Testing Stocking Densities in North American Sturgeon (*Polyodon spathula*) Culture in the Post-Embryonic Development Period

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Abstract

The paper presents the results obtained during the growth of the North American sturgeon *Polyodon spathula* during the period of post-embryonic development. Stugeon larvae aged 5 days old of *P. spathula* obtained by artificial reproduction at SCDP Nucet, were stocked and raised until the age of 30 days in two experimental variants: variant 1 (V1): 1000 ex/m ^{3} , respectively 1500 ex/tank ; variant 2 (V2): 2000 ex/m ^{3} respectively, 3000 ex/tank in 10 Ewos type fiberglass tanks (useful volume -1500 liters/tank). The water temperature during the experiments was between 17.0-22.5°C. In both experimental variants, the sturgeon fry were fed both zooplankton and artificial feed. The zooplankton administered came from specially prepared cultures. The technological indicators obtained at the end of the post-embryonic development period (30 days) were as follows: in variant 1 (V1) fry with an average mass of 6.95 g/ex were obtained (survival rate of 19.8 %) and in the variant 2 (V2) the fry recorded an average mass of 4.8 g/ex (survival rate 12.3 %). The differences recorded in survival between the two experimental growth variants were due to the fact that the adaptation to feeding with artificial feed became more difficult. Also, overcrowding causes typical manifestations that consist in the appearance of large differences between individuals that favor cannibalism.

Keywords : Ewos tanks, *Polyodon spathula*, stocking density, sturgeon larvae.

1. Introduction

Polyodon spathula, belongs to order *Acipenseriformes* and family *Polyodontidae*, a breed originally from hydrographical basin of rivers Mississippi and Missouri from North America. Paddlefish, similar to sturgeons, are sought for their high quality meat and caviar.
Their meat is white, firm, and considered boneless, and their eggs are greyish-black and measure between 2.0 and 2.5mm in diameter [1-3].
The North American sturgeon (*Polyodon spathula)* has been acclimatized in Romanian, at SCDP Nucet since 1992. A number of 5000-20000 embryonated eggs and/or larvae were imported annually from the USA between 1992 and 1999. Starting from 2002, when artificial reproduction was first achieved, both domestic and foreign economic agents annually purchase embryonated eggs, larvae, pre-developed fry and of different ages from the *P. spathula* species [4].
The success of the artificial reproduction of the North American sturgeon *Polyodon spathula* and obtaining good hatching survival results made it possible to carry out numerous growth experiments. The species *Polyodon spathula* can be grown in different stocking variants (monoculture or polyculture) in earthen ponds or in protected spaces in variable densities. The growing experiences in first summer, carried out at SCDP Nucet demonstrated that *P. spathula* can be grown in monoculture in high densities of 5000, 8,000 and 10000 ex/ha, or with a complementary species for vegetation control with survival rates of 18.9% up

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to 82.8%, and net productions up to 970 kg/ha (approximately 1000kg/ha), comparable and even superior to those quoted in the specialized literature [5, 6]. Growth experiments were also carried out in the post-embryonic development stage up to the age of 30-40 days, both in ground ponds and in protected spaces (Ewos tanks, concrete tanks) in different high densities. In the first stages of life, the larvae mainly consume live food represented by cladocerans, copepods and insect larvae. According to the studies conducted, natural food represented by zooplankton (especially *Daphnia sp*.) is important both for larvae reared in earthen ponds and in intensive systems [7]. Also, both larvae and juveniles of *P. spathula* can be taught to consume commercial feed [8]. The growth rate is dependent on environmental conditions, variation in water flow, food abundance, density [9, 10]. According to the research carried out the economic importance of the species is particularly high due to the fact that it presents large dimensions and growth rate; has a planktonophage trophic regime (zooplanktonophage); it is a disease-resistant species; does not present the risk of a major ecological impact on natural aquatic ecosystems from Romania; constitutes a valuable support for an organic (ecological) fish culture [11].

2. Materials and methods

The growth experiments in the post-embryonic development stage of the species *Polyodon spathula* took place during 30 days from the moment of stocking in 10 Ewos tanks (flow-through system). The useful volume/tank was 1500 liters.

Stock material - 5-day-old larvae of *Polyodon spathula* (mean±SE initial mass of 0.0014±0.003 g) was obtained by artificial reproduction at SCDP Nucet.

To test the stocking density in the post-embryonic development stage, two experimental variants were established: first variant: 1000 ex/m^3, respectively 1500 specimens/tank; 2nd variant: 2000 ex/m^3 respectively, 3000 ex/tank. Five repetitions were made for each variant. At the beginning of the experiment, an optimal water level in the tanks was established at 0.40-0.50 m, after which it was gradually raised until the end of the experiment.

The tanks were fed with pond water; the initial flow rate was set at 7-15 liters/minute, being modified according to needs.

In both experimental variants, the larvaes were fed both natural food (zooplankton) and artificial feed. Cultures of zooplankton organisms were carried out in two earth ponds located near the pilot station for reproduction and growth in the post-embryonic period. Their preparation began in mid-March and consisted of fertilizing with organic fertilizers, fermented manure (5,000-8,000 kg/ha). Also, depending on the water temperature, fodder yeast was administered for the development and support of the zooplankton culture (3-5 kg/day/ha at a water temperature of 10-18^{o}C or 2-3 kg/day/ha at a temperature of 17-23^{o}C. The determination of doses was made according to the result of the water analysis.

The structural dynamics of the zooplankton biomass development in the feeding ponds were relatively stable. The species composition of the zooplankton in the experimental ponds was diverse (eg. *Daphnia longispina*, *D. magna*, *Moina rectirostris*, *Bosmina longirostris*, *Ceriadaphnia reticulata*, *Chydorus sphaericus* and *Cyclops sp*.) [12]. Paddlefish can be used to consuming artificial feed, but overcrowding must be avoided. As the fry grow, they must be sorted and thinned out which requires relatively large growing spaces [13-15].

Live food collected from cultures was administered "ad libitum". The tanks were cleaned daily, the feeding and swimming behaviour, the state of health were observed. The media conditions (temperature, pH, dissolved oxygen) were monitored. The station was illuminated 24 hours a day throughout the experimental period [16].

Water quality monitoring and management dissolved oxygen, pH and water temperature were measured daily at 08:00 and 16:00 hours. Dissolved oxygen and temperature were measured using an oximeter HACH HQ 40d; pH was measured with WTW pH meter.

Total weight and number of paddlefish were recorded for each tank and 20 fish from each were individually weighed and measured for TL.

Biometrics consisted of taking some measurements: total length (TL) - from the tip of the rostrum to the upper tip of the tail, length of the rostrum (r) and weight (w).

Figures 1 Ewos tanks – testing stocking densities during the post-embryonic development period in *P. spathula*

A tailor's centimeter and a Kern electronic analytical balance were used.

Following the gradual decrease in the amount of zooplankton, a feed (0.5 mm) with a crude protein content of 45% was administered, 20 days after stocking. Daily observations on feeding behavior highlighted that fry accept to consume feed.

Every day, during the course of the experiments, in addition to the distribution of food, the tanks were cleaned. Anesthesia was done with tricaine MS-222 (100 mg/l).

3. Results and discussion

The growth of larvae and fry of paddlefish up to the age of 30 days, it is the most delicate technological phase, because it includes the period of transition from the mixed type of feeding - to active feeding, at which point, a decrease in the abundance of specific food could have negative consequences. In the first 10 days after the fry stocking of paddlefish were active in the whole water mass presenting a lively oriented swimming, more in the water current. They feed actively, by hunting and grabbing, but the food is mostly sought on the edges or in the bottom area of the tanks. This feeding behavior is determined by the concentration of zooplankton (*Daphnia longispina, D. pulex* and *D. magna* juveniles*)* in the respective areas.

Until the age of 20 days, the fry feed exclusively by grasping (they hunt large zooplankton forms, after which, the specimens that have a good growth rate (TL=70-80 mm), switch to alternative feeding, i.e. perform characteristic filtering movements (swimming with the mouth wide open, sudden changes of direction, twisting, etc.).

During the 30 days of growth experimentation, 3 critical moments were identified, determined by a low level of zooplankton biomass in the growth spaces:

- at the stocking - from the first day to the 3rd day (the moment of transition to exogenous feeding);
- from the 16th day to the 23rd day after hatching (the transition phase to alternative feeding – by filtering);
- from the 23rd to the 30th day post hatching, when the zooplankton biomass in the crops decreases, against the background of increasing requirements for the ingestion of natural food by the paddlefish fry, which is associated with the decline of the zooplankton biomass from cultures.

The growth of the North American sturgeon *Polyodon spathula* regardless of age and growth technology is largely determined by water quality and the availability of specific food (zooplankton).

In order to ensure the conditions for the development of phyto and zooplankton in the live food culture basins, an appropriate program for their preparation was established. Also, the stocking of the tanks with *Polyodon spathula* larvae was programmed to be carried out when the live food crops reached the optimal conditions of development. For example, water temperatures >15°C or <28-30°C negatively influence the appearance and development of specific food, hence the decrease in the rate of growth and development of fry, and sometimes the rather high

occurrence of the phenomenon of mortality in the fish farm.

As the larvae began to consume feed, the zooplankton was administered in smaller and smaller quantities and then it was given up permanently. As a result of the observations on the feeding behavior, it was decided that the feed should be administered in such a way as to avoid waste and implicitly the alteration of the growth environment due to the decomposition of uneaten food. The water quality parameters, according to Order MMGA 161/2006, fell within the optimal ranges for this species and age. Thus, during the experimental period, the water temperature was between 17.5°C and 22.0°C; The pH was in the range 6.8-8.2; dissolved oxygen in water had values >6 mg O_2 /l; organic matter <30 mg $KMnO_4$ /l; nitrates (NO_2^-) recorded values of 2-3 mg/l and for nitrates (NO_3^-) the values were between 20-30 mg/l.

Dead specimens were collected, counted and removed. Growing paddlefish in high densities requires increased attention, as some diseases may occur. Among the diseases, ichthyophthiriosis (produced by *Ichthyophthirius sp*.) appeared accidentally. For prevention and control, baths were made with NaCl (1.5-2.0%) for 3-5 minutes, depending on water temperatures.

The appropriate hygienic and sanitary conditions were also maintained.

In studies on the water quality requirements and diseases affecting this species in culture, it is stated that there is less data compared to other species [17]. However, the species appears to grow well under a wide range of water quality parameters (e.g. water temperature 15-27°C; oxygen saturation variation from 30%; pH 6-9).

The technological indicators obtained at the end of the post-embryonic development experiment were as follows: in version 1 (V1) fry were obtained with an average weight of 6.95 g/ex (survival rate of 19.8%) and in version 2 (V2) fry recorded an average weight of 4.8 g/ex (survival rate 12.3%). The results are presented in Table 1.

The size of *P. spathula* fry was determined by biometrics (total length, rostrum and weight determination) at the end of the experiment. The fry were not fed 12 hours before the measurements were taken. Fish were weighed individually (error, ±0.1 mg).

Total length (TL) and joint length (r) measured from the tip of the spatula to the eye were determined. The results of the measurements constituted as averages of the two experimental variants are graphically represented in Figures 2 and 3.

Table 1. Technological indicators obtained at the end of the post-embryonic development period (30 days)

Technological indicators	Variant 1		Variant 2	
	Stocking	Harvest	Stocking	Harvest
Total ex/tank	1500	297	3000	369
Useful tank volume (m^3)	1.5		1.5	
Ex. /mc	1000	198	2000	246
Average mass (g/ex)	0.025	6.95	0.025	4.8
Fish biomass (g/ tank)	37.5	2064	75	1771
Fish biomass (g/m^3)	25	1376	50	1180
Survival (%)	-	19.8	-	12.3

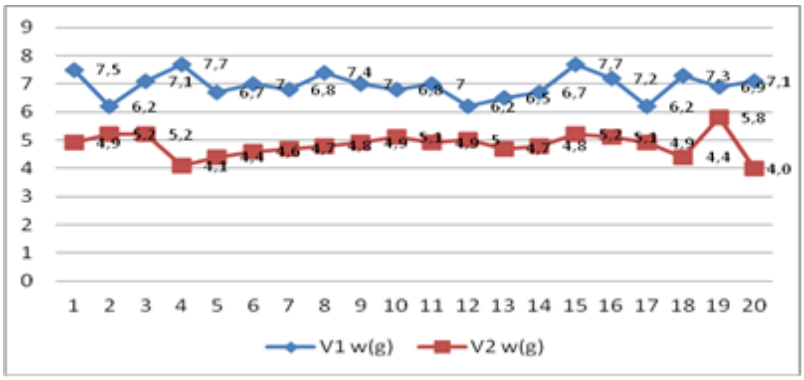

Figure 2. Comparative situation of body mass (W) in the stocking density test experiments of *P. spathula* in the post-embryonic development stage

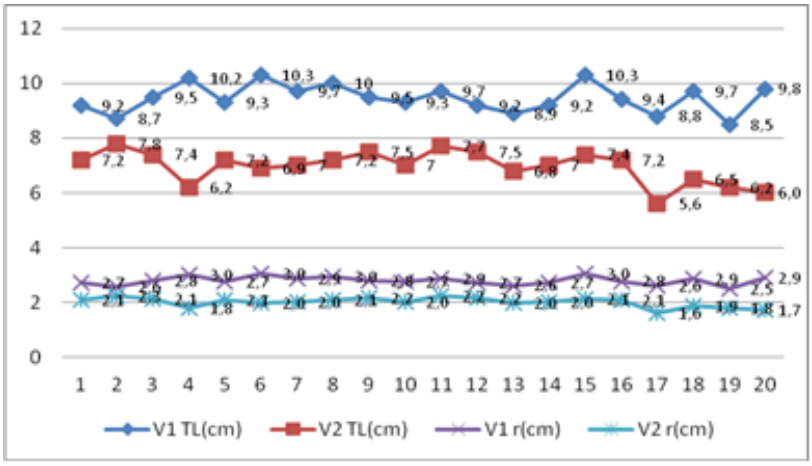

Figure 3. Comparative situation - total length (TL) and rostrum (r) in the stocking density test experiments of *P. spathula* in the post-embryonic stage of development

Growth experiments in the post-embryonic stage of development have been carried out over several years. Analyzing the results obtained in the 2 experiments, it can be concluded that the most important factors that determine survival are: the quality of the culture environment and the abundance and quality of the administered food (zooplankton).

Good survival and growth was observed of *P. spathula* juveniles reared in ponds with water temperature gradually increasing from 17 to 29°C over a 4-month growth period [18]. Our results are in agreement with those presented in the specialized literature [19] about significantly better survival and growth of juveniles reared at 21ºC than those reared at 17°C.

Disturbance of environmental conditions when growing in high densities can produce important consequences through losses due to diseases. The losses recorded were not due to diseases.

The results on growth experiment of *P. spathula* are consistent with the data in the specialized literature [720] which show that the optimal temperature range is located between 18-20ºC, values higher than 24ºC are unfavourable, and at temperatures above 28ºC, mortalities are massive. Survival and growth are greatly reduced at temperatures below 16ºC.

4. Conclusions

Experiments testing high densities during post-embryonic growth have confirmed that the most important factors contributing to growth and survival are water quality and natural food density.

Analyzing the results obtained in the 2 experiments, it can be concluded that the most important factors that determine survival are: the quality of the culture environment and the abundance and quality of the administered food (zooplankton). The differences in survival between the two experimental versions of the rearing density test arise because not all larvaes adapt quickly to feed feeding and the large differences between individuals that appear against the background of typical manifestations of overcrowding favour cannibalism. After sorting the fry, the phenomenon of cannibalism is reduced.

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