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Distribution and growth of blue sucker in a Great Plains river, USA

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Abstract Blue sucker, *Cycleptus elongatus* (Le Sueur), was sampled in the Kansas River, Kansas, USA to determine how relative abundance varies spatially and growth compares to other populations. Electric fishing was conducted at 36 fixed sites during five time periods from March 2005 to January 2006 to determine seasonal distribution. An additional 302 sites were sampled in summer 2005 to determine distribution throughout the river. A total of 101 blue sucker was collected ranging from 242 to 782 mm total length and 1–16 years old. Higher catch rates were observed in upper river segments and below a low-head dam in lower river segments, and catch rates were higher during November in the upriver sites. Kansas River blue sucker exhibited slower growth rates than other populations in the Great Plains including populations as far north as South Dakota.

KEYWORDS: Blue sucker, *Cycleptus elongatus,* Kansas River.

Introduction

Blue sucker, *Cycleptus elongatus* (Le Sueur), is distributed throughout the Mississippi and Missouri river drainages, USA. Its range extends from Montana south to Mexico, and east to Pennsylvania (Moss, Scanlan & Anderson 1983; Morey & Berry 2003; Vokoun, Guerrant & Rabeni 2003). Twenty-three states within the blue sucker range classify the fish as a species in need of conservation due to human alterations to its natural habitat (Williams, Johnson, Hendrickson, Contrereas-Balderas, Williams, Navarro-Mendoza, McAllister & Deacon 1989).

Modifications to rivers throughout the U.S. plains states have raised concern about the status of large-river fishes, including the blue sucker (Williams *et al.* 1989; Galat, Berry, Gardner, Hendrickson, Mestl, Power, Stone & Winston 2005; Lyons 2005). Blue sucker declines have been attributed to river modifications such as dams, impoundments and channelisation reducing preferred habitat (Tomelleri & Eberle 1990; Pflieger 1997; Vokoun *et al.* 2003). Although studies have focused on blue sucker spawning events (Vokoun *et al.* 2003), no studies to our knowledge have evaluated the distribution, abundance and habitat use of blue sucker throughout a large river across several seasons. However, Peterson, Nicholson, Fulling & Snyder (2000) described the distribution, abundance and habitat use throughout a large river for the congeneric south-eastern blue sucker, *Cycleptus meridionalis* Burr and Mayden.

In Kansas, blue sucker is found in the Neosho, Missouri and Kansas rivers, and are considered a species in need of conservation (Cross & Collins 1995; Haslouer, Eberle, Edds, Gido, Mammoliti, Triplett, Collins, Distler, Huggins & Stark 2005). Moss *et al.* (1983) found that blue sucker spawned from April to June in the Neosho River, but little is known about the Kansas River population. Metcalf (1966) and Cross & Collins (1995) suggested that blue sucker would be

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found only in the lower segments of the Kansas River primarily below dams where water is discharged from several reservoirs on tributaries of the Kansas River. This study had two primary objectives: to determine the distribution, relative abundance, size structure and growth of blue sucker throughout the Kansas River; and to determine if relative abundance varied seasonally throughout the river.

Materials and methods

Study area

The Kansas River begins near Junction City, Kansas at the confluence of the Smoky Hill and Republican rivers and flows east 274 km to its confluence with the Missouri River. The Kansas River drainage is about 157 000 km^2, or approximately 12% of the Missouri River watershed (Metcalf 1966). The Kansas River watershed includes 18 large (> 650 ha) reservoirs and nearly 13 000 small impoundments (Sanders, Higgins & Cross 1993), but Bowersock Dam (a low-head dam at river km [rkm] 83, approximately 5–7 m high, depending on water levels), is the only dam found on the mainstem Kansas River (Quist & Guy 1999); however, Johnson County Weir (a small rock water intake structure used to divert river flows) at rkm 27 may also limit fish movement at low discharge. Sand is the dominant substrate throughout the river with few gravel beds, but one large gravel bed is located near rkm 235 at the mouth of the Big Blue River. The river consists of many shallow secondary channels, vegetated islands and sand bars (Quist, Tilma, Burlingame & Guy 1999), and mean depth is typically < 1.5 m throughout most of the river (Makinster 2006).

Field collections

All electric fishing was conducted by boat using a Coffelt Model VVP 15 electric fisher. The boat was equipped with a single boom with an 8-dropper Wisconsin-style ring electrode. All blue sucker collected were measured [total length (TL), mm] and the first pectoral ray on the left side was removed for age analysis and the fish were released near their capture site.

Two sampling designs were employed to meet our objectives. Longitudinal sampling was conducted to determine the relative abundance of blue sucker throughout the Kansas River during the summer. Fixed sites were sampled throughout the year to determine if blue sucker congregate at different areas of the river during different seasons.

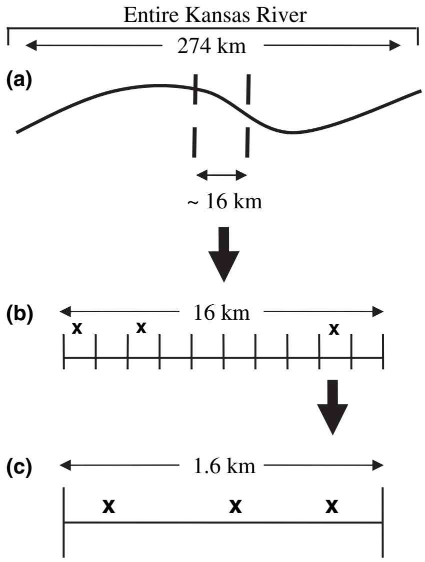

Figure 1. (a) The Kansas River was divided into 16 km segments and, within each 16 km segments, three randomly selected 1.6 km sections were chosen for sampling (b). Within the chosen sections three sites were selected for electric fishing based on habitat availability (c).

Longitudinal sampling

The Kansas River was divided into 18 segments of about 10–16 km. Three 1.6-km sections were randomly selected in each segment, and three sites (Fig. 1) were chosen based on habitat availability (see next paragraph) and electric fished using high-frequency pulsed DC output (7–11 A; 300–500 V; 35–40 Hz) for 5 min per site. In addition, up to three randomly selected 1.6-km sections were sampled based on habitat availability within each segment with low-frequency pulsed DC electric fishing (2–6 A; 180–250 V; 15–20 Hz) for 5 min per site as part of an ongoing flathead catfish, *Pylodictis olivaris* (Rafinesque), study (Makinster & Paukert, in press). A total of 302 longitudinal sites were sampled along the shore throughout the river once during May–August 2005.

Within each site, shoreline habitat was classified as mud-bank, rip-rap (length of rocky shoreline with rocks of various sizes) or log jam (pile of woody debris ≥4.5-m long, partially submerged and extending from the shore into the water). Only one habitat was sampled at each site, and all three habitats were sampled in a 1.6-km section if present. If a habitat was not present, additional available habitats were sampled. For example, if mud bank was the only available habitat, then three mud bank sites were sampled in that 1.6 km section.

Seasonal sampling

The seasonal distribution of blue sucker throughout the Kansas River was assessed by sampling 36 fixed sites approximately bimonthly from March 2005 to January 2006 (five sampling periods: March–April, June–July, September, November and January). The 36 fixed sites consisted of six randomly selected sites at each of six locations from the confluence with the Missouri River to rkm 238. The locations were rather uniformly distributed, except one location was immediately upstream and one location immediately downstream of Bowersock Dam. Each site was sampled for 5 min with high-frequency pulsed DC electric fishing (see above).

Age analysis

Studies of blue sucker and other catostomids have indicated that fin rays are a preferred non-lethal method of age analysis (Beamish & Harvey 1969; Rupprecht & Jahn 1980; Quinn & Ross 1982; Sylvester & Berry 2006). These studies compared scale ages to fin-ray ages and found that fin rays provided the better non-lethal method for ageing catostomids. In addition, fin rays have been validated for white suckers *Catostomus commersonii* (Lacepède) (Beamish & Harvey 1969; Quinn & Ross 1982). Therefore, pectoral fin rays were assumed to be a reliable method to age blue sucker.

The pectoral fin rays were cross-sectioned using a Buehler Isomet low-speed saw with a diamond cutting blade (Quist & Guy 1999). Three cross-sections were removed from each of the rays at three different thicknesses (1.0, 1.2 and 1.4 mm) and analysed using an image analysis system (Image-Pro Plus; Media Cybernetics, Silver Springs, MD, USA; Brenden, Hallerman & Murphy 2006) to determine age. The rays were aged similar to the methods used by Rupprecht & Jahn (1980) by counting opaque bands under transmitted light. Annular distances were measured from the focus to the outside of each annulus, and the Fraser-Lee method of back calculation was used to account for fish growth before the formation of the hard structure of the ray. The intercept value (*a*) (DeVries & Frie 1996) was 25 mm based on the body length and pectoral-ray radius regression of 45 blue sucker measured in this study.

Statistical analysis

High- and low-frequency electric fishing was used in the summer sampling to describe longitudinal distribution. A *t*-test was conducted to determine if catch rates differed between pulse frequencies. Catch rates of blue sucker with high-frequency electric fishing were greater than catch rates with low-frequency (*t*-test for unequal variances, $t = 2.01$, d.f. = 255, $P = 0.046$; Table 1). Therefore, only the 132 sampled with high-frequency electric fishing were used to describe habitat use and longitudinal distribution of blue sucker. Blue sucker total lengths (*t*-test for unequal variances, $t = -0.39$, d.f. = 61, $P = 0.700$) and ages (*t*-test for unequal variances, $t = -0.78$, d.f. = 61, $P = 0.438$) did not differ between the high- and low-frequency electric fishing (Table 1); therefore, the blue sucker captured in low-frequency electric fishing were included in the length and age analyses. To account for unequal representation of the habitats in each river segment, total mean catch rate per segment was calculated by taking the mean catch rate for each habitat in a segment and then calculating the mean of the habitat means to give each habitat equal weight for each segment. Summer distribution of blue sucker was assessed visually by plotting mean catch rate of high-frequency electric fishing by 16 km river segments.

An analysis of variance (ANOVA) was used to determine if mean blue sucker catch rate differed among habitats using only the high-frequency data. A two-way ANOVA was used to test for differences in blue sucker catch rate over time and among sites for the seasonal, fixed site sampling. A mixed model ANOVA (PROC MIXED in SAS) was used in all analyses to account for heterogeneous variances in catch rates (Littel, Milliken, Stroup & Wolfinger 1996; Paukert, Willis & Bouchard 2004). Statistical significance was declared at $\alpha < 0.05$ and least squares means tests were used to determine where means differed if the ANOVA was significant. Power $(1 - \beta)$ analysis was calculated by methods described by Zar (1996) to determine the chance of committing a type II error for non-significant tests.

Results

Longitudinal sampling

A total of 101 blue suckers were captured (69 in longitudinal sampling and 32 in seasonal sampling) in the Kansas River between March 2005 and January 2006 from both the 168 seasonal sites (12 seasonal sites could not be sampled due to low water conditions, which occurred primarily in the late summer sampling) and 302 longitudinal sites. Blue sucker total length ranged from 242 to 782 mm; the length distribution was skewed towards fish >600 mm (Fig. 2a).

Table 1. Blue sucker mean catch rate (number per 5 min), mean total length and mean age at high- (35–40 Hz) and low-frequency (15–20 Hz) pulsed DC electric fishing and in three habitats in the Kansas River sampled from May to September 2005. Standard error is in parenthesis

Variable	*n*	Catch rate	Mean total length (mm)	Age (years)
Electric fishing pulse rate				
High frequency	132	0.252 (0.04)	633.1 (12.9)	8.60 (0.32)
Low frequency	170	0.143 (0.03)	625.8 (13.1)	8.50 (0.26)
Habitat				
Log jams	29	0.344 (0.10)	633.4 (22.3)	8.67 (0.58)
Mud banks	59	0.265 (0.08)	627.4 (23.6)	8.36 (0.62)
Rip rap	44	0.355 (0.10)	639.3 (19.6)	8.83 (0.47)

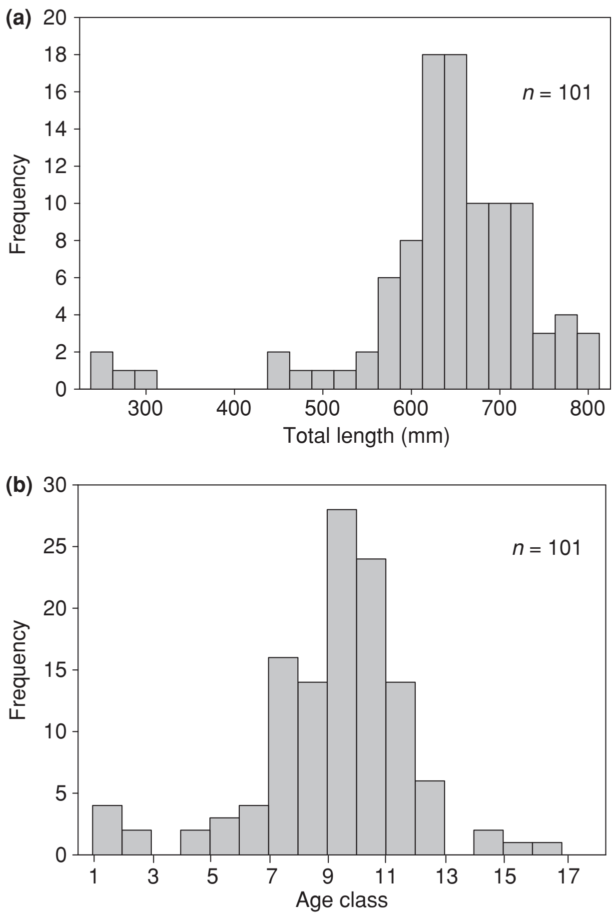

Figure 2. (a) Lengths of blue sucker collected in the Kansas River from rkm 0 to rkm 274 by electric fishing in both seasonal and longitudinal sites from March 2004 to January 2006. (b) Ages of blue sucker collected in the Kansas River from March 2005 to January 2006.

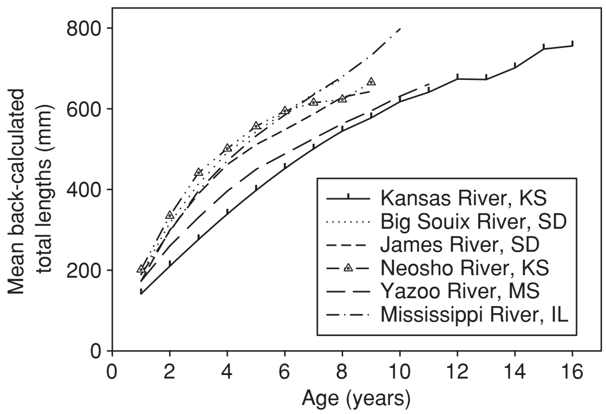

Figure 3. Mean back-calculated length at age of blue sucker collected in the Kansas River and other rivers in the Midwest and Southeast. The data for the Big Sioux and James River are from Morey & Berry (2003), Mississippi River are from Rupprecht & Jahn (1980), Neosho River are from Moss et al. (1983) and the Yazoo River are from Hand & Jackson (2003).

Blue sucker were age 1–16 years, with most fish collected in the 7–11 age classes (Fig. 2b). Kansas River blue sucker were about 200 mm at age 2, and attained 500 mm by about age 7 (Fig. 3).

Blue sucker catch rates during June–August 2005 ranged from 0.00 to 0.51 per 5 min among segments and were typically less than 0.40 (Fig. 4a). Catch rates were higher in the upper river from rkm 160 to 208 and from rkm 224 to 272 and between the Johnson County Weir and Bowersock Dam. No blue suckers were captured below the weir, directly above the dam, from rkm 112 to 128, and from 208 to 224.

Mean catch rates did not differ between log jams, mud banks and rip rap ($F = 7.00$, d.f. = 2, 129, $P = 0.732$; Table 1). However, the power of the test was low ($1 - \beta = 0.44$) suggesting more sampling is needed before conclusive statements about habitat use can be made.

Seasonal sampling

The mean catch rate in the fixed sites was not consistent among locations and seasons (season by location interaction, $F = 3.07$, d.f. = 18, 134, $P < 0.001$). The least square means comparisons indicated the upper river sites (rkm 234–237) in

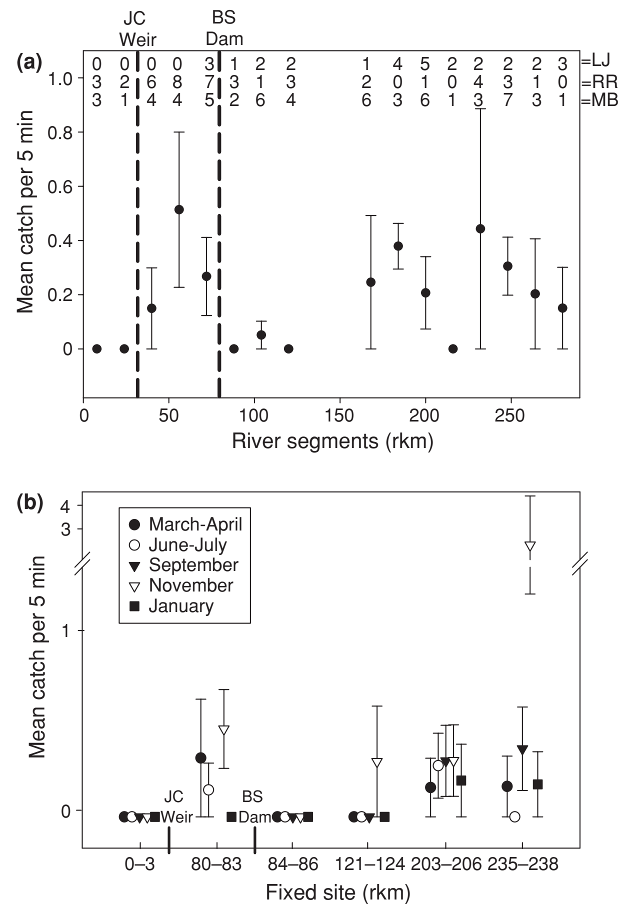

Figure 4. (a) Blue sucker catch rate for 132 longitudinal sites throughout the Kansas River sampled from June to August 2005. Log jams (LJ), rip rap (RR) and mud bank (MB) represents the number of sites sampled for each habitat in each 16-km river segment. Points without error bars indicate no fish were collected in those segments. (b) Mean blue sucker catch rate (number per 5 min of electric fishing) in the Kansas River for 36 fixed stations at six locations during March 2005–January 2006. For both panels, Johnson County Weir (JC Weir) is noted at rkm 27 and Bowersock Dam (BS Dam) is noted at rkm 83. Error bars represent 1 standard error. Points without error bars indicate no fish were collected in those areas.

November (14–15°C) had significantly greater mean catch rates (2.9 fish per 5 min, $P < 0.001$; Fig. 4b) than any other site during any season. However, high variability in catch rates yielded no differences in any other season or location. No fish were collected at the sites below the weir or directly above the dam, which was consistent with the longitudinal sampling (Fig. 4a).

Discussion

Blue sucker generally were most abundant between Bowersock Dam and the Johnson County Weir (rkm 24–83) and in the upper river (rkm 160–270). The low catch rates below Johnson County Weir may be related to the channelised morphometry of this section of the river. However, the channelised section has a mean depth of 2.94 m compared with upriver segments where mean depth was between 0.20 and 0.96 m (Makinster 2006), and the low catch in the channelised section may be influenced by reduced electric fishing efficiency in the deeper water (Reynolds 1996). The low catch rates above Bowersock Dam may be related to lower water velocities, silty substrate, and deeper water compared with other more riverine segments. Morey & Berry (2003) also found that blue sucker relative abundance was lower within 10 km above a low-head dam than below the dam in the James River, South Dakota.

Mean catch rates of blue sucker in the Kansas River were generally lower than catch rates reported by Peterson *et al.* (2000), Morey & Berry (2003) and Vokoun *et al.* (2003), and may reflect lower abundance in the Kansas River. Metcalf (1966) concluded blue sucker abundance in the Kansas River was decreasing, and blue sucker probably only inhabited the lower segments of the river. The results of this study indicate blue sucker are most abundant in the upper river segments.

Only four of the 101 blue sucker collected were less than 400 mm suggesting either low recruitment, young fish (ages 0–5) not occupying habitats sampled, or gear bias. Other studies have also collected relatively few small fish using electric fishing (Rupprecht & Jahn 1980; Moss *et al.* 1983; Peterson, Nicholson, Snyder & Fulling 1999; Hand & Jackson 2003; Morey & Berry 2003; Vokoun *et al.* 2003). River tributaries and backwaters, which were not sampled in this study, appear to be important areas for age-0 blue sucker (Muth & Schmulbach 1984; Brown & Coon 1994; Fisher & Willis 2000; Adams, Flinn, Burr, Whiles & Garvey 2006). In addition, Moss *et al.* (1983) found juvenile (ages 0–2) blue sucker in shallow riffle areas, usually over bedrock, which were difficult to sample in the Kansas River. More research is needed to determine habitat use, effective capture techniques and recruitment dynamics of young-of-the-year blue sucker.

The blue sucker population in the Kansas River appeared to have slower growth than other blue sucker populations. Braaten & Guy (2002) determined that thermal regime has a strong impact on growth of fishes, with fish having faster growth in the southern latitudes. Therefore, Kansas River blue sucker were expected to have faster growth than rivers further north, but similar to populations in Missouri and Kansas. Growth for the Kansas River was lower than other populations from South Dakota to Mississippi, USA. Even for ages commonly collected in our study (7–12), mean length was typically 10–22% less than South Dakota and Illinois populations and 13–19% less than the Neosho River, Kansas population. One possible explanation for the apparent slower growth in the Kansas River was that all of the fish in this study were aged using pectoral rays while most of the other studies used scales. Other studies have found scales provide lesser ages when compared with pectoral rays for mature white sucker (Beamish & Harvey 1969; Quinn & Ross 1982), with scales at times being in error by as much as 5 years (Beamish & Harvey 1969). Hence, ageing fish with pectoral rays could account for lower length at age for fish in this study.

Moss *et al.* (1983) reported that blue sucker spawning occurs April–June at water temperatures 20–23°C, and blue sucker abundance during the seasonal sampling was expected to be higher during spring (March–April) in the upriver locations and below Bowersock Dam as fish moved upriver to spawn. Relatively few blue sucker were collected in spring and no difference in catch rates was detected among locations. However, during spring sampling below Bowersock Dam, blue sucker were observed topping the water while sampling, but fast water velocities prohibited the collection of fish. Below the dam was the only location where many observed blue sucker escaped capture. Morey & Berry (2003) also found it difficult to effectively capture all blue sucker in the swift currents near riffles and rock dams. Nonetheless, trends in the fixed sites were consistent with the longitudinal sampling with higher catch rates in the upper river and below Bowersock Dam throughout all seasons, which suggest distribution does not change much within the river during different seasons.

The two fish collected below the dam during spring sampling were ripe males, suggesting they may have been near the dam for spawning. Although this matches the spawning conditions reported by Moss *et al.* (1983), the higher catch rates upriver in the autumn suggests these fish were preparing for spawning in November or December when water temperatures were 14°C. Vokoun *et al.* (2003) found blue sucker spawned near 16°C with fish appearing at the spawning sites at 12°C in Missouri, and Moss *et al.* (1983) suggested spawning could occur at temperatures as low as 17°C. Therefore, blue sucker in the Kansas River may be staging in upriver locations in autumn for an early spring (March–April) spawn when water temperatures were near 14–15°C.

In conclusion, Great Plains rivers have been substantially modified due to dams, channelisation and other river modifications (Sanders *et al.* 1993; Graf 1999) and many fish populations have been affected by these alterations (Williams *et al.* 1989; Galat *et al.* 2005; Lyons 2005; Peters & Schainost 2005). This study found that river modifications (Bowersock Dam and Johnson County Weir) may affect the distribution of blue sucker in the Kansas River. Mean catch rates were lower and mean annual blue sucker growth was slower than other Great Plains rivers suggesting abundance and growth rates may also be affected by these river modifications. Continued efforts to protect natural river function in the Great Plains may help conserve blue sucker and other riverine species.

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