

Bioreproductive Variation in Populations of the Freshwater Mussel *Anodonta cygnea* (Linnaeus, 1771) Depending on the Aquatic Environment in which They Grow

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Abstract

The freshwater clams *Anodonta Cygnea* are part of the aquatic population of the 3 studied fishponds. The witness pond (Wp) is similar in characteristics to their natural rearing environment, pond 1 (P2) is populated with uniform fish stock in terms of age, weight and species variation, and pond 3 (P3) is similar to pond 1 in terms of populations and characters mentioned above, but the difference is that here a platform of 8 floating cages has been introduced here, where polyculture rearing of two-summer-old fish is carried out. The variations in the growth of the clams are visibly influenced by the specific characteristics of the studied ponds, thus in the control pond the bivalves had a weaker growth rate, in the second pond they had visibly higher values compared to the control group, in terms of total weight and standard lengths recorded. In pond number 3 (P3), characters such as total weight, standard lengths, shell mass and internal contents were compared with the two variants studied, so that the best results were obtained in pond 3 where integrated multitrophic aquaculture is applied.

Keywords: aquaculture, aquaculture products, IMTA, pond, sustainability, swan mussel, waste

1. Introduction

The approach to solving water protection issues used in aquaculture and fish farming is changing and the premise that wastewater is an important resource and not a waste is now predominant, with current research being directed towards the development of simpler, more energy-efficient and economically acceptable technological solutions for wastewater treatment [1, 2]. Mainly the application of these strategies is targeted at the application of biotechnologies, especially where favorable climatic conditions and large land areas

are used. The mechanism of treatment of wastewater used in aquaculture, by microbiological methods or biofiltration mechanisms are not laborious processes and can be reduced to the extraction of specific substances from wastewater directly with plants or through the food chain with animals that make up the food chain of the culture environment [3]. The aquatic biomass produced can be used as food or feed, with obligatory sanitary inspection, or as emergent in the by-product process. This paper presents the principles of application of integrated multitrophic aquaculture methods by utilization of wastewater and residues remaining in the technological stream.

Considered as secondary consumers, freshwater bivalves are more efficient at biofiltering the lower layers of water bodies, are more efficient at

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detecting disequilibrium in physico-chemical water parameters and are successfully adapting to recent climate change [4, 5].

The freshwater mussel species of the genus *Anodonta cygnea* is found in aquatic ecosystems of Europe and Asia, populating almost all rivers, lakes, ponds in Moldova and Romania [6]. In terms of environmental preferences, they frequent stagnant or shallow flowing waters up to 10 m deep, but in most cases, they populate they frequent places with a substrate, muddy- sandy substrate or in aquatic plant deserts of aquatic landscapes.

Recent studies on this species, however, are insufficient to cover current information needs, therefore among the sable to maintain their proportion of stock populations relative to their ranable to maintain their proportion of stock populations relative to their range studies found, it can be observed that these creatures are sensitive to organic pollutants, readily adaptable to changing environments and able to maintain their proportion of stock populations relative to their range [7].

Among the most recent studies today, the water crisis is a topic in full progress and, according to predictions, by the middle of the current century it will turn into a crisis of global proportions. The gap between currently available water supplies and the growing need for water, on the one hand, and the pollution of water resources, on the other hand, are becoming more pronounced by the day, so that the rational use of water resources and their

protection against further pollution, today and especially in the near future, is emerging as the main global concern. Carefully constructed fish polycultures (a larger number of different fish species in a single water body) have a more favorable effect on effluent quality than monoculture (a single species in a single water body) [8, 9]. The reason is that monoculture involves the entrainment of a narrow circle of substances and therefore has a limited effect on wastewater disposal and treatment. The advantage of monocultures is given only in the case of the final biomass, if it is used for human or animal consumption or for partial treatment of wastewater.

Depending on the aquatic environment in which it thrives, the swan mussel can adapt efficiently in any situation [10, 11]. Fluctuations in water temperature, chemistry and flow can visibly affect the instinctive behavior of the species [12, 13]. Migrations of mussels in an isolated water body occur when changes in certain parameters sensitively perturb their organisms.

Their association with the concept of IMTA is mostly applied in recirculating and aquaponic aquaculture systems [14, 15].

2. Materials and methods

The present study was carried out in three distinct water bodies (Figure 1-3).



Figure 1. Witness pond (Wp)



Figure 2. Fishpond in polyculture (P2)



Figure 3. Polyculture fish rearing pond with a floating cages platform (P3)

The constructive characteristics of the basins are as follows: surface (Wp:10000 m², P2: 2600 m², P3:35000 m²); they are equipped with individual water supply and discharge installations; Wp has a concrete slab embankment on all sides of the basin; they have an average depth of 1.5-2 m, the bottom of the basins is made of alternating layers of different components specific to hydro-technical constructions.

A different proportion of bivalves (*Anodonta cygnea*) has been introduced in all three ponds, given the fact that the three water bodies have the same water supply source (Ilfov river) and are equipped with individual water supply and discharge installations.

The population stocking data of the ponds was established so that one clam is stocked per linear meter (of the delimited area). As the characteristics of the bivalve population, the average size of the bivalves is 13.5~15 cm total length (Lt), circumference (C) 22~26 cm, weight 136~286 g (W). The analyzed ponds (Wp, P2, P3) have in the composition of the fish population multiple fish species (carp + Asian cyprinids + predatory fish). The fish stocking formula is polyculture, and in pond P3 in addition to polyculture, there is also a floating cages platform populated with 2-year-old carp (*Cyprinus carpio*). The technological operations carried out after the end of the growing season (April 2024 - October 2024) consisted in fishing all three studied ponds, assessing the fish biomass and collecting the introduced bivalves, determining the survival rate of the mussels, determining the food conversion index of the fish and correlating this index with the development of the mussel

biomass, performing biometry for the tagged mussels and determining the weight and size evolution (Lt, C, W).

The bivalves were placed in controlled spaces delimited with rigid netting to prevent them from migrating and being difficult to catch. Throughout the rearing season, additional feeds were given to the fish in the study ponds (P2 and P3), consisting of the following grains: corn (40%), wheat (30%), sunflower bran (20%), rice bran (10%). The grains were ground and mixed before administration.

3. Results and discussion

After the end of the growing season, when the stocked fish biomass stopped actively feeding, evaluation procedures were initiated. Once the fish is harvested and evaluated by determining the feed conversion index by determining the differences between the initial and final quantity (weighing the whole quantity obtained), the marked mussels were also weighed and measured in order to be able to differentiate the biometric data between the initial moment (April 2024) and the end of the season (October 2024). The amount of fish obtained from the catches was similar to previous years, so the introduction of an additional amount of mussels did not influence in any way the development of the main food chain (fish). Feed conversion ratio (FCR) - is the amount of feed consumed to obtain one kg of growth gain. It is calculated with the formula:

$$FCR = F / (B_f - B_i) \text{ (kg/kg), where:}$$

F - amount of feed fed (kg);

B_f, B_i - final and initial biomass of the batch (kg).

As a result of this calculation a FCR=1.3 (kg/kg) was obtained. Following the measurements carried out according to (Table 1.), in which the most obvious results of weight gain (Wi, Wf) of the mussels from the P3 basin were selected (the maximum - 286 g and the minimum 136 g), positive results were obtained in terms of the growth rate and the variation of the tracked biometric data.

For the witness pond (Wp) considering that the fish population is not as dense as the population norm, but the fish found here are larger in size, the total amount of fish is similar as the other two pools. The evolution of the biometrically assessed bivalve sizes is shown in (Table 2) and demonstrates a slower increase in total weight (Wi, Wf) total length (Li, Lf) and circumference (Ci, Cf).

Table 1. Biometric data record in P2 (W, Lt, C)

	W ¹ (g)		Lt ² (cm)		Circumference (cm)	
	Wi	Wf	Lti	Ltf	Ci	Cf
1.	211	234	13.5	14.4	22.5	22.9
2.	136	163	14.2	16	23.5	24.4
3.	239	250	14	14.7	23	23.8
4.	281	292	14.8	15.2	24	25.8
5.	218	229	13.6	14.1	23	23.5
6.	215	226	13.5	14	22	23
7.	261	271	14.9	15.3	24	24.4
8.	222	233	14	14.4	23.4	24
9.	256	267	15	15.9	24.5	24.9
10.	286	297	15	16	26	26.9

¹Weight measured in grams; ²Total length measured in centimeters

Table 2. Biometric data record in Wp

	W ¹ (g)		Lt ² (cm)		Circumference (cm)	
	Wi	Wf	Lti	Ltf	Ci	Cf
1.	215	236.5	13	14	23	24.1
2.	146	167.9	13.5	14.4	24.5	29.9
3.	238	314.1	14.2	15.1	24.8	26.3
4.	288	299.5	14.3	15.7	23.9	25.4
5.	240	249.6	15.1	16.1	25.7	27
6.	220	231	15.4	16.4	24.8	26
7.	221	227.6	14	15.2	22	23.3
8.	261	268.8	14.3	15.4	23.1	24.6
9.	250	257.5	13.4	15.4	24.1	25.4

Percentage-wise the most spectacular increase was 15% compared to the initial weight, the final total length (Ltf) had a maximum percentage increase of 15% and a minimum of 7%. In terms of final

circumference (Cf) the maximum increase was 6.5% and at the opposite pole the increase was with a percentage increase of 5% (the predominant percentage increase of selected bivalves).

Table 3. Biometric data recording in P3

	W ¹ (g)		Lt ² (cm)		Circumference (cm)	
	Wi	Wf	Lti	Ltf	Ci	Cf
1.	210	231	12.5	15.3	22	23.3
2.	160	185.6	13	13.9	25	26.6
3.	292	306.6	14	15.5	24.5	26
4.	248	256.6	13	14.8	25	26.6
5.	270	283.5	14.5	15.8	24	25.5
6.	218	225.6	13.8	14.7	23.6	25
7.	221	234.2	15.2	16.2	22	23.3
8.	244	254.9	15.3	16.8	25.5	27.1
9.	237	248.8	14.2	15.1	24.8	26.2
10.	280	305.2	14.1	15	25.4	26.7

In the experimental tank P3, according to (Table 3) there is a percentage increase in all analyzed biometric characters. As for the percentage of maximum weight recorded by analyzing the sample of ten selected bivalves, all of them showed a more accelerated growth than those collected and analyzed from Wp.

The positive results recorded in the two ponds (P2 and P3) can be attributed to the fact that the additional feed intake practically results in the formation of a larger feeding spectrum for bivalves as well. Since they are sedentary and do not swim long distances, when more food sources

are present in the normal feeding pattern they grow much faster. In the control pond (Wp), creating conditions similar to those of the natural environment in which the clams live, by creating a continuous flow of water supply and discharge, the lack of supplementary food, the water exchange rate and the difference created by the width of the pond also caused the growth of the clam population to be slower in weight and length, but their circumference was visibly larger in relation to total growth. This can be attributed to the higher concentration of minerals in the water, which facilitated shell development (Figure 4).



Figure 4. Freshwater mussel (*Anodonta cygnea*) biometric data recording.

4. Conclusions

Based on the three experimental variants of the study we can state that bivalves (*Anodonta cygnea*) play a positive role in freshwater bodies. Bivalves facilitate the hydro-biochemical balance of water; they can successfully be an integrant part of integrated multitrophic aquaculture. By their feeding specificity they contribute to the filtration of wastewater at the bottom of water bodies, where degradation processes of fish excretion products and other products take place. Thus, they prevent the accumulation of hydrogen sulphide and other toxic compounds present in fish waters.

The various changes in the culture environment (space, populations constituting the feed food chain, water supply/discharge rate, feed management) visibly influence the rate of development of the clam population.

Applied as an experimental variant in IMTA, the combined polyculture of freshwater fish with the

swan mussel (*Anodonta cygnea*) is a successful combination of the main feed chain (fish population) and freshwater bivalves introduced as final consumer and biofilter.

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