Comparison of continuous and discontinuous feeding regimens on the growth and survival of larval and early juvenile Atlantic sturgeon (*Acipenser oxyrhynchus*) under hatchery conditions

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Sturgeons are one of the most valuable groups of species known for their high value caviar as well as their meat. Due to overfishing and drastic habitat changes during the last century, it is now believed that sturgeons are more critically endangered than any other group of species (Beamesderfer and Farr, 1997). Yet, the demand for caviar (and to some extent the meat) is high and most likely will become higher as stocks are continued to be fished legally and illegally. The high demand for sturgeons coupled with the declining stocks points to the paramount importance of the sturgeon aquaculture to fulfill the high market demand as well as a mean to preserve the stocks. Yet, the sturgeon aquaculture only started to develop a few years ago as reviewed by Bronzi *et al*. (2011). In Atlantic Canada, due to the presence of two native species of sturgeon namely shortnose sturgeon (*A. brevirostrum*) and Atlantic sturgeon (*A. oxyrhynchus*), there is a great potential for sturgeon aquaculture. Acadian Sturgeon and Caviar Inc. is developing aquaculture practice for both of these species.

The commencement of the exogenous feeding is one of the critical stages in aquaculture of many farmed species including sturgeons. In our hatchery, the routine feeding practice for larval rearing of Atlantic sturgeon involves a mixture of newly hatched *Artemia* nauplii and dry food delivered manually at intervals of two hours from 7 AM to 9 PM. This tedious and labor intensive practice is adapted to keep both live and dry feed available for the growing larvae during day time and part of the evening. However, this practice cannot be extended throughout evening due to labor cost. To improve the larval feeding technology and thus the outcome of our hatchery practice, we applied for and were granted a research fund to

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modify an automatic feeding device to continuously deliver both live and dry food to larval sturgeons. This paper reports the outcome of the preliminary application of an automatic feed distribution system modified to deliver live feed in our hatchery.

A 6-week trail was conducted during Aug. to Sept. 2011 to investigate the effect of continuous automatic feeding versus the discontinuous manual feeding on the growth and survival of the Atlantic sturgeon under a practical hatchery environment. Fertilized eggs were obtained by artificial propagation using brood stocks caught from the Saint John River, New Brunswick, Canada. At 6 to 8 days posthatching, thirty thousand larvae of 11.3±0.52 mm (standard length±SD as described by Hardy and Litvak, 2004) were distributed randomly among 6 circular tanks (5000 larvae per tank) each containing about 250-L of water to provide the stocking density of 20 larvae L^{-1}. All tanks used a flow-through system and contained central standpipe that were screened to prevent escaping. Tank culture conditions during the course of the trial were as follows: flow=3 L/min/tank; temp 12.5-17.5°C (seasonal); dissolved oxygen=8.95-10.42mgL^{-1}. Two treatments, Automatic and Manual were assigned (each with three replicates). Automatic treatment consisted of delivery of both newly hatched *Artemia* and dry food. The *Artemia* was delivered for 10 minutes at 12 evenly spaced times/day via a modified automatic feeding device (Department of Fisheries, Western Australia). Likewise, the dry feed (Gemma Weam 0.2 and 0.3, Skretting) was delivered by the automatic feeding device every 2 hours (12 feeding per 24 hours). The feeding schedule was adjusted to deliver the dry feed 15 min prior to the live feed feeding. The Manual treatment consisted of feeding newly hatched *Artemia* and dry feed from 7 AM to 9 PM at 2 hours interval. Since a flow through system was deployed in this study and some *Artemia* and the dry feed were lost from the system, the amount of *Artemia* and the dry feed were not measured. However, the same amounts (per day) of both *Artemia* and the dry food were applied to both treatments.

Samples of 30 larvae/early juveniles were taken from each tank weekly for 6 weeks to determine the length of the larvae. Dead larvae/early juveniles (counted), uneaten food and fecal maters were removed from all the tanks daily as part of our routine operation. The effects of the treatments on the length (measured as standard length or SL) and survival for each sampling date were analyzed by the two-tailed Student *t*- test (p<0.05) using SPSS version 19. To ensure normal distribution, the data on percent survival were arcsine-square root transformed prior to analysis (Zar 1974).

Table 1 shows the percent survival and changes in SL of the larvae and early juveniles during the course of the experiment. Although no significant difference in SL was observed during the experiment, the larvae and early juveniles

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under the Automatic treatment had higher SL at the end of the trial. Survival was not significantly different during he first 4 week, however, was significantly higher under the Automatic treatment for the final two weeks of the trail.

Table 1: Effect of discontinuous and continuous feeding on survival and mean standard length of larval and early juvenile Atlantic sturgeon (A.oxyrhynchus) under hatchery condition during 6 weeks of rearing. Data are based on mean (± SD) of triplicate tanks for each treatment. Mean values bearing different superscripts in a column differ significantly *(p*<0.05).

	Week1		Week 2		Week 3		Week 4		Week 5		Week 6	
	% Survival	Length (mm)	% Survival	Length (mm)	% Survival	Length (mm)	% Survival	Length (mm)	% Survival	Length (mm)	% Survival	Length (mm)
Manual feeding (discontinuous)	99.1±0.40	^{a}13.6±0.29	^{a}96.4±1.01	^{a}15.0±0.50	82.7±2.64	^{a}15.8±0.74	79.4±1.57	^{a}19.4±0.58	65.9±3.10	^{a}21.1±1.03	^{a}60.0±6.62	^{a}21.3±0.97
Automatic feeding (continuous)	^{a}99.6±0.21	^{a}13.9±0.60	^{a}95.3±1.78	^{a}14.5±0.08	^{a}86.6±2.76	^{a}16.1±0.78	^{a}80.8±1.64	^{a}20.2±1.94	^{b}76.2±1.87	^{a}24.1±3.56	^{b}73.9±2.60	^{a}25.1±3.22

Literature is quite limited on larval and early juvenile rearing of the Atlantic sturgeon. To the best of our knowledge, this is the first report on comparing continuous live feed delivery using an automatic feeding system and discontinuous manual feeding in the larviculture of the Atlantic sturgeon in terms of growth and survival in a commercial hatchery operation. Significantly higher survival and growth for Automatic treatment during the last two weeks of this study point to the importance of the continuous presence of the food for the growing larvae and early juveniles. The only other dietary work on growth and survival of first-feeding larval Atlantic sturgeon was conducted by Mohler *et al*., (2000) who reported more than 90% survival in a 26 day trial when the larvae were continuously fed on *Artemia* nauplii. However, no comparison was made with manual discontinuous feeding in their work. Their higher survival rate may stem from shorter duration of their trail (26 day), temperature and stock related differences. Studies on larval and early juvenile nutrition of other sturgeons also point to the effectiveness of the continuous feeding during sturgeon early life histories (Ware *et al*., 2006).

In conclusion, this study provides the first comparison between the continuous and discontinuous feeding during the early

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life stages of the Atlantic sturgeon under a commercial hatchery environment and supports the notion of the importance of the continuous feeding during larval and early juvenile stages of Atlantic sturgeon. Further improvement on the automatic system based on the feeding rate and the frequency of feeding can further improve the outcome of the seed production in the sturgeon larviculture under practical hatchery condition.

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