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TEMPERATURE AND DIET AS FACTORS IN THE EARLY LIFE STAGE DEVELOPMENT OF SHOVELNOSE STURGEON

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ABSTRACT

Shovelnose sturgeon (*Scaphirhyncus platorynchus*) (SNS) are prevalent in the Mississippi River Basin and commonly used as a surrogate species for the endangered pallid sturgeon (*Scaphirhyncus albus*). Information on growth and development of early life stages of these fish is scant. Therefore, we examined SNS embryo development, conducted a feeding study to 32 days post-fertilization (dpf) and a growth study to 74 dpf. Wild-caught SNS were artificially induced to spawn. Embryos were reared at nominal temperatures of 14, 16, 18, 20 and 22°C from fertilization until hatch. Time to discrete developmental stages was documented and τ_0 was measured. The feeding study began with 14 dpf larvae being fed one of three diets. Mortality was recorded daily and length and weight taken at the beginning and end of study. Times for τ_0 were: 103 min (at 14°C); 78 (16°C); 54 (18°C), 50 (20°C); and 47 (22°C). The number of days post-fertilization from beginning to end of hatch was: 11-13 (at 14°C); 7-10 (16°C); 5-8 (18°C), 4-6 (20°C); 3-4 (22°C). Fish fed the brine shrimp diet exhibited the lowest mortality (54.6%, ±27.3), followed by the daphnia diet (62.4%, ±22) and larvae on the formulated diet had the highest mortality (93.9%, ±11.6). The brine shrimp diet had the highest total weight gain (54.9 mg±38.8) followed by the daphnia diet (34.8±8.6) while fish fed on the commercial diet had the lowest weight gain (32.3±22.84). These studies provide developmental rates for estimating fertilization and hatch times at varying temperatures and indicate that further research needs to be directed at finding an optimal diet for early life stages of shovelnose sturgeon.

INTRODUCTION

SNS are an important native species found in the Mississippi River Basin. They are commonly utilized to provide caviar and meat to the seafood industry. Also, due to their relative abundance they are used in both ecological and toxicological studies as a surrogate species to the pallid sturgeon. Information on other commercially viable species of sturgeon is well published, but detailed culture and early life stage history information on SNS is not well documented. We examined the early life stages of the sturgeon to document the development of embryos at various temperatures and experimented to find a suitable diet that promotes optimal survival and growth. In this study our objectives were 1) determine the τ_0 values at various temperatures with τ_0 = to the interval between the onset of the 1st and 2nd or 2nd and 3rd cleavage divisions. This value is used as a unit for measuring the relative duration of various embryo and juvenile developmental periods (Detlaff et al. 1993) (τ_0 experiment) 2) determine the approximate start and end of egg hatching at various temperatures (time to hatch experiment) 3) feed various diets to see which provides optimal survival and growth (feeding experiment) 4) determine length and weight values of known-age juveniles over an extended time period (growth experiment). The data generated from these experiments can be used as a valuable management tool by allowing back-calculation to natural spawning. Also, this will provide important culture information useful to hatchery managers and toxicologists.


Embryo showing 1st mitotic division


Developing embryo


Developing embryo prior to hatch

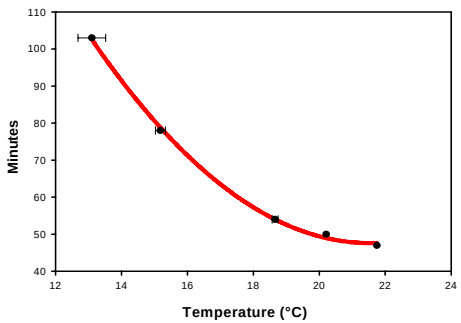
MATERIALS AND METHODS

Wild SNS were caught in the Missouri River and artificially induced to spawn with LHRHa. For the τ_0 and time to hatch experiments, oocytes were aliquoted into beakers and gradually acclimated to the specific temperature for 15 minutes, fertilized, transferred to Petri dishes and then reared at nominal temperatures of 14, 16, 18, 20, and 22 in water baths, and intensely monitored until end of hatch. The feeding experiment began with 14 dpf larvae stocked 30 fish per tank (6.5L) with 8 replicates per treatment in a 16.5L/hour flow-through well water system with a mean temperature of 19.0°C. Dissolved oxygen levels were maintained above 8.0 ppm throughout the study. Fish were fed one of three diets – live and frozen artemia, live daphnia and frozen bloodworms, or formulated Oregon Biodiet 2-3 times a day for 18 days. Food amounts were adjusted daily, based on food consumption. Tanks were cleaned of excess food and mortalities were recorded once a day. Length and weight measurements were collected prior to 1st feeding and at final takedown. The growth experiment used data collected from the feeding study until 32 dpf, then continued growout of larvae in 2 tanks for both the artemia and daphnia treatments until 74 dpf recording lengths and weights but not mortalities, every 7 days.

RESULTS

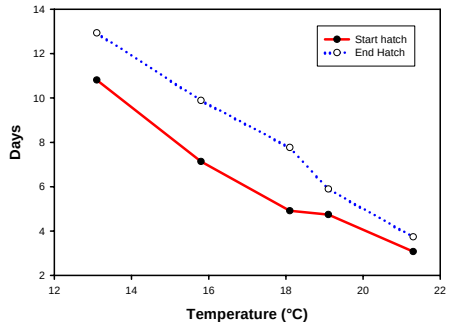
τ_0 experiment

τ_0 values for sturgeon embryos at different temperatures ±SD



Time to hatch experiment

Approximate beginning and end of hatch for SNS embryos reared at different temperatures.



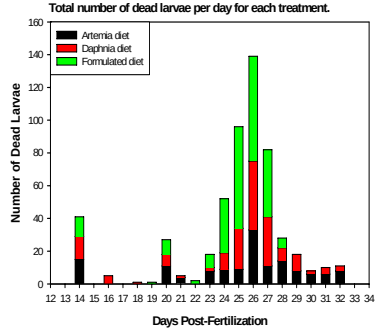
Feeding experiment

Mortality and growth of sturgeon larvae fed three different diets for 18 days at 19.0 ±.5°C (n=8).

Treatment	% Mortality mean ±SD	Total length gain (mm) mean ±SD	Total weight gain (mg) mean ±SD
Artemia	54.6±27.3a	7.9±5.6a	54.9±38.8a
Daphnia	62.4±22.0b	4.2±3.0b	34.8±8.6
Formulated	93.9±11.6c	7.2±5.1a	32.3±22.8

Values with different letters denotes significant difference at 95% CI

Total number of dead larvae per day for each treatment.



Growth experiment

Length and weight data for growth study comparing the artemia and daphnia diets.

DPF	TREATMENT	# FISH	LENGTH (mm) mean±SD	RANGE (mm)	WEIGHT (mg) mean ±SD	RANGE (mg)	MEAN TEMP
14	Artemia diet	14	18.4 ± 0.4	17.5 - 19.0	24.5 ±1.0	12.8 - 26.3	18.2 ±0.3
	Daphnia diet	13	17.9 ± 0.6	17.0 - 19.0	22.5 ±1.9	19.6 - 23.9	
19	Artemia diet	8	20.7 ± 1.1	19.5 - 23.0	34.5 ± 7.3	26.0 - 49.8	18.2 ± 0.3
	Daphnia diet	8	19.1 ± 0.7	18.0 - 20.0	24.5 ± 3.5	18.2 - 27.9	
26	Artemia diet	8	22.4 ± 2.5	20.0 - 26.0	56.0 ± 20.0	35.8 - 90.4	18.3 ± 0.4
	Daphnia diet	8	21.1 ± 0.7	20.0 - 22.0	43.7 ± 7.8	36.2 - 61.0	
32	Artemia diet	43	26.3 ± 4.3	19.5 - 36.5	79.4 ± 42.5	23.8 - 212.6	18.4 ± 0.5
	Daphnia diet	53	22.1 ± 2.3	18.0 - 26.5	57.3 ± 38.8	22.2 - 269.1	
39	Artemia diet	10	33.0 ± 5.3	26.5 - 40.0	115.6 ± 48.1	53.8 - 189.7	18.6 ± 0.8
	Daphnia diet	10	30.7 ± 4.4	23.5 - 28.0	108.1 ± 44.1	40.3 - 183.6	
46	Artemia diet	10	34.5 ± 7.7	22.0 - 46.0	165.1 ± 70.3	62.3 - 281.1	19.1 ± 1.3
	Daphnia diet	10	34.3 ± 8.1	25.0 - 47.0	155.5 ± 81.7	73.1 - 319.6	
53	Artemia diet	10	44.5 ± 5.7	31.0 - 51.0	272.9 ± 71.8	139.7 - 365.1	19.2 ± 1.3
	Daphnia diet	10	41.9 ± 10.4	26.0 - 53.5	226.1 ± 140.0	47.9 - 436.5	
60	Artemia diet	10	54.7 ± 6.0	42.0 - 62.0	415.5 ± 104.1	214.8 - 580.5	19.3 ± 1.4
	Daphnia diet	10	48.4 ± 9.7	36.0 - 60.0	327.8 ± 149.7	122.9 - 538.4	
67	Artemia diet	10	58.5 ± 8.0	43.5 - 67.5	495.4 ± 124.3	251.8 - 655.6	19.3 ± 1.4
	Daphnia diet	10	52.3 ± 9.2	40.0 - 65.0	443.8 ± 182.3	202.3 - 688.1	
74	Artemia diet	10	62.4 ± 9.0	41.0 - 73.0	536.0 ± 140.9	209.5 - 711.8	19.4 ± 1.4
	Daphnia diet	10	55.8 ± 14.3	27.0 - 73.5	484.2 ± 234.1	89.3 - 787.9	

DISCUSSIONS AND CONCLUSIONS

➢**τ_0 and time to hatch measures were greatly reduced at temperatures below 18°C.** These values are longer than what has been reported for other species of sturgeon by Detlaff et al. 1993 but concordant with reported optimal spawning temperatures for SNS which are 16.9 – 20.5°C (Keenlyne 1997).

➢**SNS larvae fed artemia had the lowest mortality and greatest growth.** The majority of these larvae had expelled melanin yolk plugs and actively fed at least 2 days earlier than those in other treatments. A large percentage of mortalities in the artemia treatment did not appear to be caused by starvation, but instead from intestinal hemorrhage. The exact cause of the hemorrhage was not determined, but possible causes include bacterial infection, incompatible food size or a nutritionally deficient diet.

➢**The formulated diet alone does not appear to be a suitable diet for SNS based on mortality.** Visual observations showed that larvae didn't consume the formulated diet. The point-of-no return for SNS larvae appears to be between 23 to 28 dpf at 19°C

➢**Bloodworms may have triggered a feeding reaction in the larvae (olfactory?).** Initially, the daphnia treatment did not receive bloodworms. However, time of first feeding of larvae fed daphnia lagged behind those fed artemia. Previously, we had observed that SNS larvae actively fed on daphnia when they were offered along with bloodworms. Thus, 2 days after larvae began eating artemia we subsequently modified the daphnia diet by adding bloodworms and surprisingly the larvae commenced feeding on the daphnia.

➢**Further research is needed to find an optimal diet for SNS larvae, however it appears that some combination of the diets tested would provide the best survival and growth.**


Newly hatched SNS larvae.


Ventral view of 17 dpf larvae showing presence of artemia in the intestinal tract.


Larvae culture tanks


Formation of yolk plug


Yolk plug prior to extrusion


Extruded yolk plug

BIBLIOGRAPHY

Detlaff, T.A., Ginsburg, A. S. and Schmalhausen, O. I. 1993. Sturgeon Fishes. Developmental Biology and Aquaculture. Berlin: Springer-Verlag.

Keenlyne, K.D. 1997. Life history and status of the shovelnose sturgeon, *Scaphirhynchus platorynchus*. Env. Biol. Fish. 48: 291-298.

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