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SHORT COMMUNICATION

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Age structure of juvenile Amur sturgeon *Acipenser schrenckii* and kaluga *Huso dauricus* in the Fuyuan reach of the Amur River, Northeast China

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Abstract

Amur sturgeon Acipenser schrenckiii Brandt 1869 and kaluga Huso dauricus (Georgi 1775) are critically endangered species with populations showing significant decline from historical levels due to overexploitation, yet little is known about their population structure. Adults are not often captured in the Fuyuan reach of the Amur River, Heilongjiang Province, Northeast China, and the government prioritizes juvenile sturgeon management. This study was conducted to determine the age and length/weight relationships of juvenile Amur sturgeon and kaluga in the Fuyuan reach of the Amur River. We estimated age using pectoral fin spine sections obtained from 65 juvenile Amur sturgeon and 50 juvenile kaluga. We compared the age estimates from two readers, and found 100% between-reader agreement in 67.7% of the Amur sturgeon and 64.0% of the kaluga. The majority of differences in estimated age were within 1 year. Length/weight relationships (LWR) were calculated, and the LWR of the Amur sturgeon and kaluga were W = 0.0025L3.106 (r^2 = 0.966) and W = 0.0022L3.175 (r^2 = 0.989), respectively. Our study provides the age structure and LWR in juveniles of two sturgeon species.

1 | INTRODUCTION

Amur sturgeon *Acipenser schrenckiii* Brandt 1869 is distributed in the Amur River, the Ussuri and Sungari River basins (Wei et al., 1997; Zhuang et al., 2002). and can also be found in coastal areas of Hokkaido, Japan (Omoto, Maebayashi, Hara, Adachi, & Yamauchi, 2004). In the middle reaches of the Amur River, male Amur sturgeon first spawn at 7–8 years and total length ~103 cm, and female Amur sturgeon first spawn at 9–10 years and total length ~105 cm (Zhang, 1985). Kaluga *Huso dauricus* (Georgi, 1775) is distributed in the Amur River basin and along the coastal areas of the Sea of Okhotsk, and in the Sea of Japan southward to Hokkaido Island (Andrey, Anastassia, & Joshua, 2007).. In the middle reaches of the Amur River, male kaluga first spawn at age greater than 12 years, and females first spawn at 16–17 years and ~224 cm (Zhang, 1985). The Amur sturgeon and kaluga historically supported commercial fisheries in the middle reaches of the Amur River, but over exploitation have significantly reduced their respective populations (Le & Chen, 1998). The most practical and widely-used technique for estimating sturgeon age is based on pectoral fin rays (Brennan & Cailliet, 1989; Koch, Steffensen, & Pegg, 2011). Earlier studies have reported the age of Amur sturgeon and kaluga (Nikolskii, 1960), but little is currently known about age of juvenile Amur sturgeon and kaluga in the Fuyan reach of the Amur River.

As we all known, the fish age determination is one of important research contents of fishery resources. Accurate age data are necessary for studying fish individual growth, population recruitment, and calculation of mortality. And the analysis of age structure of the population is also the basis for constructing the assessment model of fishery resources. Of course, due to unavailability of age selectivity information, in many age-based assessment models, the effect on fishing mortality based on age selectivity is considered as an interference parameter rather than a focus(Sampson, 2014), but ignoring age selectivity will bring bias for assessment of population structure and resources(Punt, Hurtado-Ferrof, & Whitten, 2014). At the same time, Body length and body weight are the basic biological characteristics of fish populations, which can reflect the physiological state of fish individuals and the changes in population structure and is also an important life history characteristic of fish adapting to environmental changes(Andersen, Jacobsen, & Farnsworth, 2015; Wootton, 1993). In addition, the relation between body length and body weight of fish is a very important one with respect to assessment of fishery resources, in which body length and body weight are often converted (Fei & Zhang, 1990). Therefore, studying the relation between body length and body weight is of great significance in assessment of fishery resources. In this setting, the study of the relation between the age composition and body length and weight of juvenile fish of amur sturgeon and kaluga can provide basic data for accurate assessment of resources status of the two fish species, and a scientific basis for further development of reasonable conservation and management measures of sturgeon. The objective of this study was to assess the age and the length/weight relationships of juvenile Amur sturgeon and kaluga in the Fuyuan reach of the middle reaches of the Amur River, Northeast China.

2 | MATERIALS AND METHODS

The study area was the Fuyuan reach of the middle reach of the Amur River (48°20′–48°22′N; 134°03′–134°25′E). Sixty-five Amur sturgeon and fifty kaluga were captured by drift gill nets from May 2015 to October 2017. Fish were weighed to the nearest 0.1 g, total length was measured to the nearest 1.0 mm. The pectoral fin spine was removed by cutting the ray at the articulation (Koch, Schreck, & Quist, 2008). The fin spine was placed in an envelope numbered for identification and allowed to air dry. And fin spines were cleaned of tissue residue and mounted in epoxy prior to sectioning (Koch & Quist, 2007). Embedded fin spines were sectioned with a PROXXON KG 50 low-speed saw (PROXXON, NO27150). Sections were photographed with a digital camera (OLYMPUS DP27) linked to a light microscope (OLYMPUS SZX7) and examined on a computer monitor. Fish age was estimated independently by two readers with substantial experience in aging fishes (>8 years and > 3 years). And spines were examined without knowledge of fish length, weight, or date of capture. Upon completion of initial aging, readers discussed differences in opinion regarding presumptive annuli to reach a consensus on age.

The LWR was expressed by the equation $W = aL^b$ (Ricker, 1973). Reader agreement was evaluated using an age bias plot, percent agreement, and the coefficient of variation (CV) The CV is expressed by the equation:

$$CV_j = 100 \times \frac{\sqrt{\sum_{i=1}^{R} \frac{(X_{ij}-X_j)^2}{R-1}}}{X_j}$$

where CV_j is the estimate of precision for the jth fish, R is the number of times each fish was aged, X_{ij} is the ith age assigned to the jth fish, and X_j is the average age assignment for the jth fish (Campana, Annand, & McMillan, 1995).

3 | RESULTS

3.1 | Age structure

Ages for 65 unsexed juvenile Amur sturgeon (TL 21.2–105.6 cm) and 50 unsexed juvenile kaluga (TL 22.8–86.1 cm) collected during the assessment, based on interpretation of pectoral fin ray sections, have ranged from 1to 10 years and 1 to 6 years, respectively(Tables 1 and 2).In Amur sturgeon 67.7% of the pectoral fin spine samples produced 100% agreement between readers, 26.2% of age estimates that differed by 1 year, 6.2% differed by 2 years. For Kaluga, 64.0% of the pectoral fin spine samples showed 100% age agreement between readers, 32.0% of estimates differed by one year, and 4.0% differed by 2 years. The age bias plot also showed that no significant disagreement between readers increased with estimated fish age.

3.2 | Length-weight relationship (LWR)

The LWR of the Amur sturgeon was $W = 0.0025L^{3.106}$ ($r^2 = 0.966$), and the LWR of kaluga was $W = 0.0022L^{3.175}$ ($r^2 = 0.989$) (Table 3).

4 | DISCUSSION

For the study of age structure of Amur sturgeon, the results in the present study were partial consistent with those results of Nikolskii's study (Nikolskii, 1960). The results of Nikolskii's study showed that the average total length of Amur sturgeon aged 1–3 years was less than that in this study, and the total length of Amur sturgeon of other age range was greater than that of Amur sturgeon with the same age in this study. Regarding the study of

TABLE 1 Length/weight relationships of Amur sturgeon and kaluga from the Fuyuan reach of the Amur River, Northeast China, 2015–2017

					Parameters of LWR				
Species	Stage	*n*	Total length range (cm)	Weight range (g)	*a*	A CL 95%	*b*	bCL9%	r^2
Acipenser schrenckiii	J	65	21.9–105.6	40.9–5407.9	0.0025	0.0014–0.0045	3.106	2.958–3.253	0.966
Huso dauricus	J	50	22.8–86.1	54.7–3327.5	0.0022	0.0016–0.0032	3.175	3.079–3.271	0.989

Note: J, juvenile; *n*, sample size; *a*, intercept; *b*, slope; r^2, coefficient of determination; CL, confidence interval.

TABLE 2 Age of Amur Sturgeon as estimated from annual increment counts on pectoral spines, number, mean length, and mean weight of Amur sturgeon sampled from the Fuyuan reach of the Amur River, 2015–2017

Age (years)	Number	Mean length ± *SD* (cm)	Mean weight ± *SD* (g)
1	4	23.3 ± 10.7	43.5 ± 2.2
2	5	32.6 ± 13.8	121.5 ± 13.8
3	15	42.1 ± 6.4	275.3 ± 14.2
4	20	52.0 ± 12.3	525.1 ± 30.5
5	9	64.9 ± 16.7	1,062.9 ± 88.3
6	7	73.9 ± 16.7	1753.3 ± 75.5
7	1	81.5	2,522.4
8	2	96.8 ± 5.5	3,487.5 ± 13.3
9	1	90.3	3,704.8
10	1	105.6	5,407.9

TABLE 3 Age as estimated from annual increment counts on pectoral spines, number, mean length, and mean weight of kaluga sampled from the Fuyuan reach of the Amur River, 2015–2017

Age (years)	Number	Mean length ± *SD* (cm)	Mean weight ± *SD* (g)
1	4	25.9 ± 15.4	70.6 ± 7.1
2	30	37.3 ± 13.1	232.3 ± 30.0
3	7	55.1 ± 21.1	644.4 ± 110.1
4	4	68.5 ± 37.4	1,190.5 ± 143.2
5	4	77.8 ± 14.8	2,320.6 ± 92.0
6	1	86.1	3,327.5

age structure of Kaluga, the results of Nikolskii's study showed that the average total length of Kaluga aged 1–2 years was less than that in this study, and the total length of Kaluga of other age range was greater than that of Kaluga with the same age in present study. The differences may be attributed to four aspects: (a) different sample sizes led to differences in statistical data; (b) the experience of observers was different, resulting in errors in age determination; (c) the growing environment was different, affecting the growth status of Amur sturgeon and Kaluga, for example the sampling time in Nikolskii's study was in 1915 and the location was at all basins of Amur River, but the sampling area in present study was only at the Fuyuan reach of Amur River; (d) The local government had carried out a certain number of proliferation and release with different scales in recent years, and the samples collected in this study may be partly derived from the cultured Amur sturgeon and Kaluga, and given the difference in availability and sufficiency of prey, the growth rate of these juveniles in the hatchery may be greater than that in natural waters.

As we all know, the analysis of age structure of the population is the basis for constructing assessment model of fishery resources, and accurate age data are necessary for studying fish individual growth, population recruitment, and calculation of mortality. In white sturgeon *Acipenser transmontanus*, the studies had shown the percent agreement between readers to vary from 17% to 37% (Brennan & Cailliet, 1989; Rien & Beamesderfer, 1994). We obtained between-reader agreement in age estimates higher (Amur sturgeon, 67.7% and Kaluga, 64.0%) than values reported in other sturgeon. Age estimation is challenging in older adult sturgeon, because of the close spacing of annuli near the edge of the pectoral fin spine (Nathan, et al., 2015), so the higher agreement may be attributable to our specimens being juveniles. In the present study, both sturgeon species presented higher CV between readers than the 1.8% in juvenile lake sturgeon *Acipenser fulvescens* (Balazik, McIninch, Garman, & Latour, 2012). The CV of Amur sturgeon was lower than the reported 13.6% in juvenile pallid sturgeon *Scaphirhynchus albus*, while the CV of kaluga was lower than that reported for juvenile pallid sturgeon *S. albus* (Koch et al., 2011). Many researchers suggest that a CV of 5% or lower is satisfactory for fish species of moderate longevity and reading complexity (Campana, 2001). In our study, the slightly higher CV was likely caused by false and unclear annuli. Poor readability of sturgeon fin spines may be attributed to stress associated with captive rearing and stocking, which can affect annulus deposition and create false annuli (Koch et al., 2011). The time of annulus formation was not determined in this study, although slower growth may occur during summer in other sturgeon species (Killgore et al., 2007).

After understanding the resources of Amur sturgeon and Kaluga in the Fuyuan reach, the local government can better develop management measures or determine the number of propagation and release. And the relation between length and body weight of fish is a very important one with respect to assessment of fishery resources, and in which body length and body weight are often converted, therefore, it is very necessary to fit this relation. This study determined the age and LWR in juvenile Amur sturgeon and kaluga in the Fuyuan reach. These results can be useful for understanding juvenile Amur sturgeon and kaluga population structure, and has valuable for sturgeon management of natural populations in the Fuyuan reach of the Amur River.

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