Large-scale cultivation of fingerlings of Chinese Sturgeon *Acipenser sinensis* for re-stocking

Yong-jiu Zhu [1], Qi-wei Wei [1, 2]*, De-guo Yang [1, 2], Kai Wang [1],

Xi-hua Chen [1, 2], Jian-yi Liu [1, 2], Luo-xin Li [1]

1. Key Laboratory of Freshwater Fish Germplasm Resources and Biotechnology of the Ministry of Agriculture of China, Yangtze River Fisheries Research Institute, Chinese Academy of Fishery Sciences, Jingzhou 434000, China.

2. Freshwater Fisheries Research Center, Chinese Academy of Fishery Sciences, Wuxi 214081, China

Corresponding author. Tel: +86-716-8129856; E-mail: weiqw@yfi.ac.cn

Abstract

In this study, cultivation facilities and techniques for fingerlings of Chinese Sturgeon (*Acipencer sinesis*) in workshop were introduced. Initiation of feed, domestication of formulated feed of young fish, water temperature, water quality and disease control techniques are the key factors affecting the survival rate and growth of the young Chinese Sturgeon. The optimal water temperature for fingerlings rearing should be between 18℃ and 22℃. The feed conversion rate of formulated turtle-feed was 0.45 while that of sturgeon-feed was 0.67. Under our experimental condition, Chinese sturgeon grew at 17.88mm/day in body length and 16.8mg/day in body weight. 70 days after hatch, SGR of 1-18days post-hatch was 8.34% day^{-1} and that of 18-72days post-hatch was 6.93% day^{-1}, fingerlings with 10-15cm in lengrh were produced in our workshop and were ready to be released into the natural habitats of Chinese Sturgeon. Further study should be carried out to identify the pathogen. From 2000 to 2003, 200,000 fingerlings (10-15cm in body length) of Chinese Sturgeon have been cultivated in Propagation and Re-stocking Experiment Base for Chinese Sturgeon in Yangtze River Fisheries Research Institute. Survival rate of Chinese Sturgeon is up to 90%.

Introduction

Chinese Sturgeon (*Acipenser sinensis* Gray) belongs to the family Acipenseridae, Acipenseriformes. It is a large commercial fish that only exists in China. It is famous for its large body, high growth rate and longevity. Chinese Sturgeon has once been a very important fishery product in upper Yangtze River. However, due to the construction of hydroelectric dams, water pollution and overfishing, the natural population declines and closes to the point of extinction. Recently, it has been listed on the aquatic animals of first-grade protection in China and a series of measurements toward the protection of its natural resource have brought into effect (Wei Q. W. et al, 1997). In the same time, measurement of fingerlings of Chinese Sturgeon artificially propagated and released to its habitats has been conducted in order to slow down the decrease of its population and gradually restore its natural resource.

The first attempt of artificial propagation of Chinese Sturgeon was in the 70's of the 21st century. At that time, Aquatic Resource Survey Group of Sichuan Province carried out artificial spawning of Chinese Sturgeon for the first time in Yangtze River with captured Chinese Sturgeons as broodstock using Chinese Sturgeon pituitary as spawn stimulus. After the fertilized eggs were hatched in a circular track and then cultivated in fish pond, some fry was obtained (YRARSG, 1988). Since the build-up of

Gezhouba Dam in Yangtze River has blocked the migration path of Chinese sturgeon, its natural breeding is greatly affected. To solve this problem, Chinese government decided to restore its natural population by releasing fingerlings of Chinese Sturgeon to Yangtze River with artificial propagation technique. In 1983, a cooperation group was established betweenYangtze River Fisheries Research Institute and other institutes and they completed the artificial propagation of Chinese Sturgeon understream Gezhouba Dam. In the same time, a Chinese Sturgeon Research Institute, which was designed to be responsible for the restocking of Chinese Sturgeon in Yangtze River, was established in Gezhouba Group Company. Thereafter, artificial propagation and releasing of Chinese Sturgeon to its habitats have been launched annually by Yangtze River Fisheries Research Institute and Chinese Sturgeon Research Institute. However, because the technique for artificial spawning and fry rearing was not mature and facility for young sturgeon rearing could not meet the need of sturgeon development in environment, usually the survival rate of sturgeon was under 10% and only in a few cases, the survival rate could reach 20%. In those years, fry of Chinese Sturgeon were released into the river in order to restock. Statistics showed that no more than 10,000 fingerlings of Chinese Sturgeon were cultivated before 1995. Therefore, the breakthrough in cultivation of Chinese Sturgeon fingerlings is the key for the restocking of Chinese Sturgeon resource in natural waters in large-scale.

Since 1996, we have tried to solute the problem of low survival rate of sturgeon fingerling. With improvement in facilities and rearing techniques, sturgeon fingerlings survival rate has reached more than 80%. To produce sturgeon fingerlings in large scale, a well-equipped Chinese Sturgeon artificial propagation and fingerlings rearing base was established in Jingzhou City. Between 2000 and 2003, 200,000 Chinese Sturgeon fingerlings with 10-15cm in length have been successfully reared in this base and released into Yangtze River.

Materials and methods

1. Rearing facilities

1.1 Water source and water processing system

Water supply system was composed of water tower and water pipelines. The main water source was water in the nearby reservoir. The accessorial water source was from 3 deep wells with a depth of 40m (water temperature in the wells is 18℃), which was designed to modulate the water temperature in the rearing tanks in summer and winter. The content of water tower was 400m^3. Water could be pumped from the reservoir to the water tower by 3 automatic water pumps. Before flowing into the water tower, water was filtered in quartzite tower and sterilized with UV light. Water from deep wells was firstly air-exposed in air-exposure tower to dissolve oxygen in the water and then it was filtered in quartzite tower and pumped into water supply tower. Processed water was sent to broodstocking pond and hatchery. The physicochemical property of water from the water source is listed in table 1.

Table 1 A comparison of the major physicochemical factors in water from reservoir and deep wells before and after processing

	pH		DO（mg•L^{-1}）		Iron（mg•L^{-1}）		Transparence（m）	
	before	after	before	after	before	after	before	after
reservoir	7.8±0.5	7.8±0.5	8.2±0.3	8.2±0.3	0.68±.02	0.55±0.02	0.7±0.1	2.0±0.2
wells	7.0±0.1	7.2±0.2	2.8±0.1	6.5±0.3	1.25±.01	0.81±0.02	1.0±0.0	0.8±0.1

1.2 Temperature control facilities

Sturgeon rearing workshop was designed to be temperature controllable. Walls of the workshop were built out of concrete and the roof was covered with high-strength foam with 2cm in thick, which was favorable to maintain temperature inside. In winter, when the temperature of water from the nearby reservoir was too low to be used, a steam boiler with 2 tons in content was applied to heat up the water from the water tower to 80℃ so that the temperature of water in the fish ponds could be adjusted to 18℃ to 25℃ according to the water temperature designed for the tanks. The water temperature was also controlled by sending steam to the workshop through caliduct. The temperature of the fish tanks in the workshop was automatically controlled by an electronic temperature control device.

1.3 Hatching tracks and rearing tanks

There are 10 hatching tracks, 300 fry rearing tanks and 147 fingerlings tanks in the workshop with a total area of $36m^2$, $240m^2$ and $1029m^2$ respectively. Hatching tanks had a slope floor. They have a dimension of 360cm×100cm×35cm with 12 water sprayers above. Water pipelines were used to control the water level in the tanks. The fry rearing tanks were round white plastic tanks with 1meter in diameter and 0.6meter in depth with a smooth flat floor. 2 water taps were installed above each tank to supply water for the tank and control the water flow rate and direction. Drain pipes with filter pipes and overflow pipes were in the center of the tank bottom. Fingerlings rearing tanks were round concrete tanks with a dimension of Φ3m×0.8m. Their floor was cauldron-like in shape with the drain in the center and infalls were installed above the tanks. The surfaces of the tanks were covered with ceramic tiles to make the surfaces smooth.

1.4 Air-compressing equipment

One 1.1 kw air-compressing machines and two 2.2 kw ones were equipped in the workshop. Air was sent to the pond through air-stone to enhance oxygen content in the tank. 1-2 air-stones were equipped for each square meter of tank.

1.5 Other equipment

A 90kw dynamo, a small-scale feed processing machine (it had a capacity of fabricating 150kg of soft pellet feed per hour) and a tubifex-mincing device were also used in this experiment.

2. Rearing methods

2.1 General protocol of hatching of fertilized eggs and rearing of the young Chinese Sturgeon

Approved by Chinese government, wild broodstocks of the Chinese Sturgeon were captured under Gezhouba Dam in Yangtze River. Eggs of sturgeon from artificial spawning were artificially fertilized and were hatched in hatchery net-cage that floated on the water surface of hatching tracks. Usually, fry could be hatched after 4-5 days at the water temperature between 18℃ and 20℃. It was very important to transfer the post-hatch fry to fry rearing tank in time and work on their onset of feed. When they grew to 5cm long, it was necessary to transfer them to fingerling rearing tank and start to domesticate them to formulated diet.

2.2 Main techniques and measurement

2.2.1Stocking density

With the growth of fry, it was important to adjust the stocking density of fry in the tanks. Generally, the stocking density of post-hatch fry was 4000ind./m^2 and it must be adjusted with their growth. The stocking density of young Chinese Sturgeon at different growth stage are listed in table 2.

Table 2. Stocking density of Chinese Sturgeon at different developmental stage

Size of sturgeon	1-15days post-hatch	3-5cm	5-8cm	8-10cm	10-15cm
Stocking density (ind./m^2)	4000	2000	800	500	300

2.2.1 Water quality control

(a) Previous experiment results showed that young Chinese Sturgeon was very sensitive to water temperature and the change of water temperature, especially in the early stage of fry rearing. Therefore, the water temperature should be adjusted to 18℃-22℃ and the change in water temperature within 24 hours should not exceed 2℃. Water temperature range should be between 18-25℃ in the late stage.

(b) Dissolved oxygen in the water should be maintained to be higher than 5mgL$^{-1.}$

(c) Waste in the water should be removed by changinge the water in the tank 2 times a day and tanks should be washed thoroughly every 4-6 days.

(d) Water in the tanks should be dynamic with appropriate exchange rate and flow velocity. The water in fry tanks should be exchanged 4 times a day and flow velocity should be less than 0.3m per second. In fingerling rearing pond, water should be exchanged 2 times a day and the water flow velocity should be less than 0.5m per second.

2.2.2 Initiation of feed and domestication of artificial feed

(a) Initiation of feed of young Chinese Sturgeon

When the fry grows to 2.9cm in length (about 10 days old), the young Chinese sturgeon was ready to eat external food. A mixture of *artemia* nauplii or zooplankton (rotifer and cladoceran) collected from fish pond and minced *tubifex* should be fed 8 times a day. A total amount of feed delivered each day was 40% of the total fry body weight. Zooplankton and *tubifex* should be sterilized with UV irradiation for 30 minutes and immersion in 5mgL^{-1} of Furazolidone for 30 minutes before feeding.

(b) Transition of feed

The domestication of formulated diet of young Chinese Sturgeon began when it grew to 5-6cm long. Formulated diet was delivered instead of natural feed into the tanks. Before domestication, young sturgeons were hungered for 2 times. Formulated diet was moist pellet of approximately Φ1.5mm in size. The first feed delivered to the tanks contained 30% *tubifex* and in the following feeding, *tubifex* content in the feed decreased gradually. In the process of domestication of food, feed was delivered 6 times a day and total daily feed was 15% of the body weight of the fish. After one week, 85% of the young fish would wean to formulated diet and the remaining 15% must be sorted out to another tank to repeat domestication process. This method of formulated-feed domestication was fast and efficient and the sturgeon survival rate was 95% in this process.

(c) Feeding technique after transition of feed

After transition of feed, young sturgeons were fed 4 times a day with commercially available sturgeon-special feed (it contained 42% protein) and the amount of feed for each day was 2% to 7% of the fish body weight (detailed data shown in table 3). Each feeding was completed in 2 times with 5 minute interval. Feed was spread along the edge of the tanks in case that feed might accumulate in the center and spoiled. When feeding, water supply and air supply to the tanks were stopped for 30 minutes. Dissolved-oxygen meter was used to check the oxygen in the water. Water supply and air supply must be restored immediately if oxygen shortage was found in the water.

Table3. Feed of young Chinese Sturgeon at different developmental stage

Days post-hatch	feed	Feed/fish body weight(％)
10-12	*Artemia* nauplii＋fine *tubifex*	40％
13-16	*tubifex*	30％
17-20	*tubifex* ＋ moist formulated feed pellet (self-fabricated, protein content: 45%)	15％
20-22	moist formulated feed pellet (self-fabricated, protein content: 45%)	10％
23-26	moist formulated feed pellet＋dry pellet formulated feed（commercial feed for sturgeon, protein content: 42%）	7％
27＋	dry formulated feed pellet (commercial feed for sturgeon, protein content: 42%, particle size1.5-3.0mm)	2-4％

2.2.3 Daily care

(a) Observation of fish activity. If any abnormality occurred, related measures should be taken.
(b) Personnels should be arranged to work 24 hours a day in turns in the workshop to check water, power and air supply.
(c) Extra large or small individuals should be sorted out to maintain the young sturgeon to be the same size in the same tank.
(d) Daily air temperature, water temperature, the amount of feed and the activity of the fish should be recorded. Data about fish body weight and body length should be collected every 6-10 days in order to adjust the amount of feed delivered and to collect data of fish growth.

2.2.4 Disease control

To control diseases, handling of young Chinese Sturgeon should be minimized if possible. After each grading, fish should be sterilized in $1 mgL^{-1}$ PVP-I for 1 hour. When diseases were found, infected fish should be separated and treated.

Treatment of common diseases in young Chinese Sturgeon.

(a) Red-mouth disease. Tumid and red mouth could be found in the infected fish. Red anus and occasionally bleeding in intestine was also found in the same case (shown in figure 1). Treatment of this case was to immerse the diseased fish in $1 mgL^{-1}$ of Norfloxacin for 1 hours in 3 consecutive days.

(b) Tail-decay disease. The tail fin of the diseased fish decayed and external fungi was usually found in this case. Treatment was to immerse the diseased fish in $3mgL^{-1}$ of Furazolidone for 1 hour in 2 consecutive days.

(c) *Saprolegnia sp.* disease. Floccule was found on the fish body. $400mgL^{-1}$ of NaCl and $400mgL^{-1}$ of $NaHCO_3$ were sprayed into the tanks and water supply was paused for 3 to 4 hours.

(d) *Ichthyophthirius multifiliis*. White dots distributed on the whole surface of the fish body. Infected fish usually lived away from the group and it usually caused high mortality of the fish population. Treatment of this case was to spray $50mgL^{-1}$ formalin to the tanks. Water supply was paused for 1 hour each day after treatment in 3 consecutive days.

(e) Enteritis. Diseased fish was found to be red and tumid in anus. Yellow liquid was found when pressing their venter. After dissection, no food could be found in the stomach. Congestion was found on the intestine surface. This disease was often found at the stage of domestication of formulated feed and usually resulted in death. Treatment of this was to add 15mg Norfloxacin to the feed per kg fish and the treatment lasted for 6 consecutive days.

Figure1. Red-mouth disease

3. Data analysis

The specific growth rate and food conversion rate were calculated according to the following formulas:

SGR (Specific Growth Rate) =100*(lnWt - lnWo)/ t (%day^{-1})

FCR (Feed Conversion Rate) =F/Wt – Wo

Where F represents the total amount of feed given to the fish during the experiment.

Result

1. Fingerling rearing

Between 2000 and 2003, 198,800 fingerlings (TL 10-15cm) of Chinese Sturgeon were cultivated in our experiment base and released into the natural habitats of Chinese Sturgeon. The average survival rate of Chinese Sturgeon fingerlings in the workshop (from larva to fingerling) was 86.8% and the highest survival rate reached 91%. (Data was showed in table 4. Because government prohibited catching broodstock of the Chinese Sturgeon in Yangtze River in 2002, artificial propagation had to be stopped and therefore, no data was collected that year)

Figure 2. Fingerlings of Chinese Sturgeon cultivated in workshop

Table 4 Data of fingerlings of Chinese Sturgeon Cultivation

Year	Quantity of fingerlings produced	Survival rate (%)	Average total length (cm)	Average weight (g)	Days of rearing	Average temperature(℃)
2000	66400	85.3	13.2±2.9 n=30	10.2±3.8 n=30	65	22.3±2.1
2001	82200	84.0	12.7±2.2 n=25	9.3±3.2 n=25	68	20.0±1.8
2003	50200	91.0	12.5±2.4 n=30	8.9±3.5 n=30	76	19.5±1.6
Total	198800	86.8	12.8	9.5	70	20.6

2. Growth of the young Chinese Sturgeon.

Based on the data we had collected in our experiment base, the growth rate of young Chinese sturgeon was 1.79mm/day in total length and 16.8mg/day in body weight, as shown in figure 3. SGR of 1-18days post-hatch was 8.34% day^{-1} and that of 18-72days post-hatch was 6.93% day^{-1}.

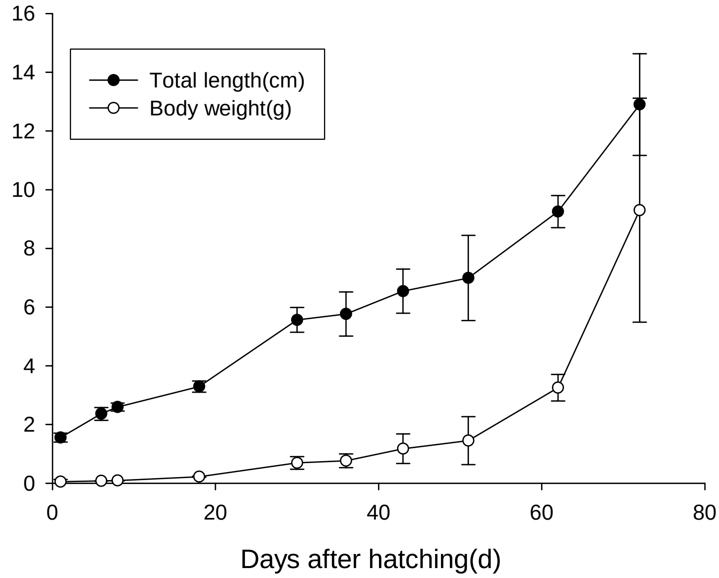

Figure 3. Post-hatching growth in total length and body weight of Chinese sturgeon

3. **Food conversion rate (FCR)**

After the young sturgeons were fed with formulated feed in our experiment base, FCR of two kinds of feed was calculated (when fish total length was 8cm-12cm, water temperature was 20±1℃). FCR of turtle-feed was 0.45 (pellet feed was made from feed powder before feeding and the protein content was 45%) while that of sturgeon-feed was 0.67 (submerged pellet feed with protein content of 42%).

Discussion

1. The effect of water temperature on the survival rate of young sturgeon.

Our results showed that water temperature and the temperature difference between day and night were key factors affecting the survival rate of young Chinese sturgeon. In 1998 and 1999 during our cultivation of Chinese Sturgeon fingerlings, the water temperature was lower than 16℃ and the temperature difference between day and night was 4℃-6℃, the survival rate was 10%-30%. This result was in accordance with Xiao's experiment (Xiao Y. Z. et al, 1999). The natural spawning season for the Chinese Sturgeon is autumn and therefore, the young Chinese Sturgeons grow up to fingerlings in winter while the natural water temperature is 6℃-14℃, which results in the low survival rate of the rearing Chinese Sturgeons fingerlings. To ensure high survival rate of the young Chinese Sturgeon in workshop, water temperature in the rearing tank must be raised to 18℃-25℃ in large-scale cultivation of young sturgeon.

2. **The effect of water temperature on rearing duration.**

In natural water temperature of Yangtze River (average 11.22℃ between Oct. and Feb.) in the natural reproduction season, 5 months are needed for young Chinese Sturgeon to grow to restocking-standard (3-5 grams in body weight) (Xiao H, 1994). Our practice of cultivation of sturgeon in workshop in 3 years demonstrated that, at an average temperature of 20.6℃, young Chinese Sturgeon could grow to 9.5 grams in 70 days and the cultivation duration was shortened for nearly 3 months.

3. The optimal time of initiation of feed for the Chinese sturgeon fry.

In order to ensure high fry survival rate, it is critical to know the optimal time of initiation of feed of the young Chinese Sturgeon. Results showed by Song B. demonstrated that to feed the hybridized sturgeon too early or too late would result in lower fry survival rate (Song B. 2003). Our observation in the rearing of Chinese Sturgeon showed that the best time for the start of feeding the Chinese sturgeon is the 10^{th}-11^{th} day post-hatch（water temperature is 20℃）.

4. Disease control

Like other cultivated fish, Chinese Sturgeon is easily infected in artificial cultivation system with high density. However, because study on large-scale cultivation of Chinese Sturgeon is relatively late than that on other cultivated fish, to date, no report is available concerning the pathogen separation, pathogen identification and drug-sensitivity trial against diseases of Chinese Sturgeon. The disease control measures that authors applied in this study was adopted from disease control methods used in carp or other sturgeon cultivation (Bauer O. N., 2002; Fred S. C., 1988; Martin H., 1999;). In the Chinese Sturgeon rearing practice, some of the disease could be controlled by the adopted methods effectively (as described in the related section of this paper). However, some diseases could not be controlled by the previous methods effectively, which is one of the focuses of future study on the Chinese Sturgeon cultivation.

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Author address: Yangtze River Fisheries Research Institute, Chinese Academy of Fishery Sciences, Jingzhou 434000, China. E-mail: zhuyj1234@vip.163.com, zhuyj1234@sina.com.