Age and Size of Spotted Gar (*Lepisosteus oculatus*) from Lake Thunderbird Reservoir in Central Oklahoma

Bryan D. Frenette
Department of Biology, University of Oklahoma, Norman, OK 73019

Richard A. Snow
Oklahoma Department of Wildlife Conservation, Oklahoma Fishery Research Lab, Norman, OK 73072

Abstract: We report the body size and population age structure of Spotted Gar from the Lake Thunderbird reservoir, OK. We collected 90 Spotted Gars ranging between 348 – 846 mm total length, and aged gars by examining annuli from the sagittal otoliths. Annuli were counted on both browned and not browned sagittal otoliths to compare the efficacy of both methods. Gars ranged between 1 and 14 years old, and percent agreement of age within one year between readers was comparable for both the browned and not browned otoliths. Back-calculated growth indicated that Spotted Gar grow quickly during the first year of life, and approach maximum size by year 4.

Introduction

The Spotted Gar (*Lepisosteus oculatus*) is one of four species of gar (Family: Lepisosteidae) that occur in Oklahoma. While globally secure, the Spotted Gar is a species of conservation concern at the northern edge of its range and is critically imperiled in Canada (Glass et al. 2011; Statton et al. 2012; David et al. 2015; NatureServe 2016), critically imperiled in Kansas, Ohio, and Pennsylvania, and is thought to be extirpated in New Mexico (Staton et al. 2012; NatureServe 2016). The basic biology of this species and other gars remains largely understudied, due in part to the reputation gars hold as nuisance fish throughout much of their range (Scarnecchia 1992). This lack of information concerning Spotted Gar holds true for Oklahoma, where few studies have focused on this species. Echelle and Riggs (1972) described early life history of gars, including Spotted Gar, in Lake Texoma. Tyler and Granger (1984) reported on size, diet, and spawning behavior of Spotted Gar from Lake Lawtonka, and Frenette and Snow (2016) described spawning behavior in Spotted Gar from Lake Thunderbird. This study describes population age using sagittal otoliths and body size of Spotted Gar in the Lake Thunderbird reservoir.

Methods

Study Area Description

The Lake Thunderbird reservoir is a man-made impoundment located in the Cleveland and Oklahoma counties in central Oklahoma, USA (Figure 1; Simonds 1999). The reservoir was build and put into operation between 1962 and 1965, and is located approximately 16km from the city of Norman, OK (Simonds 1999). Lake Thunderbird impounds the Little River, a tributary to the Canadian River, and provides water for Oklahoma City, Norman, Midwest City, Del City, and the Tinker Air Force Base (Simonds 1999). Historic and contemporary sampling did not detect Spotted Gars or other species of Lepisosteidae in the Little River and its tributaries surrounding Lake Thunderbird (Franssen and Tobler 2013). However, sampling methods from this study may not have been

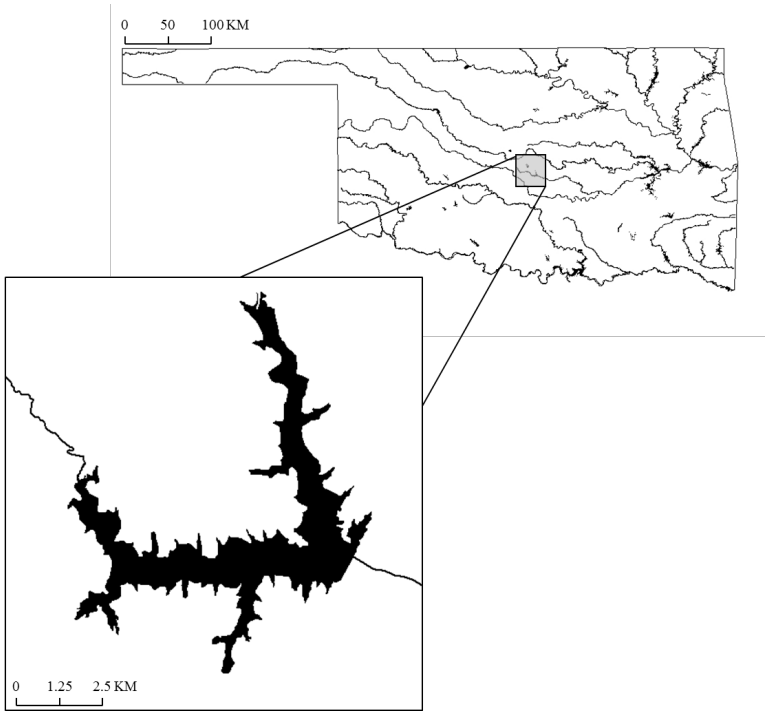

Figure 1.—Map of the Lake Thunderbird reservoir in central Oklahoma.

sufficient to efficiently capture large-bodied fishes like Gars (Franssen and Tobler 2013; M. Tobler, Kansas State University, personal communication). It was hypothesized that flooding in the late 1990's allowed Spotted Gar to migrate into Lake Thunderbird from Lake Stanley Draper to the north; Spotted Gar were not detected by sampling in Lake Thunderbird until the mid-2000's (K. Thomas, Oklahoma Department of Wildlife Conservation, personal communication).

Sampling and Data Collection

Sampling on April 25 and May 2, 2014 in the Hog Creek arm of Lake Thunderbird captured 90 adult Spotted Gar. Collections were made using boat electroshocking in areas where gar densities were high, presumably due to the spawning season. Fish were transported to the Aquatic Research Facility (ARF) at the University of Oklahoma, where they were held in a 0.04 ha holding pond until being processed for this study.

Sex identification and morphometric measures.—Prior to measuring, fish were placed into an ice bath to induce torpor. Fish were measured in mm for total length (TL) using a measuring board (±1 mm). Calipers were used to measure both head length (HL) and snout length (SnL) in mm. HL was measured from the tip of the snout to the posterior portion of the opercle. SnL was measured from the tip of the snout to the anterior start of the orbital. Both HL and SnL were measured alongside the snout on the left side of the body. Fish were weighed in kg using a digital scale. Sex of Spotted Gars was determined by examining the gamete release pathways following a standardized procedure for determining sex in Lepisosteids (Ferrara and Irwin 2001).

Otolith aging.—Paired sagittal otoliths were removed from Spotted Gar through the ventral side of the brain case. Otoliths were then cleaned and dried before processing. One otolith from each pair was browned at 104°C using a hot plate to increase the contrast between the accretion and discontinuous zones (Figure 2; Secor et al. 1992; Long and Snow 2016). Both otoliths (browned and not browned) were processed following Buckmeier et al. (2012),

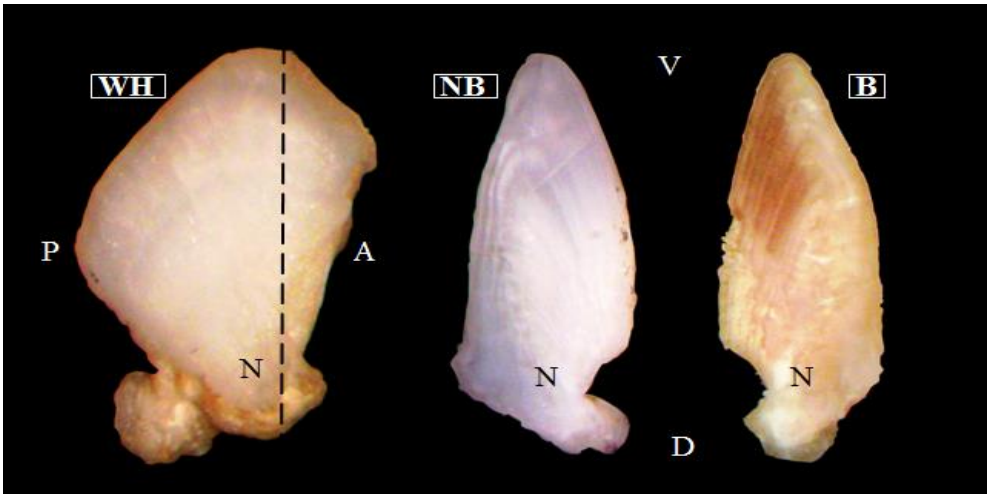

Figure 2.—Whole (WH) sagittal otolith view to the left with not browned (NB) and browned (B) ground otoliths in a transverse plane from a 653 mm spotted gar, noting orientation (P = posterior, A = anterior, V = ventral, D = dorsal). The dashed line represents the portion of the otolith that was removed starting from the anterior (A) side. The nucleus (N) is located in the dorsal region of the otolith, with annuli being estimated in the ventral (V) portion of the otolith.

where otoliths were ground in a plane transverse to the nucleus (Figure 2) using a rotary tool fixed with a grinding bit (#85422, Dremel, Racine WI). The rotary tool was attached to a table, and forceps coated in Tool Dip (Plasti Dip Internation, Blaine MN) were used to securely hold the posterior portion of the otolith during the grinding process. Sagittal otoliths were ground by placing the anterior portion of the otolith on the grinding bit and removing material until the nucleus was even with the apex of the ventral portion of the otolith (Figure 2). Otoliths were then polished using wetted 1600 grit sand paper.

Two readers independently examined the otoliths to estimate ages (Hoff et al. 1997) using an optic-mount digital camera attached to an Olympus dissection microscope (Olympus Corporation, Lake Success NY) and displayed on a high-resolution monitor. Otoliths were selected at random with the readers having no reference to fish length, weight, or sex to reduce bias. Otoliths were then placed in clay and submerged in water to reduce glare. A fiber optic filament with an external light source was used to illuminate annuli. Annuli were first counted from the nucleus margin to the outer edge, and then repeated to verify the first count. If needed, otoliths were polished multiple times to increase the clarity of and to clearly interpret the outer-most annuli (Buckmeier et al. 2012). After otoliths were estimated independently, readers estimated and agreed on ages for both browned and not browned sagittal otoliths. Independently aged otoliths were compared to agreed ages for both browned and not browned sagittal otoliths.

Statistical analyses.—Browned and not browned otoliths were compared using age bias plots to determine if precision was higher using either technique (Campana et al. 1995). Percent agreement (PA) and coefficient of variation (CV) between readers was calculated for both otolith types (Campana et al. 1995). A length frequency histogram was created to visualize the length distribution of Spotted Gar. A von Bertalanffy growth equation (Beverton 1994) was used to model back-calculated total length-at-age using non-linear regression. Non-linear regression was used to describe the weight-length relationship of the population. Due to sample size being low, data for both male and female Spotted Gar were pooled.

Results and Discussion

We collected 24 female and 66 male Spotted Gars, ranging in size between 348 – 846 mm TL (average = 601.1 ± 82.5 mm), from the Lake Thunderbird reservoir (Table 1). Sex ratios were not 1:1 across all ages sampled. This is likely a relic of sampling time and methodology, as gars were targeted during the spawning season. Spawning aggregations of gars typically consist of a greater ratio of males than females (Echelle and Grande 2014; Frenette and Snow 2016). The length-frequency distribution of Spotted Gar appeared to be bimodal, with fewer large (730 - 760 mm TL) individuals than smaller (530 - 630 mm TL) individuals (Figure 3). Gars are known to be sexually dimorphic in body size, with females being larger, on average, than males (Love 2002; McGrath and Hilton 2012; McDonald et al. 2013). In our sample from Lake Thunderbird, female Spotted Gars where, on average, larger (651.7 ± 124.2 mm TL) than males (582.7 ± 48.9 mm TL). The modelled von Bertalanffy growth curve indicates that Spotted Gar from Lake Thunderbird approach maximum length quickly ($K = 0.81$), with individuals in the population growing to half of their expected TL in the first year of life and approaching infinity ($L_\infty = 609$ mm) by age 4 (Figure 4). The weight-length relationship suggests that Spotted Gar experience positive isometric growth (Figure 5). It is worth noting that, since sexes were pooled to calculate growth, any sex-specific differences in growth are masked. However, because the sample size of females was low, the difference in back-calculated growth was minimal compared to when females were excluded from the analysis. Nonetheless, the results hold with the knowledge that gars, including Spotted Gar, grow rapidly during the first year of life (Matthews et al. 2012; David et al. 2015).

Ages assigned using both techniques (not browned and browned) ranged from 1 to 14 years (Table 1). Exact agreements for browned otoliths were 55.4% for reader 1 and 32.1% for reader 2, whereas PA within 1 year was 84.7% for reader 1 and 63.3% for reader 2. CV estimates for browned otoliths were 6.5% for reader 1 and 11.1% for reader 2. Results for not browned otoliths were similar, with exact agreements of 57.1% for reader 1 and 30.7% for reader 2. PA within 1 year for not browned otoliths was 81.3% for reader 1 and 65.1% for reader 2, and CV estimates were 6.1% for reader 1 and 10.6% for reader 2. Age bias plots for both techniques provided similar age estimates and did not consistently under- or overestimate ages (Figure 6), however readers felt that annuli were more clearly visible in browned otoliths. Caution should be used, however, when estimating ages using browned otoliths of Spotted Gar, as false annuli are more defined using this technique and, without experience, are harder to eliminate during estimations.

This study represents the first report of age and size structure of Spotted Gar from the Lake Thunderbird reservoir, and contributes to our understanding of the basic biology of this species in Oklahoma.

Table 1.—Average (± 1 SD) and range (minimum - maximum) of morphometric measurements and age for Spotted Gar from Lake Thunderbird. Measurements are reported for males, females, and for pooled sexes. TL = total length; HL = head length; SnL = snout length; W = weight; A = age.

	Pooled		Female		Male	
	Mean	Range	Mean	Range	Mean	Range
TL (mm)	601.1 ± 82.5	348 - 846	651.7 ± 124.2	356 - 846	582.7 ± 48.9	348 – 674
HL (mm)	143.4 ± 27.5	85 - 240	164 ± 41.7	85 - 240	135.9 ± 13.7	88 – 162
SnL (mm)	96.7 ± 21.2	60 - 173	112.5 ± 30.8	60 - 173	91 ± 11.9	62 - 121
W (kg)	0.82 ± 0.4	0.11 – 2.45	1.14 ± 0.6	0.11 – 2.45	0.70 ± 0.19	0.11 – 1.32
A (yr)	7.1 ± 2.1	1 - 14	6.8 ± 1.8	1 - 9	7.2 ± 2.2	2 - 14

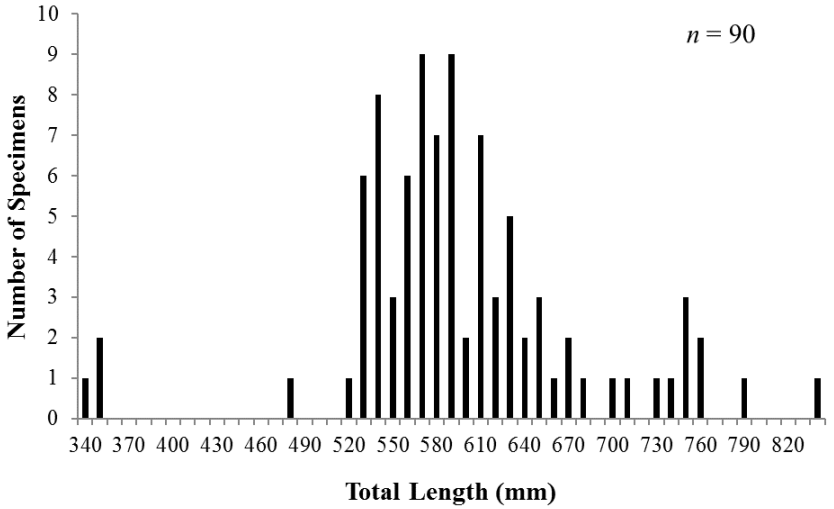

Figure 3.—Length-frequency (TL in mm) histogram for Spotted Gar captured from Lake Thunderbird during spring of 2014.

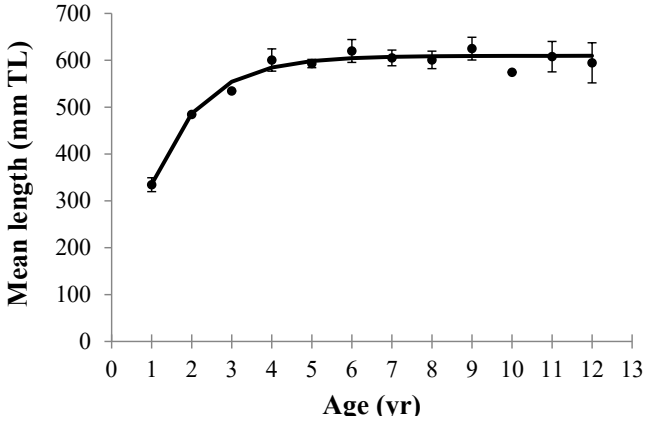

Figure 4.—Length and age for Spotted Gar collected from Lake Thunderbird during spring of 2014. The solid line represents the modeled von Bertalanffy growth curve. Error bars represent SE.

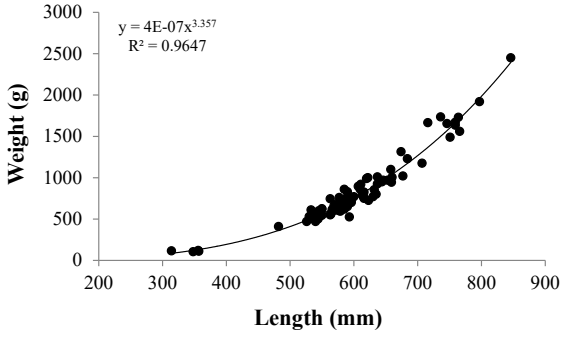

Figure 5.—Length-weight relationship for Spotted Gar captured from Lake Thunderbird during spring of 2014. The solid line represents the fit between L-W.

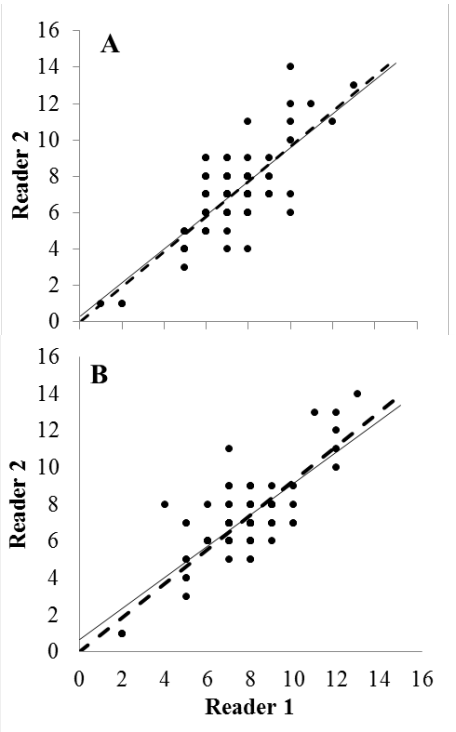

Figure 6.—Age bias plots between readers for (A) browned and (B) not browned sagittal otoliths of Spotted Gar from the Lake Thunderbird reservoir. The dashed line represents a 1:1 relationship between readers 1 and 2. Bias between readers is represented by the solid line.

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