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INNOVATIVE MODIFICATIONS TO "CARAFA" TYPE INCUBATOR AIMED AT IMPROVING INCUBATION EFFICIENCY IN SILVER CARP *Hypophthalmichthys molitrix* (Valenciennes, 1844)

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Abstract

The success of the fish eggs incubation period is conditioned by the quality of the biological material, the environmental conditions and, last but not least, the device in which the incubation is carried out. At Research and Development Station for Fisheries Nucet (S.C.D.P. Nucet), the incubation of eggs obtained through artificial reproduction of the silver carp Hypophthalmichthys molitrix (Valenciennes, 1844) is carried out in the "Carafa" type incubator. It had some disadvantages, which is why certain improvements were made. After their implementation, an increase in efficiency was observed, such as: reduction of labour, improvement of work quality, obtaining higher indices at the hatching percentage of 92.6%, the survival percentage from hatched larvae to 3-5-day old larvae of 91.3%, as well as the survival percentage from embryonated eggs to 3-5-day old larvae of 84.5%. Thanks to the innovative modifications made to the "Carafa" type incubator, they were implemented and are currently used successfully in the artificial reproduction station within the S.C.D.P. Nucet.

***Key words**: fish egg, enhanced, hatcheries, reproduction, spawning.*

INTRODUCTION

In recent decades, reproduction and incubation technologies have developed more and more intensively with increasingly frequent applications in current aquaculture (Radu et al., 2018). This is due to the higher degree of technological sophistication of the operational flows used in aquaculture, as well as the latest generation of equipment used in the technological process (Dobrota et al., 2024).

Artificial reproduction is difficult to achieve due to the manipulation of fish outside their habitat, resulting in mortality rates of up to 50% in parents and offspring (Dobrota et al., 2021).

Embryonic development represents the most important stage in the process of formation and development of the new organism (Kamilov et al., 1996).

This period includes the time interval in which the egg, after fertilization, goes through a series of qualitatively distinct processes: segmentation and formation of the blastula, gastrulation and formation of the embryonic sheets, outline and development of the embryo, differentiation of the main organs, emergence of the functions of some systems, etc. The period ends with the hatching of the embryo (Woynárovich & Horváth, 1983; FAO, 2023).

To obtain 3-5-day old fish larvae, from a quantitative and qualitative point of view, it is necessary that incubation to be carried out in conditions as close as possible to those found in the natural environment. When incubating eggs, losses can be significant and this has significant negative financial impacts (Hermelink et al., 2013; Dobrota et al., 2023).

The most important factors at this stage are the temperature and physico-chemical characteristics of the technological water, the quality of the biological material from a genetic point of view and, finally, the characteristics of the incubator in which the fish egg are incubates.

MATERIALS AND METHODS

At S.C.D.P. Nucet, incubation is carried out in "Carafa1" type incubators, with a volume of 280 Litter of water.

The incubators design are approximately 40 years old, and over time a series of disadvantages have been observed.
During the incubation period, losses of biological material are recorded because, after hydration until hatching, the eggs were clumping in the water filtration area, a certain pressure was created on the eggs and in some of them the outer membrane cracked.
Also, during the hatching period, the workload required to clean the filters was one person per 7-8 "Carafa 1" incubators, because if they were not cleaned on time, there was a risk that the filters would be lifted outside the incubator and the biological material would be lost. During the hatching period, the filters clog very often, and the eggs are pressed into the filter to a greater extent, where, again, losses occur.
To avoid these losses, the filters must be cleaned as often as possible to release the pressure that the water exerts on the eggs, thus reducing losses (Figure 1).

Figure 1. Incubator: (a) without improvements; (b) with improvements (original)

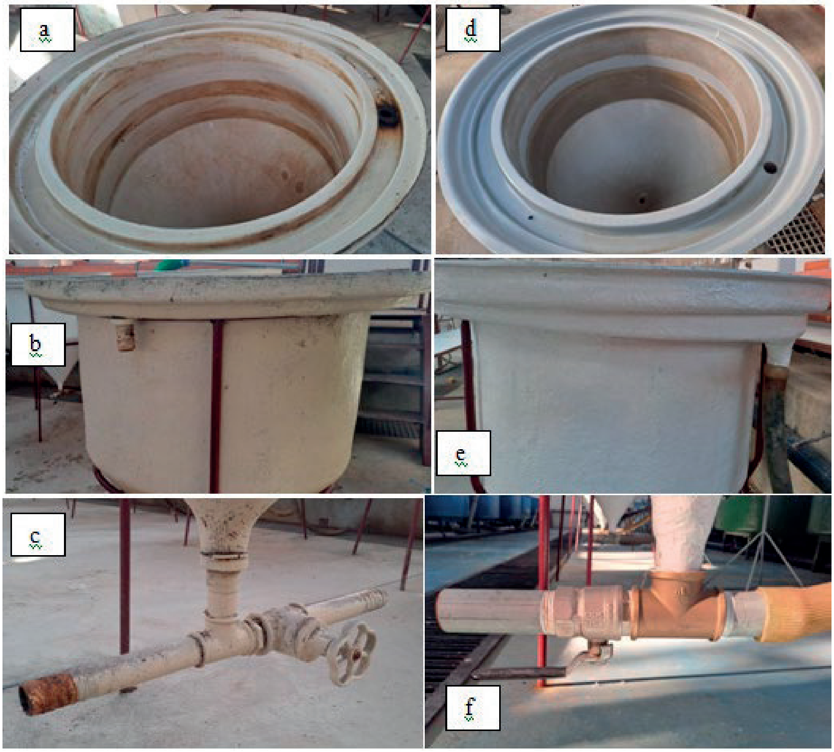

Figure 2. Incubator without improvements (a, b, c); incubator with improvement (d, e, f) (original)

Since the outlet of the "Carafa 1" type incubator does not have a drain slope (Figures 2a, 2b), and the outlet diameter was undersized, part of the discharged water flowed over the upper lip along its entire diameter. Thus, the operator performing the filter cleaning operation had to wear protective equipment in order not to get wet, given that the air temperature is 20-35ºC and creates thermal discomfort for him.
The edges of the upper lip of the incubators "Carafa 1" were not finished, and the operator either damaged the protective equipment, from the elbows to the base of the palm, or there was a risk of skin irritation meeting that rough fiber glass surface. Due to these shortcomings, a

series of measures were taken to improve this incubator.

Thus, a new "Carafa 2" type incubator was designed and built, to which improvements were made to address the shortcomings, as follows:

- creating a slope for the drainage of the wastewater (Figures 2d, 2e);
- finishing the edges of the upper lip (Figures 2a, 2d);
- equipping the incubators with taps, pipes and filter support made of stainless materials (Figures 2c, 2f);
- increasing the filtering surface (Figure3).

In 2023 and 2024, the incubation of silver carp eggs *Hypophthalmichtys molitrix* (Valenciennes, 1844) was carried out in "Carafa 1" type incubators and "Carafa 2" type incubators. The experiments were carried out in the pilot artificial reproduction station no. 4, at S.C.D.P. Nucet. In each year, three lots of silver carp broodstock were used from which sex cells were harvested, fertilized and incubated. The reproduction period in both years was June. For each batch were used 30 incubators, 15 incubators for each variant. In 2023, incubation was carried out for batches L1, L2 and L3, and in 2024, incubation was carried out for batches L4, L5 and L6.

The experimental variants were carried out as follows:

- variant V1, where 15 "Carafa 1" incubators were used, three batches per year, introducing 15 kg of eggs (1 kg of eggs/incubator);
- variant V2, where 15 "Carafa 2" incubators were used to which improvements were made, three batches per year, introducing 15 kg of eggs (1 kg of eggs/incubator).

For the hatching percentage calculation, the formula was used:

$$\text{Hatched Egg Rate (\%)} = \frac{\text{no. hatched eggs}}{\text{no. stocked eggs*100}} \quad (1)$$

For the survival percentage from embryonated eggs to 3-5-day old larvae calculation, the formula was used:

$$\text{SV 3-5 days (\%)} = \frac{\text{no. 3-5-day old larvae}}{\text{no. stocked eggs*100}} \quad (2)$$

Following the conduct of the experiment, statistical analyses were used to obtain the results. Data analysis was performed using MS Excel and the results were presented in tables and graphs.

RESULTS AND DISCUSSIONS

During the two years in which the experiments were conducted, physicochemical parameters of the technological water were monitored. The results obtained were interpreted in accordance with the provisions of the "Regulation on the classification of surface water quality" and were correlated with data from the specialized literature and the legislation in force for waters used for aquaculture and it was found that the parameters obtained were within the limits of the regulation. The water temperature in both years in which the experiments were conducted ranged between 20-25.5ºC. Dissolved oxygen ranged between 6.3 and 8.8 mg L^{-1}.

To achieve the innovative improvements, a team of specialists from S.C.D.P. Nucet was formed. To improve the incubator, the team considered the following aspects:

- larger filtration surface of technological water when discharged from the incubator;
- reducing the workload;
- avoiding the destruction of protective equipment and/or injury to operators;
- easier working conditions.

To obtain a larger filtration surface for technological water, a new filter was designed. The filter that the "Carafa 2" type incubator is equipped with has the shape of a truncated cone. The "Carafa 1" incubator filter has a metal structure (formed from two circles, the one at the base made of flat strip of iron with a width of 5 cm, and the one at the top made of a bar with a diameter of 5 mm thick, joined in place by bars with a diameter of 5 mm thick) which is covered in a nytal mesh. After a short period of time, the metal structure rusts and destroys the nytal mesh where it is in contact with the metal.

To obtain a larger surface area for filtering the wastewater, the height of the new filter was changed from H = 35 cm to H = 54 cm. In this way, the filtering surface was almost doubled (Figure 3).

Figure 3. The new filter- on the left side;
the old filter - on the right side (original)

To prevent corrosion, the metal structure of the new filter was made of stainless steel.

The improvements made to the "Carafa 2" incubator were by replacing the metal parts (pipes, taps, etc.) with parts made of stainless materials, such as stainless steel and/or bronze (Figures 2c, 2f) and creating a 5 cm deep drainage slope for the water outlet channel, to increase the volume of water taken up by the siphon.

Table 1. Results obtained during the incubation period in the two years of study

Specification		2023			2024		
Lot		L1	L2	L3	L4	L5	L6
No. of incubators		15	15	15	15	15	15
Quantity of eggs stocked (kg)		15	15	15	15	15	15
Quantity of eggs per incubator (kg)		1	1	1	1	1	1
No. of eggs stocked		13500000	13500000	13500000	13500000	13500000	13500000
No. of eggs per incubator		900000	900000	900000	900000	900000	900000
Incubators without improvements	Hatching percentage (%)	79.6	81.1	80.7	80.2	79.4	80.6
		Mean = 80.3					
	No. of hatched larvae	10746000	10948500	10894500	10827000	10719000	10881000
Incubators with improvements	Hatching percentage (%)	91.7	92.6	92.5	93.1	92.5	93
		Mean = 92.6					
	No. of hatched larvae	12379500	12501000	12487500	12568500	12487500	12555000
Incubators without improvements	Larvae survival rate (%)	89.4	90.6	90.3	91.3	90.7	90.7
		Mean = 90.5					
	No. of 3-5-day old larvae	9606924	9919341	9837734	9885051	9722133	9869067
Incubators with improvements	Larvae survival rate (%)	91.7	90.8	90.7	91.1	92.1	91.4
		Mean = 91.3					
	No. of 3-5-day old larvae	11352002	11350908	11326163	11449904	11500988	11475270
Incubators without improvements	Survival rate from fertilized eggs to 3-5-day old larvae (%)	72.1	72.6	72.8	72.9	72.8	72.6
		Mean = 72.6					
Incubators with improvements	Survival rate from fertilized eggs to 3-5-day old larvae (%)	84.3	83.8	84.2	85.4	85.1	84.4
		Mean = 84.5					

The incubation duration of eggs was 36-44 hours in both experimental variants in the two years of study, the variation being a function of the temperature of the technological water. From the observations made, it was found that the eggs during the hatching period crowded towards the nytal filter in variant V1. The average hatching percentage per batch recorded higher values in the V2 variant, falling within the range of 91.7% in batch 1 of 2023 and 93.1% in batch 4 of 2024. In V1 variant, where "Carafa 1" incubators were used, the values were lower, ranging from 79.4-81.1%.

According to Urooj et al. (2018) the hatching rate of silver carp eggs *H. molitrix* was 70%.

The lowest average value was recorded in 2024 in batch 5 (79.4%) and the highest average value was recorded in 2023 in batch 2 (Figure 4, Table 1).

After hatching, the larvae were further maintained in incubators until they were 3-5-day old, after which they were stocked in the ponds or delivered to the beneficiaries. The survival rate of larvae from hatching to 3-5-day old had close values in both experimental variants, falling within the range of 89.4-92.1%.

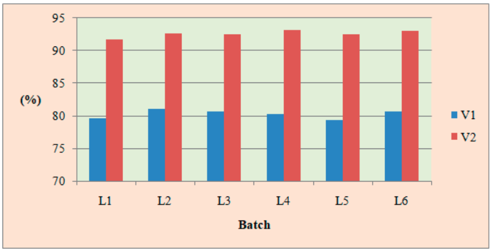

Figure 4. Evolution of hatching percentage for the 6 experimental batches

In the variant in which "Carafa 1" incubators were used (V1), the best average value was recorded in batch 4 of 2024 of 91.6%, and the lowest was recorded in batch 1 of 2023 of 89.4%. In the variant in which "Carafa 2" incubators were used (V2), the best average value was recorded in batch 5 of 2024 of 92.1%, and the lowest was recorded in batch 3 of 2023 of 90.7%.

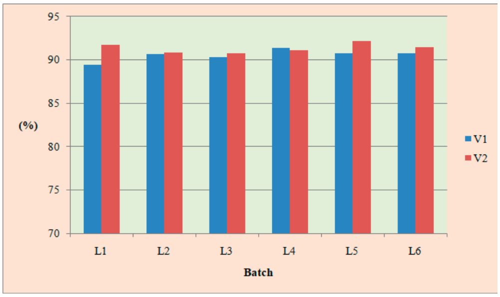

Figure 5. Evolution of larval survival percentage for the 6 experimental groups

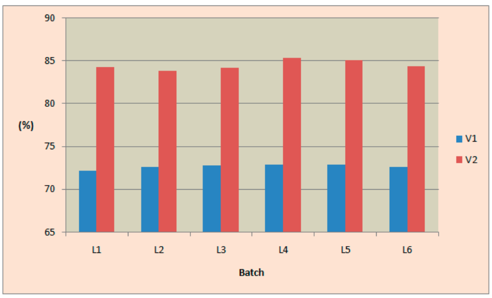

Figure 6. Evolution of survival percentage from fertilized eggs to 3-5-day old larvae

In 2024, in batch 4, the average larval survival value was higher in variant V1 of 91.3% compared to variant V2 of 91.1% (Figure 5, Table 1).

In other research, the survival of silver carp *H. molitrix* larvae in the first 3-5-days was between 57-68%, depending on food and water temperature variations (Bouaziz et al., (2021; Majdoubi et al., 2022).

The close results indicate that the larger filtration surface and the changes made to the incubator do not directly influence the survival of the larvae at this stage.

The percentage of survival from fertilized egg to 3-5-dayold larva in all experimental groups during the 2 years of study was differentiated in the two experimental variants. In the V2 variant, where "Carafa 2" incubators were used, the results recorded were superior and had values that ranged between 83.8% in batch 2 in 2023 and 85.4% in batch 4 in 2024. In variant V1, the results obtained were modest, so that the lowest value recorded was 72.1% in batch 1 in 2023, and the highest was 72.9% in batch 4 in 2024 (Figure 6, Table 1).

In a study conducted in Morocco, it was observed that the survival rate from embryonated eggs to 3-5-day old larvae decreased to 48.8% in silver carp *H. molitrix*, when the eggs were over-matured or incubated under inappropriate conditions (Sharma et al., 2023).

CONCLUSIONS

Due to the design and construction of the filter with a larger filtration surface, positive results were recorded such as: higher survival in the process of incubation of eggs until hatching; higher survival percentage in the incubation process from fertilized eggs to 3-5-day old larvae; reduction of the workforce from one operator per 7-8 incubators to one operator per 20-25 incubators.

Replacing metal parts (pipes, faucets) with stainless steel or bronze parts has resulted in them no longer clogging, rusting, and, implicitly, degrading. Thus, they no longer need to be replaced, and the costs of repair and purchase of spare parts have been reduced.

The design and resizing of the water outlet channel meant that it could be routed to the outfall pipe and completely drained. This made it unnecessary to equip the operators with protective damp-resistant clothing. Additionally, the top edge of "Carafa 2" was made 20 cm wide and finished to prevent further damage to protective equipment and irritation to the operators' arms.

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