Int Aquat Res (2010) 2: 113-119
ISSN 2008-4935
Available online at www.intelaquares.com

International
Aquatic Research

Effect of water temperature on the timing of initial feeding of Persian sturgeon *Acipenser persicus* larvae

Afshin Ghelichi[1*], Nourmohammad Makhdoomi[2], Sarah Jorjani[1], Ali Taheri[2]

[1]*Department of fisheries, Islamic Azad University- Azadshahr Branch, Azadshahr, Iran*
[2]*Shahid Marjani Sturgeon Culture Center, Golestan province, Iran*

Received: 7 October 2009; Accepted: 28 July 2010

Abstract

The initial feeding time for fish larvae is considered a critical period because it influences their subsequent survival and growth.This study was carried out to elucidate the effects of water temperature on initial feeding of Persian sturgeon *Acipenser persicus* larvae.The larvae were stocked in three large circular fiberglass tanks that were supplied with 16 ± 4 l /min/tank of water at 3 different temperatures (15, 16 and 17 °C).The effect of the first feeding on the growth was tested by providing feed beginning on day 9 and was continued on days 10, 11, 12, 13 and 14 post hatch.The larvae were fed on newly hatched Artemia nauplii at 50% body weight/day.Thirty fish larvae were randomly sampled from each experimental tank on day 8 every 4 hours to determine gut content and the presence of melanin plug in the hindgut.However, exogenous feeding occurred in our study on days 12, 11 and 9 post hatch at 15, 16 and 17 °C, respectively.Food in larval stomachs was observed at the same time that melanin plug was present in the hindgut. Therefore the expulsion of melanin plug can not really be used to determine the time of transition to active feeding. These results confirmed that temperature affected timing of digestive tract development of fish larvae and food should be offered to sturgeon larvae when the gut gets ready for food absorption anatomically and physiologically.

Keywords: Water temperature, Timing of initial feeding, Persian sturgeon, *Acipenser persicus*

Introduction

Sturgeons (Acipenseriformes) are one of the most ancient groups of the Chondrosteii, with 27 species distributed in the temperate waters of the Northern Hemisphere, Eurasia and North America (Birstein 1993). The high value of the caviar produced from sturgeon eggs has precipitated over-fishing by both commercial fishers, poachers and sport fishers have contributed to the collapse of a number of stocks, particularly in the Caspian Sea (Rosenthal et al. 1999). However, many conservation programs now include restocking as a means to rebuild sturgeon population.

The initial feeding time for fish larvae is considered a critical period because it influences their subsequent survival and growth. Short period of food deprivation after yolk absorption can result in abnormal behavioral and morphological development, degeneration of the alimentary tract and trunk musculature, and reduction in food utilization efficiency and feeding activity (Heming et al. 1982). Unsuitable management, such as inadequate feed quantity and quality, periods of food deprivation after yolk sac absorption and excessive stocking density can result

* Corresponding author. Email: afshin_ghelichi@yahoo.com. Tel: +98-911-171 8698, Fax: +98-174-673 4601.

in a high level of cannibalism (Gisbert et al. 2000). Consequently, exogenous feeding is normally very important, especially in fish cultured where food availability can be manipulated.

Sturgeon larvae production is considered to be one of the most difficult phases of hatchery rearing. Under artificial conditions, once larvae hatch from the egg and deplete their intraembryonic yolk sac reserves, their survival depend on multiple factors, such as the nutritional input, rearing system design and hatchery management (Conte et al. 1988). Such adaptations alter the relationship of the developing fish with the environment (Dettlaff et al. 1993). This information would be useful to fish farmers for estimating fingerling production, to improve rearing techniques and for hatchery management and evaluation of the quality of fish produced (Krasnodembskaya 1993).

There is a considerable difference of opinion among fish culturists as to when fry should receive their initial feeding (Heming et al. 1982; Piper et al. 1983). It is generally recommended that food should be offered to fish larvae when they attain feeding ability, i.e., when fry exhibited a swim-up behavior (Twongo and MacCrimmon 1976; Piper et al. 1983; Koss and Bromage 1990). Furthermore, it has been reported that higher mortality occurs in brook trout (*Salvelinus fontinalis*) fed early as compared to those deprived of food for up to 5 days after swim-up (Piper et al. 1983; Koss and Bromage 1990). Nevertheless, fish culturist generally start feeding when 50% of fry are at swim-up stage because if fry are denied food much beyond yolk-sac absorption, some will never begin to feed (Piper et al. 1983; Kamler 1992). Environmental factors such as temperature, water quality, food abundance can directly affect the behavior of fishes hold in artificial conditions (Piper et al. 1983; Richmond and Kynard 1995). The specific behavior, such as swimming-up or melanin ejection can be used as an indicator of when to start feeding larvae (Gisbert and Williot 1997).

Feeding rate, water temperature, and fish size are the three most important factors on the growth of fish (Brett 1979). Water temperature has long been recognized as a key environmental factor controlling the metabolism, growth, and reproduction of fishes and other aquatic ectotherms (Deng et al. 2003). Thus determining the optimal water temperature is important to the success of any aquaculture operation. There is little information on the effect of temperature on initiation of the first feeding of sturgeon larvae growth. The objective of present study was to examine the effect of different water temperatures on the timing of first feeding of Persian sturgeon *A. persicus* larvae.

Materials and methods

The experiment was conducted in Shahid Marjani Sturgeon Culture Center, Iran. Persian sturgeon larvae were obtained by induced spawning of 14 females in 3 periods of time which had been injected intramuscularly with sturgeon pituitary and fertilized with milt from 10 injected males. After 5-6 days, the larvae were hatched.

First, second and third treatment groups of larvae were examined at 3 different temperatures including 15, 16 and 17 °C. The larvae were stocked in 3 circular fiberglass tanks (1.75 m diameter, 0.5 m water depth, 880 L volume). Each tank was supplied with 16 ± 4 l/min of aerated freshwater. The main water source was one of the streams of Gorgan River. The tanks were kept under an artificial 24 h indoor light of hatchery saloon. During the experimental period, dissolved oxygen and pH were routinely monitored. The pH varied in the range of 7.9-8.3 and dissolved oxygen content was higher than 7.5 mg/l.

Larvae stocked in each tank was at a density of 17 larvae/l (1500 larvae/tank). Initial larval weight and total length were 19.4 ± 1.6 mg and 11.5 ± 0.6 mm, respectively. Each experimental treatment group contained three replicate tanks. Except for the water temperature, the experimental conditions and diet used in this study were similar.

The larvae were fed by newly hatched Artemia nauplii (*Artemia urmiana*) every 4 hours at 50% body weight at the density of 1128 ± 317 nauplii/l. Tanks were cleaned four times daily to remove uneaten food and dead larvae. Effect of water temperatures on the timing of initial feeding was tested by providing feed from day 9 and was continued on days 10, 11, 12, 13 and 14 post hatch at different temperatures. Thirty larvae were randomly sampled from each experimental tank on day 9 every 4 hours at the time of feeding to determine gut content and the presence of melanin plug in the hindgut. After observing the digestive tracts, the larvae were divided into the following four groups: 1) Fed larvae with melanin plug, 2) Unfed larvae with melanin plug, 3) Fed larvae without melanin plug, and 4) Unfed larvae without melanin plug.

The larvae in each group were counted and given as percentage. Mean was given with standard error of mean (± SEM) and were compared using one-way analysis of variance (ANOVA) followed by Duncan's multiple comparison test at $P < 0.05$ by SPSS 16.

Results

First treatment group (t = 15 ºC)

Fed larvae with melanin plug showed that their number at 13d post hatch was more than their number at 12 and 14 d post hatch days ($P < 0.05$) (Fig. 1A). Unfed larvae with melanin plug indicated that their number was highest on 12 d post hatch, compared with their number of larvae at 13 and 14 d post hatch ($P < 0.05$) (Fig. 1B). Fed larvae without melanin plug exhibited the opposite result in comparison with the former one, i.e. their number on 14 d post hatch was higher than their number at 12d post hatch ($P < 0.05$) (Fig. 1C). For unfed larvae without melanin plug, the number of larvae at 13 d post hatch was higher than their number on the other days ($P < 0.05$) (Fig. 1D).

Second treatment group (t = 16 ºC)

Fed larvae with melanin plug had their number at 13 d post hatch greater than their number at 12 and 11 d post hatch ($P< 0.05$) (Fig. 2A). Unfed larvae with melanin plug showed the increased number of larvae at day 11 post hatch, which was greater than days 12 and 13 post hatch ($P< 0.05$) (Fig. 2B). For fed larvae without melanin plug, the higher number of larvae at 13 d post hatch was observed than 12 and 11 d post hatch ($P< 0.05$) (Fig. 2C). There was no significant difference in larvae number at 11, 12 and 13 d post hatch for unfed larvae without melanin plug ($P > 0.05$) (Fig. 2D).

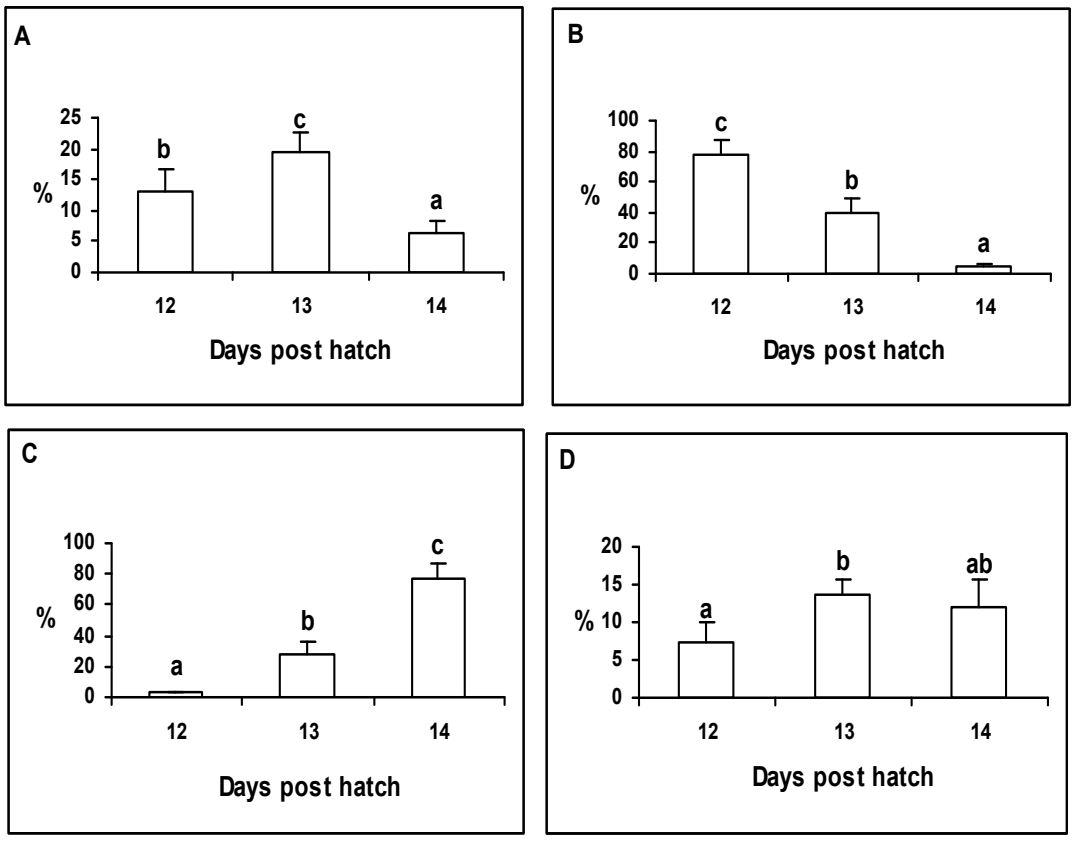

Fig. 1. Number of the Persian sturgeon larvae in each group as percentage at 15 ºC. A. Fed larvae with melanin plug, B. Unfed larvae with melanin plug, C. Fed larvae without melanin plug, D. Unfed larvae without melanin plug. Bar represent the standard deviation (n= 30). Same small letters on the bar indicate no significant difference ($P > 0.05$).

Third treatment group (t = 17 ºC)

There was not a significant difference in the number of larvae at 10 and 11 d post hatch for fed larvae with melanin plug (Fig. 3A). Unfed larvae with melanin plug exhibited greater number of larvae at 10 d post hatch rather than 11

d post hatch ($P < 0.05$) (Fig. 3B). Fed larvae without melanin plug showed an adverse result with former one. The number of larvae at 11 d post hatch was higher than their number at 10 d post hatch ($P < 0.05$) (Fig. 3C). Unfed larvae without melanin plug did not show a significant difference in their numbers at 10 and 11 d post hatch (Fig. 3D).

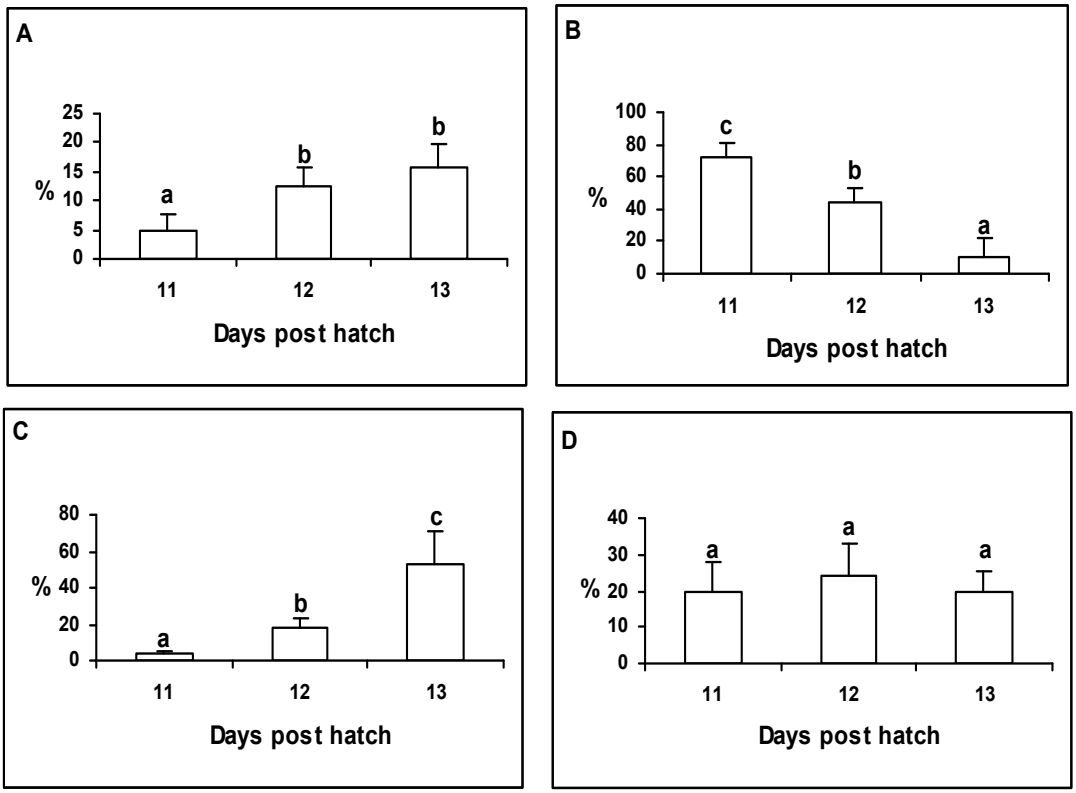

Fig. 2. Number of the Persian sturgeon larvae in each group as percentage at 16 ºC. A. Fed larvae with melanin plug, B. Unfed larvae with melanin plug, C. Fed larvae without melanin plug, D. Unfed larvae without melanin plug. Bar represent the standard deviation (n= 30). Same small letters on the bar indicate no significant difference ($P > 0.05$).

Discussion

An important aspect of larval rearing for commercial aquaculture is to determine the exogenous initial feeding time, which is considered as one of the most critical periods during larval rearing. The delays in food availability may result in various degrees of food limited fish larvae, influencing their subsequent growth and survival. According to the results, the onset of exogenous initial feeding depends on water temperature.

Traditionally, hatchery produced sturgeon larvae and fingerlings were raised on live food organisms, e.g. oligochaetes (*Enchytraeus* and *Tubifex*) and zooplanktonic organisms, such as Daphnia or *Artemia salina* (Monaco et al. 1981; Buddington and Doroshov 1984; Dabrowski et al. 1985). In this study, *Artemia urmiana* was used for feeding of larvae.

Several factors are known to be associated with the effect of temperature on fish growth (Hung et al. 1993). These include dissolved oxygen (Brett 1979), maximum feed intake (Brett and Higgs 1970; Nimi and Beamish 1974), and level of feed intake required for maintenance (Brett 1979). For other sturgeon species, when larvae begin to feed, they possess an anatomically complete and functional digestive tract with a high degree of morphological organization, which allows them to be fed directly on artificial diets. Temperature affects timing of digestive tract development of fish larvae. The onset of exogenous feeding in this study was observed on days 12, 11 and 9 post hatch at 15, 16 and 17 °C, respectively. These results confirm the importance of the initial feeding time and suggest

that food should be offered to sturgeon larvae when the gut gets ready for food absorption anatomically and physiologically. Our results showed that the timing of first feeding of Persian sturgeon larvae is quite close to that reported for *A. transmontanus*, which varied from 8 to 11 days post-hatch at 16-18 °C (Doroshov et al. 1983), 12 days post-hatch between at 15 and 17 °C for *A. transmontanus* (Gawlicka et al. 1995) and for *A. baerii* that occurs at between 9 and 11 days post-hatching at 18 °C (Gisbert and Williot 2002).

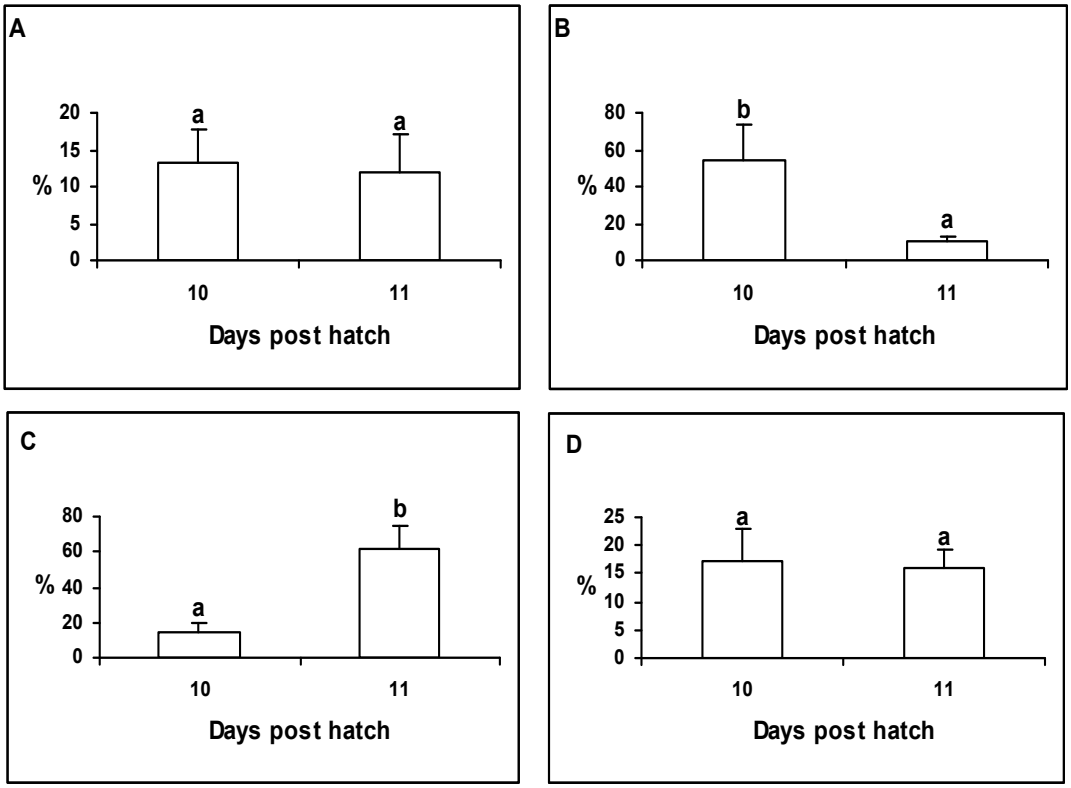

Fig. 3. Number of the Persian sturgeon larvae in each group as percentage at 17 ºC. A. Fed larvae with melanin plug, B. Unfed larvae with melanin plug, C. Fed larvae without melanin plug, D. Unfed larvae without melanin plug. Bar represent the standard deviation (n= 30). Same small letters on the bar indicate no significant difference ($P > 0.05$).

First feeding in Persian sturgeon larvae is related to the expulsion of the melanin plug, which is eliminated after first feeding with the first feces that it is in agreement with the findings of Gisbert and Williot (1997) for *A. baerii*. In contrast, the end of the endogenous feeding phase is considered to occur in *A. transmontanus* and *A. gueldenstaedti* larvae with the extrusion of the melanin plug (Monaco et al. 1981; Dettlaff et al. 1993; Gawlicka et al. 1995). Buddington and Dettlaff et al. (1993) pointed out that the pigment plug in the spiral valve is eliminated just prior to oral feeding in *A. transmontanus* and *A. gueldenstaedti*. Moreover, Dettlaff et al. (1993) noted that pigment plug ejection could provide a practical guideline to determine the onset of exogenous feeding in *A. gueldenstaedti*. However, in Persian sturgeon, the extrusion of melanin plug can not readily be used as a criterion to determine the timing of the transition to active feeding. Present results showed that the onset of exogenous feeding time for Persian sturgeon larvae also corresponded with apparent depletion of yolk sac reserves. Results suggest that precautionary first feeding sturgeon larvae before the completion of yolk sac resorption during the phase of transition between yolk sac nutrition to external feeding recommended for white sturgeon larvae (Conte et al. 1988) do not provide any advantage. Yolk absorption could be a useful visual guide to determine the best time to offer sturgeon larvae for their first diets and it is used commonly in other species such as salmonids (Piper et al. 1983).

The end of the endogenous feeding stage takes place with the macroscopically depletion of yolk sac. At the microscopically level, the resorption of a yolk mass separates the esophagus and the cardiac stomach. Earlier food

distribution before the completion of yolk sac reserves did not provide any advantage to larvae. The expulsion of melanin plug can not really be used as a criterion to determine the best time for first feeding larvae, as it seems the consequence of first feeding.

Present findings showed that the simultaneous presence of food particles and melanin plug in the alimentary canal, and confirm that the melanin plug is ejected from the spiral valve just after first feeding with first excretion. According to Gisbert et al. (1998) and present results, the expulsion of melanin plug seems not to be an appropriate visual criterion to commencement of feeding in Persian sturgeon. Temperature affects timing of digestive tract development of fish larvae.

In conclusion, at higher temperatures Persian sturgeon larvae feeding starts earlier. Therefore, larvae feeding should be done depending on the temperature and the expulsion of melanin plug is not a suitable index to start larvae nutrition.

Acknowledgements

We thank the staff at the Shahid Marjani Sturgeon Culture Center who assisted with this project. This work was supported by Islamic Azad University- Azadshahr Branch.

References

Birstein VJ. 1993. Sturgeon and paddlefishes: threatened fishes in need of conservation. Cons Biol 7: 773-787.

Brett JR. 1979. Environmental factors and growth. In: Hoar WS, Randall DJ, Brett JR (Eds), Fish Physiology. Bioenergetics and Growth, vol. VIII. Academic Press, New York, pp. 599-675.

Brett JR, Higgs DA. 1970. Effect of temperature on the rate of gastric digestion in fingerling sockeye salmon (*Oncorhynchus nerka*. J Fish Res Board Can 27: 1767-1779.

Buddington RK, Doroshov SI. 1984. Feeding trials with hatchery produced white sturgeon (*Acipenser trasmontanus*). Aquaculture 36: 237-243.

Buddington RK, Doroshov SI. 1985. Digestive and feeding characteristics of the chondrosteans. Environ Biol Fish 14: 31-41.

Conte F, Doroshov SI, Lutes B, Strange EM. 1988. Hatchery manual for the white sturgeon with application to other north American *Acipenseridae.,* Department of Animal Science, University of California.

Dabrowski K, Kaushik SJ, Fauconneau B. 1985. Rearing of sturgeon (*Acipenser baeri*, Brandt) larvae I. feeding trial. Aquaculture 47: 185-192.

Deng Df, Koshio S, Yokoyama S, Bai SC, Shao Q, Cui Y, Hung SSO. 2003. Effect of feeding rate on growth performance of white sturgeon (*Acipenser transmontanus*) larvae. Aquaculture 217: 589-598.

Dettlaff TA, Ginsburg AS, Schmalhausen OE. 1993. Sturgeon Fishes. Springer-Verlag. 300pp.

Doroshov SI, Clark WHJ, Lutes PB, Swallow RL, Beer KE, McGuire AB, Cochran MD. 1983. Artificial propagation of the white sturgeon (*Acipenser transmontanus*). Aquaculture 32: 93-104.

Gawlicka A, Teh SJ, Hung SSO, Hinton DE, de la Noue J. 1995. Histological and histochemical changes in the digestive tract of white sturgeon larvae during ontogeny. J Fish Physiol Biochem 14: 357-371.

Gisbert E, Williot P. 1997. Larval behavior and effect of the timing of initial feeding on growth and survival of Siberian Sturgeon (*Acipenser baeri*) larvae under small scale hatchery production. Aquaculture 156: 63-76.

Gisbert E, Williot P. 2002. Advances in the larval rearing of Siberian Sturgeon. J Fish Biol 60: 1071-1077.

Gisbert E, Williot P, Castello-Ovary F. 2000. Influence of egg size on growth and survival of Siberian sturgeon (*Acipenser baeri*) under small scale hatchery condition. Aquaculture 183: 83-94.

Gisbert E, Rodriguez A, Castello-Ovary F, Willot P. 1998. Histological study of the development of the digestive tract of Siberian Sturgeon (*Acipenser baeri*) during early ontogeny. Aquaculture 167: 195-209.

Hung SSO, Lutes PB, Shqueir AA and Conte FS. 1993. Effect of feeding rate and water temperature on growth of juvenile white sturgeon (*Acipenser trasmontanus*). Aquaculture 115: 297-303.

Heming TA, McInerney JE, Alderdice DF. 1982. Effect of temperature on initial feeding in alevins of chinook salmon (*Onchorhyncus tshawytscha*). Can J Fish Aqua Sci 39: 1154-1162.

Kamler E. 1992. Early Life History of Fish. Chapman and Hall, London, 416 pp.

Koss DR, Bromage NR. 1990. Influence of the timing of initial feeding on the survival and growth of Hatchery-reared Atlantic salmon (*Salmo salar*). Aquaculture 89:149-163.

Krasnodembskaya KD. 1993. Adaptation of sturgeon larvae in relation to problems of sturgeon culture. In: Proceedings Second International Symposium on Sturgeon (Gershanovich, A. D. and Smith, T.I.J., eds), p. 76. Moscow: VNIRO.

Monaco, G, Buddington, RK and Doroshov, SI. 1981. Growth of white sturgeon (*Acipenser trasmontanus*) under hatchery condition. J World Mariculture Soc 12: 113-121.

Nimi AJ, Beamish FWH. 1974. Bioenergetics and growth of Largemouth bass (*Micropterus salmoides*). Can J Zool 52: 447-456.

Piper RG, McElwin IB, Orme LE, McCraren JP, Flower LG, Leonard JR. 1983. Fish hatchery management. Washington: U.S. Fish and Wildlife Service.

Rosenthal H, Bronzi P, McKenzie D. 1999. Highlights of the 3rd Symposium on Sturgeon: conclusion and recommendations. J Appl Ichthyol 15: 1-6.

Twonge TK, MacCrimmon HR. 1976. Significance of the timing of initial feeding in hatchery rainbow trout, *Salmo gairdneri*. J Fish Res Board Can 33(9): 1914-1921.