Status of Silver Carp (*Hypophthalmichthys molitrix*) and Bighead Carp (*Hypophthalmichthys nobilis*) in Southeastern Oklahoma

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Silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*H. nobilis*) are native to southeastern Asia and have been introduced throughout much of the central and southeastern United States. Prior to this study, incidental capture of individual bighead carp had been reported from the Neosho River and Grand Lake, and from the Red River; no silver carp had been reported from Oklahoma. However, in response to several reported sightings by anglers in the Kiamichi River during Spring of 2012, we conducted a survey for silver and bighead carp in the Kiamichi River and three other lentic systems in Choctaw and McCurtain counties in southeastern Oklahoma. We used electrofishing gear and gill nets to sample over 5 days during June, 2012. In so doing, we captured a total of 13 *Hypophthalmichthys*, including five silver carp and eight bighead carp, and we collected or detected them in three of the four water bodies sampled. Among the fish captured, we measured weight, length, and egg mass (of females), and removed pectoral spines to determine age, and report these summary statistics in this paper. Silver and bighead carp appear to be well established in southeastern Oklahoma, and it is likely that they are reproducing.

INTRODUCTION

Carp of the genus *Hypophthalmichthys* are native to southeastern Asia and were introduced in many areas of the United States in the early 1970's, primarily for uses in aquaculture and biological control (Kolar et al. 2007). Escape from aquaculture facilities, sewage lagoons, and reservoirs followed, and Asian carp have become well-established in much of the Mississippi River basin (Fuller et al. 1999), including states adjacent to Oklahoma. By 1982, silver carp had become well-established in Arkansas and Louisiana as a result of escape from hatcheries (Freeze and Henderson 1982). In Oklahoma, Pigg et al. (1993) reported that bighead carp were present in the Neosho River system in 1992, and in Grand Lake and Lake Hudson in 1996 (Pigg et al. 1997), suggesting downstream dispersal in that river system. Bighead carp have been reported from Grand Lake as recently as 2011 (Long and Nealis in press). There are no prior records of silver carp in Oklahoma, and until recently, there were no records of either species outside of the Neosho/Grand river system. However, in Summer 2010, a bighead carp that had been harvested from the Red River in Bryan County by a bow fisherman was verified (Matt Mauck, Oklahoma Department of Wildlife Conservation, personal communication), and in Spring 2012, several reports of angler sightings of fish that fit the description of *Hypophthalmichthys* were received by the Oklahoma Department of Wildlife Conservation (ODWC), including a high-quality photograph. The 2012 reports

were from the Kiamichi River downstream from Hugo dam, in the Red River drainage of southeastern Oklahoma. These reports prompted us to conduct a baseline survey to address the following objectives with respect to *Hypophthalmichthys*: (1) confirm their presence in the Kiamichi River, (2) determine if they are present in other connected waterways, (3) provide descriptive population statistics of any individuals captured, and (4) comment on the likelihood for additional distribution and dispersal in southeastern Oklahoma.

METHODS

We sampled four connected lotic systems in Choctaw and McCurtain counties. These included the Kiamichi River downstream from Hugo Dam, the Red River near the Choctaw-McCurtain County border, and Clear Creek and Garland Creek in McCurtain County (Figure 1).

On June 6-8, 2012, we used two electrofishing boats accompanied by a single chase boat to sample the Kiamichi River downstream from Hugo Dam to approximately the state highway 109 crossing. One electrofishing boat was equipped with a Smith-Root 7.5 GPP electrofisher, the other with a Smith-Root 2.5 GPP electrofisher. Because we were only seeking to confirm the presence of the target species, we did not attempt to standardize gear or record total sampling effort, and only *Hypophthalmichthys* were retrieved by netters.

An additional sampling trip was conducted June 18-19, 2012. We electrofished the Kiamichi River downstream from the state Highway 109 crossing, as well as in the Red River, Clear Creek, and Garland Creek, using the same procedure as previously described. In Garland and Clear Creeks, electrofishing was initiated at their respective confluence with the Red River and proceeded upstream until we reached shallow water that precluded any further upstream sampling. Additionally, we used gill nets to sample during this trip. Three experimental gill nets were set in the Kiamichi River

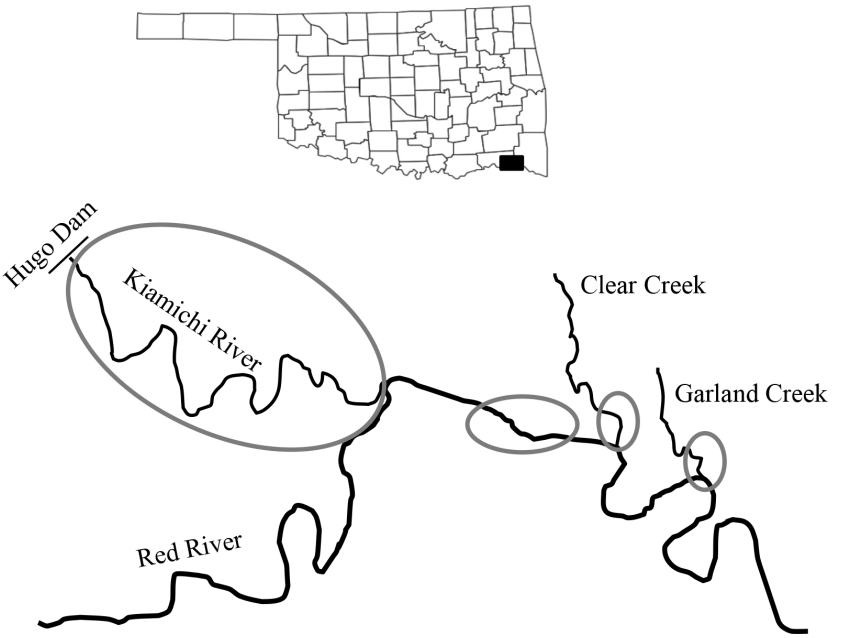

Figure 1. Locations (stream segments in ovals) from which silver and bighead carp were captured or detected from four streams in Choctaw and McCurtain Counties, Oklahoma (inset), June, 2012. Both species were captured from the Kiamichi River and Garland Creek; one or both species were visually detected in the Red River.

within the downstream-most 3km of river; these nets were 40.5x 1.9 m, their mesh size ranged from 5.08–10.16cm, and they were set at approximately 11 am and retrieved the following day at approximately 3 pm. A fixed-mesh gill net was set in Garland Creek at its confluence with the Red River; this gill net was 64.7 x 1.9m, with a 7.62cm mesh, and was set at 5pm and retrieved the following morning at 9am.

In addition to the target species captured, we made note of the number seen jumping out of the water. All *Hypophthalmichthys* captured were weighed and measured, gender was determined, pectoral spines were removed for age determination, and the egg mass was removed from females and weighed. Additionally, the egg mass from one female was preserved in ice for later egg enumeration. In the laboratory, pectoral spines were cross-sectioned following the procedure described by DeVries and Fry (1996) and age was estimated by three independent observers. Eggs from the individual female were enumerated by counting the oocytes within each of five 1g samples to determine the mean number of eggs/g, and that value was multiplied by the total egg mass to determine the total number of eggs (Crim and Glebe 1990).

RESULTS

We electrofished approximately 20 km in the Kiamichi River, 4km in the Red River, 500m in Garland Creek, and 300m in Clear Creek. We did not attempt to retrieve non-target species, but high numbers of succumbing fish indicated that electrofishing was effective at all sites except the Red River. Though we did not measure conductivity in the Red River, low capture rates were likely due to high conductivity values that are typical in that system.

We captured a total of 13 *Hypophthalmichthys*, including five silver carp and eight bighead carp, and we estimate that we saw approximately 20-25 additional specimens jumping out of the water as we electrofished. All captured were from electrofishing; though we gill-netted for a total of 100 net-hours, no target species were captured in gill nets. Among the 13 fish captured, eight were from the Kiamichi River and five were from Garland Creek (Table 1); none were captured from Clear Creek or the Red River, though

Table 1. Characteristics of 13 bighead and silver carp captured from two streams in Choctaw and McCurtain Counties, Oklahoma, June, 2012.

Species	Water body	Gender	Age	Length (mm)	Weight (kg)
Bighead carp	Garland Creek	F	3	914	9.7
Bighead carp	Garland Creek	F	2	940	10.0
Bighead carp	Garland Creek	F	3	965	11.4
Bighead carp	Garland Creek	M	4	1092	12.4
Bighead carp	Kiamichi River	M	4	940	10.8
Bighead carp	Kiamichi River	F	4	940	10.8
Bighead carp	Kiamichi River	F	12	1092	22.9
Bighead carp	Kiamichi River	F	7	1168	16.7
Silver carp	Garland Creek	F	2	787	6.8
Silver carp	Kiamichi River	F	-	813	7.7
Silver carp	Kiamichi River	F	3	813	6.4
Silver carp	Kiamichi River	M	4	813	6.1
Silver carp	Kiamichi River	F	4	889	8.6
Mean			**4**	**936**	**10.8**

several were seen jumping out of the water while we electrofished the Red River. It is also noteworthy that we saw (but did not retrieve) approximately 10-15 grass carp *Ctenopharyngodon idella* in Garland and Clear Creeks as they succumbed to electrofishing. Among the 13 *Hypophthalmichthys* captured, ten were females and three were males. Mean length was 972mm (range = 813–1168mm) and mean weight was 10.8 kg (range = 6.1–22.9 kg). Age estimates (N = 12) based on pectoral spine annuli were 2 - 12 years. Among the females captured, egg mass comprised an average of 20% of total body weight (range = 14 - 27%). Among the single female for which eggs were enumerated, there were 390 eggs/g of egg tissue, which equated to 2.37 million eggs in that female, or 77,975 eggs/kg of body weight (Table 1).

DISCUSSION

We confirmed the presence of Silver and bighead carp in the Kiamichi River below Hugo Dam, as well as in connected waters that comprise the lower Red River drainage. Bighead carp found in the Neosho/Grand River in northeastern Oklahoma in the 1990's were believed to have escaped from a hatchery in Kansas (Pigg et al. 1997). Long and Nealis (in press) concluded that a single age-9 individual captured from Grand Lake in 2011 was too young to have resulted from an introduction in the early 1990's, and suggested that it represents an additional, unknown introduction or undocumented reproduction. Silver and bighead carp have not been grown in aquaculture in Oklahoma, but have been established in the Red River drainage in Louisiana since at least 1980 (Freeze and Henderson 1982), including the Red River, and we believe this is the likely source of their occurrence in southeastern Oklahoma.

While these fish do not yet appear to be in high relative abundance, they appear to be established in the Red River drainage in Oklahoma. We do not know if silver and bighead carp in the Red River and its tributaries in Oklahoma are reproducing, and we did not sample for smaller life stages. Researchers have shown that bighead and silver carp reproduce in riverine areas with relatively high velocities (>0.7 m/s), high turbidity, and water temperatures > 18 C, often move long distances prior to spawning, and produce semi-buoyant eggs that may drift considerable distances downstream (Virigin et al. 1978; DeGrandchamp et al. 2007; Garvey 2007; Kolar et al. 2007). Because the Red River receives frequent high flows during the spring and summer in the form of reservoir releases from Lake Texoma, it seems likely that conditions for successful reproduction are frequently met. All of these factors suggest that silver and bighead carp will likely proliferate in the Red River drainage in southeastern Oklahoma. Ostensiby, the Denison Dam would prevent silver and bighead carp from entering Lake Texoma, but if they do, the Washita and upper Red Rivers would likely provide suitable habitat for spawning and all life stages. During Summer 2012, ODWC received a single report of a sighting of a large, silver fish jumping out of the water in the Washita River. If this sighting represents *Hypophthalmichthys*, this would imply that they occur upstream of the Denison Dam (Lake Texoma). However, these reports remain unconfirmed, and to date, no standardized sampling efforts have resulted in capture of any *Hypophthalmichthys* in Lake Texoma (Matt Mauck, Oklahoma Department of Wildlife Conservation, personal communication).

Predicting the current and future distribution of silver and bighead carp in southeastern Oklahoma is largely speculative; however, understanding their current distribution along with connectivity of waters may provide some insight. Three major drainages in Eastern Oklahoma appear to pose the greatest threat of invasion: The Red River and its tributaries, the Little River and its tributaries, and the Arkansas River and its tributaries.

Because *Hypophthalmichthys* are present in the mainstem of the Red River in Oklahoma, as well as in large tributaries such as the Kiamichi River, and small tributaries such as Garland Creek, it is likely that they will be in nearly all tributaries of the lower Red River in Oklahoma (and Texas). Consequently, silver and bighead carp are likely to occupy (either currently or in the near future) Boggy and Blue Rivers and their tributaries. Furthermore, in their native range, these species often use floodplain habitats as juveniles (Abdusamadov 1987), which may facilitate dispersal into waters within the floodplain such as oxbow lakes.

The Little River in Oklahoma includes two major tributaries- the Glover and Mountain Fork Rivers- and collectively these make up the "Three Rivers" area. Downstream of the confluence of these three rivers, the Little River flows into southwest Arkansas, and eventually into the Red River. Silver and bighead carp have not been documented in the Little River in southwestern Arkansas; however, they occur in the Red River in Arkansas, so their presence in the Little River in Arkansas is plausible (Jeff Quinn, Arkansas Game and Fish Commission, personal communication). The Little River in Arkansas is impounded by a large dam at Millwood Lake, which may effectively serve as a migration barrier and prevent further upstream movement into the Little River and its tributaries. This suggests that invasion into Oklahoma via the Little River is unlikely. Nevertheless, "bait bucket" introductions above Millwood Dam could occur.

Silver and bighead carp occur in relatively high abundance in the lower reaches of the Arkansas River in Arkansas, but only bighead carp have been documented as far upstream as Dardenelle Reservoir and the vicinity of Ozark, Arkansas (Jeff Quinn, Arkansas Game and Fish Commission, personal communication). However, it is noteworthy that these species have been documented to move long distances, including through lock and dam systems, in relatively short periods of time (Garvey 2007). Consequently, invasion into the Arkansas River in Oklahoma is also plausible, and there is the continued threat of bait bucket introductions.

It is beyond the scope of this study to describe all of the potential ecological impacts of silver and bighead carp, and there is a plethora of literature available on the topic. However, because it is an obvious and important topic, we provide a partial list of potential impacts, as summarized in a thorough review by Kolar et al. (2007). Because they are planktivorous and can attain high relative biomass, their potential impacts are many. Demonstrated impacts on habitats and water quality have included changes in nutrient contents, sediment resuspension, increased turbidity, reduced dissolved oxygen, and increased nitrogen. Demonstrated impacts on trophic dynamics have included increased algal blooms (through trophic cascades associated with removing select algal species), and may include changes in the benthic community, inhibition of sight-feeding predators due to effects on turbidity, changes in the size structure of the zooplankton community, and alteration of the benthic macroinvertebrate community through high levels of excrement deposition and organic enrichment of the bottom. Demonstrated competitive interactions with other fishes are many and globally widespread. Where introduced in India, silver and bighead carp dominated the commercial catch within 10 years, and were negatively correlated with abundance of native planktivores. Similar examples of competitive displacement by silver and bighead carp have been shown in the Middle East, China, Germany, Thailand, and the Mississippi River basin in the United States. In the majority of these cases, planktivorous fishes, and especially planktivorous fry, are the most affected. In the Mississippi River basin, there is particular concern that silver and bighead carp may reduce abundance of planktivores such as gizzard shad, threadfin shad, and emerald shiner, all of

which are important to a large number of other fishes and birds that prey upon these species. Additionally, silver and bighead carp may affect other fish species through spatial displacement, and have been shown to be problematic with respect to spread of communicable fish diseases. For a more thorough review of the potential impacts, see Kolar et al. (2007).

In conclusion, bighead carp have appeared from the Neosho River system periodically since 1992, and more recently, silver and bighead carp appear to have become established in the Red River drainage in Oklahoma downstream from Lake Texoma. While these fish are not highly abundant at this time, there are multiple year-classes present, they are attaining large body size (upwards of 22 kg in our samples), and all females collected were carrying large relative volumes of eggs. Additional invasion in Oklahoma waters may be curtailed by existing dams, but the threat of intentional or unintentional bait-bucket introductions remain, and predicted and demonstrated negative ecological impacts are many.

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