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INNOVATIVE TECHNOLOGIES FOR FISH BREEDING WITH MINIMAL IMPACT ON THE ENVIRONMENT

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Abstract

This study refers to the common carp (Cyprinus carpio), which is an adaptable species that enriches the variability of quantitative and qualitative characteristics and increases genetic diversity. Local aquaculture populations of common carp, called "landraces," have developed due to different environmental conditions and breeding efforts. However, the introduction of carp in some areas has led to negative impacts on natural aquatic ecosystems. To improve the quality of economically important fish species, the variation in morphological, physiological, and biochemical characteristics is utilized. In this study, a patent application for a system for reproduction, selection, and growth of fish fry with the simulation of natural conditions is described. The article explains the method used to replicate the natural aquatic environment and create viable products with high genetic adaptability to its conditions. The process falls into the category of extensive aquaculture, promoting sustainable aquaculture by increasing the percentage of ecological and environmentally friendly productions. The study concludes with the results and the development of a set-up of the station for laboratory use.

***Key words**: aquaculture, artificial inteligence, future, technologies.*

INTRODUCTION

One of the most adaptable species in the wild and aquaculture conditions, the common carp enriches the variability of quantitative and qualitative characteristics and increases its genetic diversity.

Local aquaculture populations of common carp have developed within the species due to different environmental conditions, the efforts of fish farmers to breed them, and the relatively small size of the breeding population due to systems of strictly closed breeding grounds. Different genotypes were specifically developed after the middle of the last century and are referred to as "landraces" (Bakos, 1979). These populations are adapted to the local environment and have a high level of genetic diversity.

The introduction of *Cyprinus carpio* in many areas has led to a significant development of aquaculture, and carp farming now plays an important role in the economies of many countries. On the other hand, in some developed countries, such as the United States and Australia, where the species is not consumed outside the poorer segments of society, it is considered a pest (Dowal, 1996) and significant efforts have been made to eradicate it.

The negative impact of *Cyprinus carpio* on natural aquatic ecosystems is clearly observed in their behavior, such as uprooting and destroying aquatic plants as a result of their feeding habits (Laird, 1996). Carps also increase water turbidity by digging and mixing the top layer of the bottom, which decreases light penetration and destroys macrophyte populations in spawning grounds of photophilic species (Star, 2011; kerutokoi.com).

The main purpose of fish breeding is to improve existing breeds and hybrids and to develop new breeds, thereby increasing their productivity. To improve the quality of economically important fish species, their variation in many morphological, physiological, and biochemical characteristics is utilized. A significant proportion of this variation is heritable, and its value is very high in fish populations, which helps in the application of fish selection methods.

Compared to domestic animal husbandry, aquaculture is a relatively young science in

China and India, having been in vogue for a long time, but the domestication of fish and the creation of breeds that differ from their wild parents in terms of high productivity traits actually began only a few centuries ago. With the notable exception of the golden crucian carp, ornamental carp, and perhaps the common carp, few fish can be considered domesticated, even though some strains of trout, for example, are much more adapted to hatchery conditions than their wild counterparts (FAO, 1985).

Among the representatives of *Cyprinus carpio* suitable for aquaculture activity, only the common carp has been bred for a sufficiently long period, and distinct breeds of this species have been developed through selection. In the USSR, these include the Ukrainian carp, Ropsha carp, first-generation hybrids of domestic carp and Amur Wild carp, Nivchan carp, Central Russian carp, Kazakh carp, Kasnodar carp, Belarusian breed, and Parra breed (Kirpichnikov, 1981). In Israel, there is the carp "Dor-70" (Wohlfarth, 1980), and in Hungary, the Hungarian strain (Bakos, 1979).

MATERIALS AND METHODS

In order to carry out this work, the data that formed the basis of the patent application titled "System for Reproduction, Selection, and Growth of Fish Fry with the Simulation of Natural Conditions" was centralized. The patent is registered with the Romanian State Office for Inventions and Trademarks.

Materials

The block diagram of the installation for fish breeding and selection, as presented in Figure 1, describes the setup used inside the laboratory.

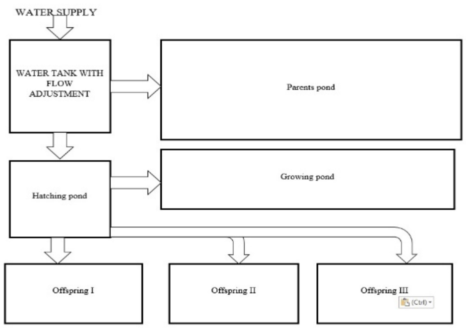

Figure 1. Block diagram of the installation for fish breeding and selection

The tanks are made of glass and filled with water from the breeders` aquatic environments.

A hydrological station is used to measure and monitor the qualitative parameters of the reference aquatic environment in order to replicate it in the reproduction station (Figure 2).

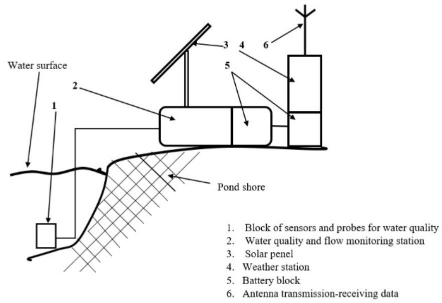

Figure 2. Installation for monitoring parameters of aquatic environments

Three specimens of *Cyprinus carpio* that have reached sexual maturity are represented by the biological material.

Methods

Portions of the aquatic environments from which the breeders come and where the offspring will be released are mapped out to be created inside the reproduction station (Figures 3, 4).

Figure 3. Overall map of fish farm for catch and release fishing (Google maps)

Figure 4. Map focusing on the area of interest with the exact area to be replicated clearly marked (Google maps)

All the materials used to replicate the natural aquatic environment are purchased from the reference aquatic environment, aiming to create viable products with high genetic adaptability to its conditions.

By applying these techniques, the process falls into the category of extensive aquaculture, at most semi-intensive, promoting sustainable aquaculture by increasing the percentage of ecological and environmentally friendly productions. It is especially important that the food is ecologically sound, with the possibility of carrying out a sustainable and efficient activity for the conservation of resources.

The installation for monitoring parameters of the aquatic environment has been installed on the shore of the lake that provides for the breeders.

By virtue of the application of new technology, namely the ability to multiply carp at any time of the year and to apply genetic analysis on the parents and offspring, electroanesthesia was used to anesthetize the adult specimens, both the female and the three males. (Șerban, 2020).

The applied method proved to be of real help, allowing the individuals to not be injured during manipulation, but it also led to the elimination of the semen without interfering with the pituitary gland. The observed semen was collected on a smear and analyzed in the physio-pathological analysis laboratory of USV Iași, with the result being the eligibility for reproduction, ascertaining the maturity and the ability to reproduce.

RESULTS AND DISCUSSIONS

After putting all the information together, we developed a set-up of the station shown in Figure 5 for laboratory use.

Figure 5. Laboratory set-up for hatching (original)

The selected biological material is represented by three *Cyprinus carpio* individuals: a female ornamental carp variety Koi Doitsu Kin Matsuba (Figure 6) and three male common carp varieties with scales, mirror, and topless (Figure 7.).

Figure 6. Koi Doitsu Kin Matsuba under laboratory conditions (original)

Figure 7. Aquaculture carp, var. mirror under laboratory conditions (origanl)

The ornamental carp variety Koi Doitsu Kin Matsuba comes from a controlled environment, with special feed being administered during the growth process to maintain the color and exceed the standard growth parameters, an important aspect in aquaculture (Bhaskar, 2015).

Feeding was carried out four times a day during the periods when the water temperature was between 18-28°C, and gradually, depending on the evolution of the temperature, a single ration per week was applied with the commercial feed, which falls qualitatively into the premium class for ornamental fish. The qualities that recommended this feed were the presentation in floating extruded form, with 4mm granulation, and the nutritional composition of 37% protein and 8.5% fat.

The female Koi Doitsu Kin Matsuba was 13 months old, 25 cm, and 900 g at the time of purchase and transfer to the laboratory. It was in perfect health. For the last 5 months, it has been kept in a glass aquarium with 130 l of water from its place of origin. It has been fed the same food as before acquisition, and only aeration and filtration operations have been applied to the aquatic environment. Filtration was applied during the summer, and now, with the aquatic environment temperature at 8-9°C, filtration is no longer necessary and feeding is applied once every 7 days. After 5 months in the laboratory, the specimen's metric indices are 31 cm and 1600 g, which falls within the limits of growth rates of ornamental carp (Table 1).

Table 1 Growth rate of ornamental carp*

Age (years)	Total length (m)	Body mass (kg)
0.5	0.12	0.05
1	0.23	0.3
1.5	0.32	1.1
2	0.39	1.4
2.5	0.45	2.25
3	0.51	3.15
3.5	0.55	4
4	0.59	4.95
4.5	0.62	5.7
5	0.64	6.55
5.5	0.67	7.3
6	0.69	7.86
6.5	0.71	8.48
7	0.72	9.03
8	0.73	9.5
9	0.75	10
10	0.76	10.4

*Adapted after koi owner`s notes (original)

The specimen purchased for the present study comes from a group of fifty ornamental carp of various varieties, all of the same age, purchased in Hungary. During its development, from the age of three months, it was kept in an outdoor pool on EPDM sheeting (Ethylene-Propylene-Diene-Monomer mixed with carbon black, oils, vulcanizing agents, and other auxiliaries). Great importance was given to transparency in order to observe the reactions of the carp and to identify any possible dysfunctions in the new aquatic environment.

Regarding stress, the female did not show extreme forms of manifestation, like the specimens of common carp that were brought to the laboratory. Used to the high transparency of the aquatic environment, it had no specific reactions to stress after transport or during handling during the study (e.g. no jumps when cleaning the filter).

The males selected for the present study come from an extensive rearing system, wherein feeding is almost non-existent, and food is provided by the natural productivity of the accumulation into which they are released in autumn, after being harvested from the pre-development ponds. This system of growth lends itself to accumulations with very large surface areas of water, where it is not profitable to invest in feed or incentives for the natural productivity of the pond.

Under these conditions, the fish are closer to the category of wild ones, exhibiting some characteristics in this regard. Carp raised in an extensive system differ from the others by the orange color of the lower part of the body, high tonicity, and vigorous appearance. At the time of harvesting, they are manifested by strong jumps and kicks that have a prolonged duration and a high intensity compared to common carp intensively raised, for example. Thus, due to this behavior and their vigor, they only lasted a maximum of 72 hours in the laboratory. Due to the strong impact on the walls of the aquarium, they presented parameters incompatible with life within a maximum of 3 days.

The three males selected to be transported to the laboratory - the scaled, mirrored, and topless varieties - were bred in June 2021 and are currently "parked" in a rearing pond at the collaborating farm. To ensure that there is no risk of losing the parents, they are kept in the conditions of the farm. They will only be brought to the laboratory for the application of reproductive procedures and the collection of samples for genetic analysis.

Carp length and body mass are parameters of interest in aquaculture, and in the extensive rearing system, the nutritional quality of the final product tends to be as close as possible to that of wild carp. As a result, Tables 2 and 3 highlight the standards encountered in wild carp and the limits of the recommended parameters in aquaculture, respectively.

Table 2 Growth rate of wild carp*

Age (years)	Total length (m)	Body mass (kg)
1	0.15	0.088
2	0.22	0.286
3	0.29	0.640
4	0.37	1.190
5	0.43	1.893
6	0.48	2.495
7	0.52	3.192
8	0.57	4.108
9	0.61	5.156
10	0.65	6.042

*after Papadopol, cited by Kaszoni, 1974

Table 3 Development periods and body mass of aquaculture common carp*

Period	Duration	Body mass (g)
Larval	3-7 days	0.025-0.05
Juvenile	15-30 days	0.2-1.0
Fingerlings	45-85 days	25-50
Youth	120-170 days	250-500
Adult	120-170 days	>1 000
Breeder	2-4 years	>4000
	1-2 years	>3000
	0.75-1 years	>2000

*According to FAO, 2022 and Bud - adapted

By comparison, it is easily seen that wild specimens weigh more than 1,000 g at the age of four years, while in aquaculture systems this weight is reached much earlier, after the second summer, at 16-17 months.

Specimens considered eligible for the present study fall within the standard measurements recommended in aquaculture: 27 cm and 1500 g (with scales), 27 cm and 1450 g (mirror), and 28 cm and 1500 g (topless). The three males are part of the same batch, and the same development technologies were applied to them; the differences are only registered as an aspect of their own evolution in the extensive system.

The semen obtained from the parents is divided into three equal parts and evenly distributed in the three aquatic environments that are the subject of the study: the aquatic environment of males, females, and bottled water.

These environments are in three aquariums, with each aquarium being introduced to 150 liters of water from each environment.

To create the necessary conditions in nature, *Pinus sylvestris* branches are placed as evenly as possible to cover as much of the available surface as possible, providing support for the adhesion of the fertilized eggs so that they do not pass underneath (Figure 8.).

Gauze "baskets" were created inside each aquarium and attached to the edges of the aquarium with special glass hooks in order to achieve aeration, swirling, and filtration inside the aquatic environment without disturbing the spawn attached to the pine branches.

Aeration (Figure 9), filtering, and heating (Figure 10) operations were applied to each environment. As seen in Figure 11, the aerators used had adjustable flow and direction, making it possible to swirl the water under the gauze "basket". On the opposite side, the filters were mounted, which also had the aeration function. Thus, the aquatic environment was swirled in both directions, ensuring the necessary conditions for the development of the larvae. On the same side as the filter was positioned the thermometer, which had an adjustment for the temperature value. By swirling the water on the opposite walls of the aquarium, the temperature was kept constant throughout the mass of the aquatic environment, avoiding large temperature fluctuations that are very dangerous for the development of future offspring.

Figure 8. Set-up for fertilized spawn (original)

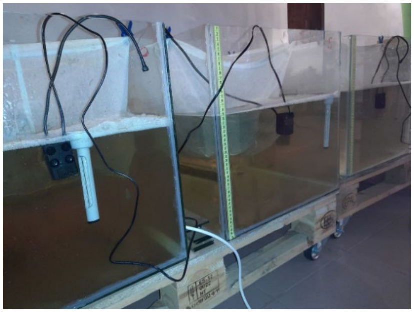

Figure 9. Aeration method applied to aquariums (original)

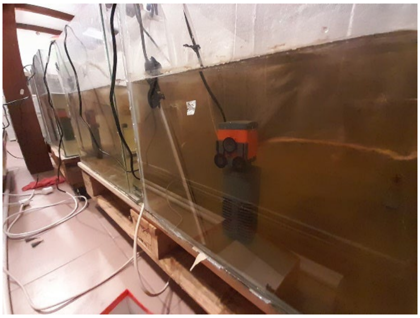

Figure 10. Method of filtering and heating aquariums (original)

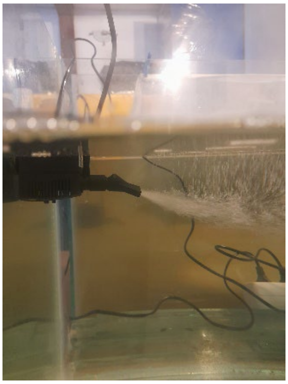

Figure 11. Aerator in operation (original)

To collect the data and create the database, a program specially developed for the used installation was used. It allows the user to set the time period during which the recordings are made, as well as the minimum and maximum limits of the monitored parameters, and it issues warnings regarding the recorded fluctuations (Figure 12.).

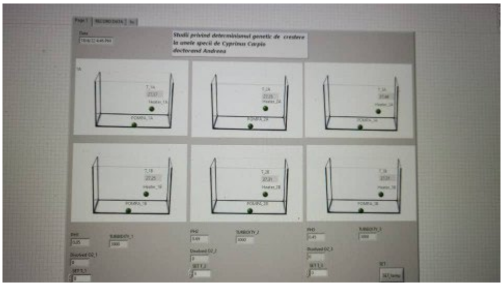

Figure 12. Software used in data collection (original)

After collecting the data, a sufficient database was created to conclude the effects of the techniques and technologies applied in the study at the aquaculture laboratory level.

CONCLUSIONS

The study describes the development of an installation for the reproduction, selection, and growth of fish fry with the simulation of natural conditions. The installation uses a hydrological station to monitor and replicate the qualitative parameters of the reference aquatic environment and biological material from three *Cyprinus carpio* individuals. The female is an ornamental carp variety Koi Doitsu Kin Matsuba, and the three males are common carp varieties. The feeding is carried out with a special feed, with high nutritional value, and is applied gradually, depending on the temperature of the water. Electroanesthesia was used to anesthetize the adult specimens, both the female and males, and the observed semen was collected on a smear and analyzed for eligibility for reproduction. The results showed that the setup can successfully replicate natural conditions for fish breeding, selection, and growth, promoting sustainable and environmentally friendly productions. The study's implication is that the findings can contribute to sustainable aquaculture and the conservation of resources. Further research is needed to explore the potential of the installation and the possibilities of genetic analysis.

REFERENCES

Bakos, J. (1979). *Crossbreeding Hungarian races of common carp to develop more productive hybrids*. In: Advances in Aquaculture (T.V.R. Pillay & W.A.Dill eds.), England: Fishing News Books Publishing House, 633–635.

Bhaskar, P., Pyne, S.K., & Ray, A.K., (2015). Growth performance study of Koi fish, *Anabas testudineus* (Bloch) by utilization of poultry viscera, as a potential fish feed ingredient, replacing fishmeal. International *Journal of Recycling of Organic Waste in Agriculture,* 4, 31–37.

Bud, I., & Diaconescu, Ș. (2010). *Breeding of carp and other fish species.* Bucharest, RO: Ceres Publishing House.

Dowal, R (1996). *Freshwater Fish of South-Eastern Australia* [ed. by Dowal R]. Chatswood, NSW, Australia: Reed Books Publishing House, 247 pp

FAO (1985). *Lecture Notes on Composite Fish Culture and its Extension in India*.

FAO (2022). *Leveraging automation in agriculture for transforming agrifood systems*.

https://www.kerutokoi.com/post/koi-varieties-benigoi

Laird, C.A., & Page, L.M. (1996). Non-native fishes inhabiting the streams and lakes of Illinois. *Illinois Natural History Survey Bulletin, 35*(1), 51.

Șerban, A., Ivancia, M., Caunii, V., & Creangă, Ș. (2021). Study on the electroanesthesia of some specimens of *Cyprinus carpio*. *Scientific Papers-Animal Science Series: Lucrări Ştiinţifice - Seria Zootehnie,* 76, 128–133.

Star, B., Nederbragt, A.J., Jentoft, S., Grimholt, U., Malmstrom, M., Gregers, T.F., & Jakobsen, K.S, (2011). The genome sequence of Atlantic cod reveals a unique immune system. *Nature, 477* (7363), 207–210.

Wohlfarth, G.W., Lehman, M., & Hulata, G. (1980) The story of "Dor-70", a selected strain of the Israeli common carp. *Bamidgeh, 32*(1), 3–5.