths of these tributaries. Muncy (1958) and others have shown that adult channel catfish are highly susceptible to capture in hoop nets during the spawning season. Smith and Hubert (1989) concluded that seasonal trends in hoop net catches within a Great Plains river system were associated with spawning migrations into tributary creeks. In this study, CPUE of hoop net samples represents the proportional abundance of channel catfish migrating into each tributary prior to spawning. Thus, despite the shortened sampling interval, spring hoop net sampling measured the relative numbers of channel catfish migrating into the Kings, Mulberry and Buffalo Rivers, with the assumption that catfish collected at the mouth of each tributary were migrating into that tributary. This assumption was supported by an absence of recaptures, and the fact that a number of marked catfish were recaptured 50 to 60 km upstream within the tributaries later in the summer.

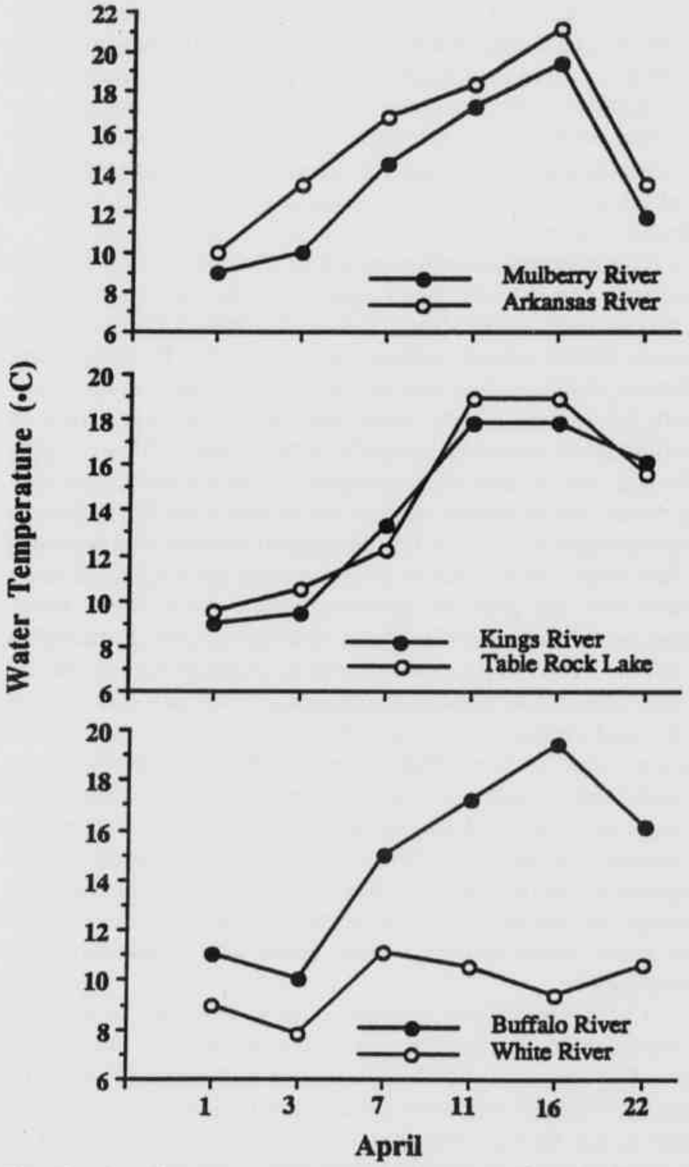

Fig. 2. April water temperature patterns for the Kings, Mulberry and Buffalo rivers, and their respective confluence.

The appearance of channel catfish moving into the Kings, Mulberry and Buffalo rivers conforms with similar patterns of spring movements reported for other waters (e.g., Humphries, 1965; June, 1977; Smith and Hubert, 1989). However, the number of channel catfish migrating into the Buffalo River was significantly less than was observed in the Kings or Mulberry rivers, although the measured physical characteristics (water temperature, turbidity, total discharge) did not significantly vary among these tributaries. Similarly, Brown (1967) reported a lack of spring channel catfish movements into the Buffalo River. This suggests that reduced inputs from migratory stocks of channel catfish since completion of Bull Shoals Dam in 1952 may partially account for the lower reproductive output and sparse adult population observed in the Buffalo River. In Wisconsin, it has also been suggested that without annual migrations of channel catfish, the population in the Wisconsin River would be sparse (T.D. Pellett and D. Fago, Wisconsin Department of Natural Resources, unpublished data).

The relatively small number of channel catfish migrating into the Buffalo River appears to be due to the presence of cold White River tailwaters, which had a significantly lower mean temperature than the Buffalo River during the sampling period. Studies on other cold tailwaters have shown that spawning of warmwater fishes is inhibited by release of hypolimnetic waters (Pfitzer, 1962; Brown, 1967), and that changes in water quality, especially water temperature, appear to be the most likely factors associated with disruption of natural stream communities (Edwards, 1978). Prior to construction of Bull Shoals Reservoir, the present coldwater reach of the White River had an historically abundant channel catfish population (Keith, 1964). The subsequent hypolimnetic release of cold water below Bull Shoals Reservoir has eliminated channel catfish (Brown, 1967) as well as other native warmwater species (Hoffman and Kilambi, 1971) from coldwater reaches of the White River. The coldwater reach may also eliminate temperature cues needed by channel catfish for spring migration. In contrast, no apparent barriers to migration exist downstream from the Kings or Mulberry Rivers; thus, channel catfish are able to move freely between these rivers and their respective confluence.

Cold White River tailwaters act as a barrier to channel catfish migration similar to that reported from other studies. For example, McCammon and LaFaunce (1961) suggested that the relatively closed population of channel catfish in the Sacramento River, California, was the result of a cold tailwater which inhibited movement up-river, increased salinity inhibited down-river movement, and the presence of a diversion dam prevented migration into a major tributary. Similarly, Welker (1967) reported that a lowhead dam appeared to inhibit up-stream movement of channel catfish in the Little Sioux River, Iowa, and McCammon (1956) found that the Palo Verde Weir on the lower Colorado River acted as a barrier to upstream channel catfish movement because tagged fish were caught at the base of the weir and few, if any, catfish moved upstream across the barrier.

Newcomb (1989) recognized the importance of excluding structures that hinder channel catfish passage to important seasonal habitat areas in the Missouri River and its tributaries. Sparse populations of channel catfish observed in some waters may be due to restrictions on catfish migration if suitable habitats for both spawning and overwintering are not available. The need for these specific habitat areas is illustrated by the extensive upstream or downstream movements documented from channel catfish tagging studies. Although clear-water Ozark streams such as the Kings, Mulberry and Buffalo rivers have abundant spawning habitat such as large boulders and rock crevasses, suitable overwintering areas appear to be limited because there are relatively few deep pools (>5 m), especially in downstream reaches.

Results from this study suggest that the sparse channel catfish population in the Buffalo River may be partially attributed to reduced inputs from historic migratory stocks due to cold White River tailwaters. Additional research is needed to quantify the importance of annual pre-spawning migrations for long-term maintenance of tributary channel catfish populations.

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