REPRODUCTION OF PIKEPERCH (*SANDER LUCIOPERCA LINNAEUS, 1758*): ARTIFICIAL SPAWNING GROUND TECHNIQUES AND EMBRYO MONITORING

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Abstract. Our present work was carried out on reproduction techniques of the pikeperch on artificial spawning grounds with the main objective to improve the embryonic and larval development. The experimentation was performed at the level of the aquaculture farm of Ain Sultane (Ain Defla, Algeria) over the spring 2021. We have chosen the pike-perch spawners from a dam that allows them to reproduce easily in this biotope where they find a lot of forage fish (cyprinids) available for the larvae. The spawning grounds were launched before the pikeperch breeding season to ensure that the target species can use the artificial substrates to lay their eggs. The total number of spawning grounds designed were 19 of 1 m^2. Feeding of the larvae started with egg yolk (vitellus) and *Saccharomyces cerevisiae* (yeast) for 3 days, after that, the larvae were fed with small zooplankton (rotifers). The distribution of the food was gradually increased with the administration of cladocerans (bosmina) and copepods until the end of the larval phase. The results obtained showed that the egg densities collected on these spawning grounds were quite high. An average of 24,2000 eggs was counted per spawning ground with 193,600 fertilized eggs, thus a very high fertilization rate of pikeperch of 80%. The incubation of the eggs lasted 8 days at a temperature of 18°C which fluctuated between day and night and which delayed the embryogenesis and the hatching. We observed a mortality rate evaluated at 20% due in particular to an overloading of the breeding tanks which provoked cannibalism due to the genetic predisposition of this carnivorous fish. Our larval monitoring was not regular (distance from the farm) which intensified cannibalism and consequently mortality. We can conclude from these results and considering the difficult experimental conditions that we were able to create conditions similar to natural conditions for the reproduction of pikeperch.

Keywords: Sander, reproduction, artificial spawning grounds, fertilization, mortality.

INTRODUCTION

Aquaculture is the fastest-growing food-production technology (Edwards et al., 2019). Fishing and aquaculture remain, for hundreds of millions of people across the world, a resource of prime importance, whether it is food, nutrition, income or livelihood. In 2014, the world supply of fish has reached the figure record of 20 kg per inhabitant, thanks to the strong growth in aquaculture, which provides now half of the fish intended for the human consumption (FAO, 2016).

It is also known that aquaculture covers a very wide range of aquatic farming practices with respect to species, environments or systems used, and that it involves very different resource use patterns. As a result, there is a range of options for diversifying methods to improve food and income production in many rural and peri-urban areas

(FAO, 2020). Algeria has different continental aquatic ecosystems, such as dams and different water sources, which can be an asset for the development of fish farming and continental fishing (Meddour et al, 2005).

Aquaculture, unlike other forms of animal production, commonly targets carnivorous species for culture (Boyd et al., 2020). Among these species, The pike-perch (*Sander lucioperca, Linnaueus 1758*) which is an ichthyophagous species native of eastern Europe and western Asia and introduced to other European, Asian and north African countries (Specziár and Turcsányi, 2017 ; Bousseba et al., 2020). Its spawning behavior showed that its reproduction could take place deep in lakes and did not need macrophytic substrates. Therefore, the species sensitivity to water level fluctuations is low, which is frequently artificially maintained in reservoirs by stocking. Thus, it could be interesting to develop sustainable, sport fishery of pikeperch in reservoirs (Argillier et al., 2012). Besides, the increasing demand for stocking material and the highly variable effectiveness of methods used to date for the artificial reproduction of pikeperch have prompted several groups of scientists to study and then develop more effective methods for reproducing this species, and, as a consequence, increase the production of stocking material (Zakęś and Demska- Zakęś, 2009).

Pikeperch remains the most abundant carnivore in the water reservoirs in Algeria since its introduction in 1986 in the Ghrib dam where 20 spawners were imported from Hungary (Meddour et al, 2005). However, few studies have focused on the biology and reproduction of the species and, as a result, references are lacking to assess its adaptation to artificial conditions. In this contex, this study aimed to monitor the embryonic and larval development of the Pikeperch in the artificial spawning grounds.

MATERIAL AND METHODS

Choice of the experimental phase

The selected experimental phase was from February to April 2021**.** It was the phase of spawning and hatching, as well as the period of feeding of larvae and juveniles**.** We chose the Ghrib dam which is one of the largest reservoir dams located 30 km from Ain Sultane aquaculture farm (Khemis Miliana, Ain Defla, Algeria). This dam was chosen for the first tests of floating artificial spawning grounds. It benefits from a mountainous location that allows the flow of ice and a water level of 400 m favorable to the reproduction of this type of fish (Figure 1).

The basic structures of Ain-Sultane aquaculture farm

This farm was created in 2019 with the objective of reproducing noble species and using intensive techniques to accelerate their growth.

It is equipped with 15 large geomembrane pools, with a diameter of 15m, a depth of 1.20m and a volume of 220.000L; 10 Small geomembrane pools of 5m³. All pools are equipped with a system of draining (Figure 2). The hatchery: its surface is 200m², thermo regulated and composed of 12 pools of 8.10m3 equipped with a draining system (Figure 3). The breeding water is very rich in organic matter and trace elements is used to irrigate fruit trees to increase productivity.

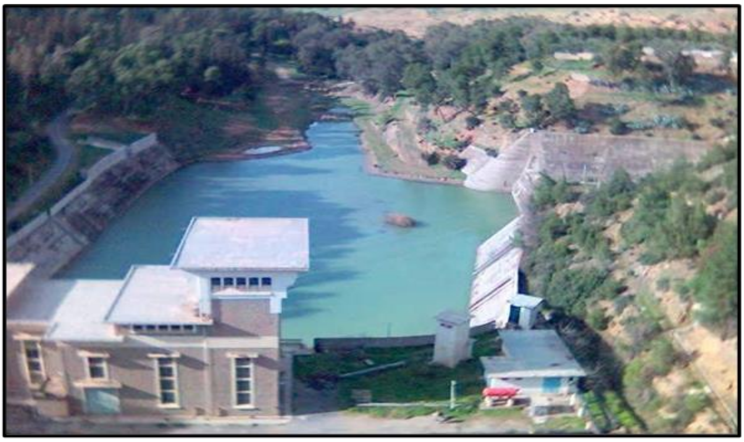

Figure 1. Ghrib Dam: Directorate of Water Resources, Ain Defla.

Figure 2. Aquaculture farm of Ain Sultan

Figure 3. Ain Sultane hatchery

Fabrication of artificial spawning grounds

Artificial spawning grounds are generally classified according to the method of attachment, and are distinguished into fixed spawning grounds and floating spawning grounds. For this study we used the floating spawning type (Figure 4, 5).

Figure 4. Spawning ground fabrication

Figure 5. Final shape of spawning grounds with floats

This system is formed by tri-welded of 1m² covered by the wire sunk vertically in the bottom of the water body, it is connected to plastic float bodies and a vertical weight by a rope to be maintained in place. The filasse replaces the submerged aquatic vegetation as a support for oviposition. It can be treated again and then reintroduced into the water bodies.

The spawning grounds were disinfected by a mixture of water and bleach (Na cl) or H2O2 (water oxygen) or KMNO4 (potassium permanganate) for 15 minutes, then immersed in pure water and dried for 24 hours under the effect of sunlight before transferring them to the dam.

Installation of spawning grounds in the dam

The launching of the spawning grounds was carried out before the reproduction period of the Sandre in order to ensure that the target species can use the artificial substrates to lay their eggs.

All the floating artificial spawning grounds were put in water on February 2021 (23 spawning grounds), and on March 2021 (12 spawning grounds). They were first assembled in the boat before being put in the water to finally be towed to the location with the ideal depth (1m-1.5m). The type of spawning grounds chosen requires the use of floats and bricks connected by a rope to be maintained in place, moreover a weight is connected to the center of the spawning grounds by a rope of 8m. This weight plays a double role, it maintains the whole of the device in place and ensure a tension which prevents the spawning grounds from getting tangled.

The spawning sites in the water are all located 20 to 50m from the shore (Figure 6).

Figure 6. Spawning grounds in the Ghrib Dam

It is necessary to examine the spawning grounds every 4 days to control the condition and presentation of the spawning grounds, to observe the presence or absence of eggs and possibly to clean the spawning substrate and to move the spawning grounds in case of absence of eggs.

Collection and transport of the eggs

After several observations, we recovered the spawning and we removed the tri-welded so that we can put the spawning substrate in a bag filled with water and finally transport them to the farm.

We put the eggs collected in pure and oxygenated water and we ensured that the spawning grounds were completely immersed in water, they were distributed over 7 ponds: Four small ponds of volume 4.9m3 and three large ponds of 200 m3 volume.

Incubation and hatching of pikeperch eggs

Incubation of fertilized pikeperch eggs was carried out on the spawning substrate in a rectangular tank. In order to maintain the temperature constant between 14 and 16 C° a daily control was carried out during the whole incubation period (Figure 7).

Figure 7. Fertilized pikeperch eggs attached to the wire

Monitoring of embryogenesis

The development of the egg is a rapid process that goes from the swelling of the egg to the embryonic morphogenesis: egg swelling phase, cleavage phase, embryonic phase: The phase of cell division and germ development and the phase of embryo development.

Larval rearing

We started feeding the larvae on the second day after hatching. At the end of the resorption of the yolk sac, the larvae swim horizontally. The larvae were fed with egg yolk 5 times a day and *Saccharomyces cerisaie* (yeast) for 2 days. After the third day, we started feeding with small zooplankton (rotifers) three times a day, the distribution of food increases gradually until the end of the larval phase. The renewal of the water at 80% took place every 3 days with a continuous aeration. The ponds were covered to protect them from light.

Zooplankton culture

Zooplankton is the preferred food for most fish larvae during their early life stages, because regardless of its nutritional value and very high digestibility, this live food is easily detected and captured by the larvae, due to its small size, swimming movements in the water column.

In our experimental work, we produced zooplankton from cow manure. In a bag, we put a quantity of dejections or nozzle of (excrements) cows (Figure 8). This organic matter increases the natural food (phytoplankton and zooplankton) and a quantity of lime (CaCO3) according to the PH in order to increase the PH of the mediums and to obtain high concentrations of chlorophyll at the end. Finally, 500 g of fertilizer is added, which contains nitrogen, phosphorus, and potassium (N.P.K.), which are the main mineral substances used by the phytoplankton. The bag should be well closed and small holes should be made for the penetration of water and the progressive decomposition of organic matter and its leaching into the water. It is necessary to take care not to provoke a eutrophication of the water. The purpose of this operation is to obtain the phytoplankton necessary to feed the zooplankton.

In a second step, daphnids were collected with a plankton net and put in the phytoplankton tank after 6 to 12 days to obtain zooplankton. The dominant zooplankton groups found in the animal droppings are rotifers, cladocerans, and copepods.

Figure 8. Zooplankton culture

RESULTS

Results of recovered spawning grounds

The following table showed the number of the spawning grounds recovered with the average number of eggs.

Table 1.

Spawning sites recovered with number of eggs
(Sample of 1 cm2= 11 eggs)

Number of spawning grounds	Number of eggs
22	0002222
7	2010222
0	010222

Fertilization rate

Figure 9 presents the calculation of spawning ground area

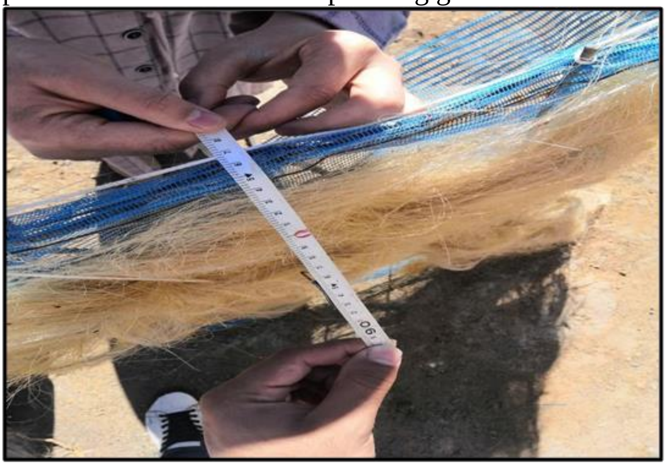

Figure 9. Calculation of Spawning Area

Area (spawning grounds) =∑surface area of 4 faces
Area yarn = ((100×100) ×2) +((100×5) ×0) =22000 cm².
Total number of eggs: 11× 22000= 242000.
Fertilization rate = number of eggs fertilized×100/total number of eggs
Total number of eggs→100%, Total number of fertilized eggs → X
X : number of fertilized eggs
Total number of fertilized eggs : 242000×80/100=193600
Fertilization rate: 193600×100/242000=80%.

Mortality rate

Number of dead eggs ×100/number of eggs: 20×100/100= 20%.
Number of eggs →100%, Number of dead eggs→ X
Number of dead eggs=number of eggs ×20/100=48400
Total number of larvae = number of eggs×80/100=3678400
Total number of unfertilized eggs = number of unfertilized eggs ×20/100=919600

Total number of eggs = number of eggs in 1 spawning ground × number of spawning grounds = 4598000

Results of embryogenesis monitoring

The embryonic cycle continues inside the egg shell, which the larvae break down upon hatching by their frontal enzymes during the incubation period.

Embryonic cells are derived from the fertilized egg by cell divisions, resulting in a typical stereo-like development (blastomeres), and then embryonic development begins.

The embryonic phase of the pikeperch begins at the moment of the egg fertilization. It is characterized by an endogenous nutrition of the embryo from the yolk salc and is divided into three sub-phases:

the cleavage phase covers the beginning of embryonic development as well as the stages morula, blastula and gastrula until the beginning of organogenesis. The embryonic phase begins when organogenesis is initiated and ends once hatching is complete. The eleuthero-embryonic phase starts after hatching and lasts until the end of the resorption of the yolk sac and the beginning of the exogenous feeding (Figure 10).

First movement stage

Pre-hatching stage

Hatched larva

Fry size

Figure 10. Embryo development

Cost of the necessary material and working hours

We made the spawning grounds reinforcement ourselves. Thus, the cost price of the framework was relatively low but the number of working hours necessary to its realization was rather important, since each spawning ground required 6 hours of work: Loading and unloading of equipment 2 hours-Assembling the reinforcement 3 hours-Spawning ground substrate assembly: Spawning sites installation on the mooring poles: 1.5 hours, i.e. a total of 9.5 hours of work.

DISCUSSION

The first reports of attempts to obtain the sex products of this pikeperch date to the nineteenth century. However, to date the methods usually used to accomplish this are either natural spawning or semi-natural spawning conducted in earthen ponds. Fertilized pikeperch eggs are also obtained by deploying various types of artificial nests in the natural spawning grounds of this species (Zakęś and Demska- Zakęś, 2009).

In the current study, we cannot yet consider that the floating artificial spawning grounds are definitively perfected because many aspects of their structures and their functioning are still correctable. However, according to the data of this work, we note that the pikeperch accept to come and lay eggs successively on the same floating artificial spawning grounds on bottoms of more than 4 m. The density of eggs in the pelagic zone is comparable to that observed on the spawning grounds installed at the level of the coast. This result can be explained in part by the very favorable weather conditions that prevailed in March during the pikeperch spawning period. As reported, at most localities, S.lucioperca spawns in spring when the temperature increases to 8 °C (Blabolil et al., 2019). It is likely that the improved presentation of the spawning grounds also plays a role in explaining this increase. According to Gillet (2001), it is important that the substrate forms a dense network in order to retain the eggs while facilitating the circulation of water. Steffens et al. (1996) recommend using larger cages (volume – 30-50 m^3) for pikeperch reproduction with a water temperature for hatching 16-20℃. Kokurewicz (1969) revealed, however, that the best larval development and longest body length is obtained when the eggs are incubated at a water temperature of 12.0-16.0C. Schlumpberger and Schmidt (1980) also reported to use larger spawning nests (1.8 (L) × 0.7 (W) m; surface area 1.26 m2). The spawners are usually stocked into such cages at a density of 2-5 females and 4-10 males, and spawning usually occurs after two to three days.

The use of artificial spawning grounds can be considered by water body managers to promote natural recruitment of fish, particularly in environments where natural spawning grounds are very degraded, such as in reservoirs with variable levels. This technique does not require considerable investments, but on the other hand, it demands a big staff for the installation and maintenance of the spawning grounds, particularly when water turbidity or eutrophication rapidly cause deposits to form on the spawning substrate.

Artificial spawning grounds, in addition to their direct interest in the restocking of water bodies, makes it possible to acquire a certain amount of useful information on the spawning habits of pikeperch. It would be interesting, during late March and early April, to immerse the artificial spawning grounds more deeply to test this hypothesis. The duration of the embryonic development of the pike-perch is 4 to 6 days (75°C- days on average), on the different spawning grounds that we have followed. During the second half of March, this phenomenon lasted less than 5 days. It is well known that hatching and larval development are temperature dependent (Čech et al., 2012). At high temperatures, larvae can hatch earlier, however, a longer time at the egg stage in colder conditions can improve fish development (Blabolil et al., 2019). If we refer to the number of degrees/day cited in the literature for the embryonic development of pikeperch), this suggests that the calculation of degrees/day should be based on maximum temperatures rather than on averages. The fluctuations or maximum temperature occurs from 11:00

AM to 2:00 PM. If there are drastic decreases in water temperature, pikeperch can discontinue spawning, and if these conditions hold, the females can even reabsorb their oocytes (Zakęś and Demska- Zakęś, 2009). The larvae move into the pelagic zone and in late summer large individuals migrate into the littoral zone (Blabolil et al., 2019).

The first bottleneck after hatching is switching to exogenous feeding, when adequate food in type and quantity have to be present (Blabolil et al., 2019). More specifically, the latter authors reported that *Sander lucioperca* larvae switch to exogenous feeding at 5-6 mm LS at an age of 8 days. Live foods are the main organisms involved in the feeding of fish larvae. They are particularly important in the rearing of fish larvae whose yolk sac is rapidly depleted while their digestive system is still rudimentary. Zooplankton have an effect on the physico-chemical and planktonic parameters of the water, it increases the PH, conductivity and the amount of nutrients (ammonia, phosphorus, nitrite and nitrate) which contributes to a good growth of the plankton population (Tavares et al. 2009). Thus, the use of organic waste improves the phytoplanktonic and zooplanktonic biomass of the fertilized water (Garg, 1996; Garg and Bhatnagar, 1999; Tavares et al., 2009). Rotifers are successfully used as live food for several fish species to improve larval growth and survival performance for the increase of production yield (Villegas et al., 1990; Reitan et al., 1993; Lim and Wong, 1997; Castell et al., 2003). At high temperatures, fishes have a higher metabolic rate compared to cold conditions and fish starvation is more likely due to high demands on the available food (Blabolil et al., 2019).

CONCLUSION

In our study, we explored the controlled reproduction of pikeperch by monitoring hatching and embryos in artificial spawning grounds at the aquaculture farm (Laaribi Sadek). For the results we obtained a total number of 242000 eggs and 193.600 fertilized eggs thus a very high fertilization rate of the pikeperch of 80% as well as a very low mortality rate of 20 %. Two months after fertilization and feeding, that is to say at the beginning of May, we obtained a fish of 2.8cm length. We can conclude from the results we obtained during this work that it is an encouraging outcome considering the difficult experimental conditions, and we were able to create conditions similar to natural conditions for the reproduction of pikeperch. The controlled reproduction of pikeperch is the solution to prevent the extinction of this species if we can improve the quality of the biotopes in which these fish live, demanding towards the environment and in particular eager for oxygen. Given the economic and nutritional value of pikeperch, in the future it will be important to use artificial reproduction to increase the survival rate of fry and thus increase fisheries production.

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