



UNIVERSITY OF LIFE SCIENCES "KING MIHAI I" FROM TIMISOARA

"YOUNG PEOPLE AND MULTIDISCIPLINARY RESEARCH IN APPLIED LIFE SCIENCES"



"Young people and multidisciplinary
research in applied life sciences"

16-17 November, 2023

Increasing the natural productivity of fish ponds by applying the IMTA concept for efficient use of natural resources

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Abstract: Aquaculture operates according to a principle of rational use of nature's trophic base, being in strict correlation with the biological period of growth and development of the fish stock in an area unit. In practice, the period during which the biological material is developing (polyphagy period) is exploited on the one hand, and the period during which the food spectrum is differentiated on the other. This gives polyculture particular advantages over monoculture, thus broadening the possibilities for exploiting the natural food base, when the biological material populated has a different food spectrum. Expanding the food base of ponds leads to increased final productivity. Obtaining and maintaining live food over a longer period of time is the main goal, followed by the processes initiated to achieve phytoplankton and zooplankton production through the administration of different types of manure.

• Introduction

At present, aquaculture farming technologies are based on a feeding system based on the use of both live feed and granular feed. Increasing natural productivity is an essential element in making production costs more efficient, but also for the welfare of fish stocks, which develop more harmoniously when the proportion of feed available to the fish is varied. Obtaining micro and macro food is necessary for increasing the natural productivity of ponds and for sustainable exploitation of the aquatic environment.

Different processes are used to produce a live feed culture for fish, depending on the needs of the farm and the fish stock. Aquaculture in Romania in general is focused on polyculture, less often monoculture and the farming of various economically valuable fish species. Polyculture is the best solution for cost efficiency because the feed value is much higher, given the different feed spectrum of the fish that make up the fish population. A good determination of the proportions of a stock within a pond has a direct proportional effect on the costs involved in purchasing additional feed. In order to exploit aquatic bioresources in a complex way, polyculture rearing experiments are carried out in anthropogenic aquatic ecosystems - ponds, which are defined from a trophic point of view by the presence of animal and plant populations that have an important trophic role, directly or indirectly on the main consumers (fish).

In order to obtain a higher fish production (>1000 kg/ha) a strict control of several factors involved in the system such as: stocking formulas, feed formulas, pond fertilization, water supply, maintenance works, etc. The starting point in developing an efficient rearing technology is knowledge of the trophic base of the ponds to be exploited, their control mechanisms, nutritional requirements and the biology of the crop species. Intensive fish farming makes it possible to exploit the land base (water) by obtaining a high production of fish meat per unit area in a short period of time, with lower economic and workforce costs.

• Material and method

- In order to increase the natural productivity of a pond, a series of technological operations directly influenced by the physico-chemical parameters of the water are carried out, as well as the determination of the optimal period of growth of aquatic microorganisms. In order to fully exploit the productive capacity of ponds, it is necessary to determine the groups of organisms that contribute to the final production of fish and to identify the factors that contribute to it.
- The creation of a zooplankton culture involves preparing ponds for culture initiation by administering various 'ingredients' that are intended to feed the aquatic organisms in practice.
- The first stage involves preparing the tanks under study (two 1400 m² tanks of the same depth and identical construction). The preparation consists of complete emptying of the ponds and leaving them on dry land for 10 days, chlorinating them by distributing 80 kg/ha of lime chloride in order to disinfect them, distributing as evenly as possible on the slopes and on their platform 300 kg/ha of untreated lime to improve the calcium values in the soil (with the aim of increasing the quality and quantity of the plankton), uniform distribution of 3 t/ha of manure, clearing of vegetation from the basin platforms and slopes, soil homogenisation work to a recommended depth of 30 cm.
- Before flooding the ponds, strategically place piles of manure (of known origin, of different origins, depending on the specific needs) of about 150-200 kg (total quantity for one hectare, 3 t), stop the water supply and discharge so as not to recirculate the water, flooding takes place gradually leaving a period of 10-12 days until the stimulation of aquatic organisms is achieved, then distribute daily for 7-9 days 3 times a day brewer's yeast 0.5 kg/day + 0.5 kg/meal rice flour, diluted in 10 l water. After flooding is carried out shortly, to avoid the development of aquatic vegetation and Spirogyra algae, a 1 mm mesh side screen is fixed in the feeding area and a 3 mm mesh side screen is fixed at the outlet.

To maintain the habitat during the growing season, *Spirogyra* algae and submerged vegetation are removed if it necessary, a permanent maintenance water flow of 10 l/s/ha is ensured and, if necessary, mechanical aeration of the water is carried out at dawn and during hot periods using aerators. The surface of one of the two ponds (BP6) is covered with netting for protection against ichthyophagous birds 15 cm wide, fixed along the dikes on iron and wooden posts.



Figure 1. Experimental pond BE6 covered with a predator netting (original)



Figure 2. Experimental pond BE7 without a predator netting (original)

• Results and discussions



- The qualitative and quantitative determination of aquatic organisms was carried out at species level after their numerical and gravimetric evaluation. For phytoplankton characteristic, the following were followed: numerical density, total biomass, algal group weight and species dominance. All these determinations were influenced by the different preparation of the two basins studied. The same parameters were analysed for zooplankton.
- The first pond, BE6 was covered with predator netting, the distribution and source of manure was different than for pond BE7. The chemical composition of the manure differed between species as shown in Table 1. Properly prepared manure can be used to increase the agricultural productivity of the land on which it is distributed. In addition to nitrogen, phosphorus, potassium and calcium, manure contains a significant amount of organic matter that is not found in synthetic fertilisers and is used to regenerate humus, (the component of soil that is necessary for the growth of animal and plant organisms). Comparing the data from table 1. Horse manure has a lower water content than cattle and pig manure, so the concentrations of nitrogen, phosphorus and potassium are higher in this case. The most suitable type of manure for fish farming is fermented manure, due to its high nitrogen, potassium, phosphate and calcium content, but the organic matter in its constitution has the lowest weight. The application of the Integrated Multi-Trophic Aquaculture (IMTA) concept to the studied technological flow in the two ponds BE6 and BE7 is based on increasing their natural productivity and introducing a carefully proportioned fish population into the system so that feed and live feed consumption is achieved at full capacity. Boosting natural productivity combined with good production management leads to a significant reduction in economic losses. The proportions of populations of aquatic organisms (phytoplankton and zooplankton) found at peak growth in both basins differ as follows:

Table 2. Phytoplankton population structure during the growing season in BE6.

Sampling interval	Density unit/l	Cyanophyta %	Chlorophyta %	Bacillariophyta %
May	3664	1	79	20
June	3109	4	49	47
July	4997	15	83	2
August	2405	3	57	40
September	1686	10	36	54

Table 3. Phytoplankton population structure during the growing season in BE7.

Sampling interval	Density unit/l	Cyanophyta %	Chlorophyta %	Bacillariophyta %
May	3529	-	71	29
June	3079	5	45	50
July	4198	12	78	10
August	2090	2	47	51
September	1480	6	44	50

Table 4. Zooplankton population structure during the growing season in BE6.

Sampling interval	Density unit/l	Cladocera %	Copepoda %	Rotatoria %
May	282	-	79	21
June	209	29	31	40
July	298	33	20	47
August	314	-	64	36
September	180	-	48	52

Table 5. Zooplankton population structure during the growing season in BE7.

Sampling interval	Density unit/l	Cladocera %	Copepoda %	Rotatoria %
May	298	-	21	79
June	234	-	82	18
July	159	8	30	62
August	229	-	28	72
September	207	-	53	47

• Conclusions

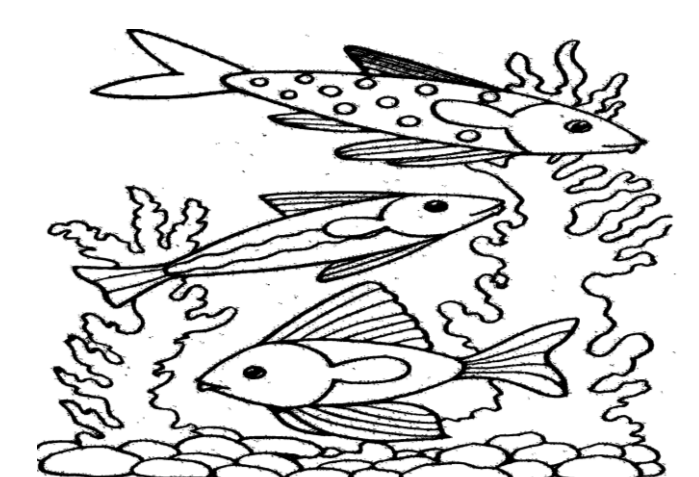
- By conducting concurrent cultures of aquatic organisms in the two studied ponds we can observe visible differences in the phytoplankton and zooplankton populations determined. Their development periods are also different in both experimental variants, with the change of the working protocol. The BE6 pond being covered with protective netting and having a different type of manure applied to it had a longer period of maintenance of active biocenosis, thus resulting in a higher natural productivity than BE7.

Due to the clearly superior chemical composition of the applied manure the active biomass was quantitatively much higher. The higher weight of the obtained results was directly influenced by the positioning of the manure piles, the specific microclimate formed due to the protective netting that obstructed the airflow and matter content of the manure is approximately double that of three to four month fermented manure. Nitrates and ammonium salts come from the degradation of dead organic matter or from nitrogen fixation processes in water, a process caused by nitrifying bacteria. Phosphorus plays an essential role for living organisms because the organic phosphorus compounds adenosine triphosphoric acid and adenosine diphosphoric acid are the main macroenergetics used by the organism, entering into the structure of the skeleton and the composition of nucleic acids. further influenced the natural evaporation and stratification process of the pond water. The water temperature was also directly influenced by the installation of the net. However, in addition to the abundant zooplankton and vegetation in the water, vegetation on the basin dikes has also developed, creating even less possibility for air currents to enter the system.

Both experimental variants provide an additional feed source for the fish populations that are introduced into the system, thus making feed and supplementary feed costs more efficient. Efficient exploitation of natural productivity in freshwater ponds practically applies IMTA principles, which are based on the active interconnection of the biotope and biocenosis established by the system. The highest efficiency in increasing natural productivity was obtained in the experimental variant applied in BE6 where the mixture of sheep manure and fully fermented manure was used in the ratio of 60% fully fermented manure and 40% sheep manure. Intensive fish farming, which makes much more efficient use of natural water resources, is characterised by reduced expenditure per unit area through minimum effort and maximum yield.



Figure 3. Collecting live fish food (zooplankton) in BE6 (experimental pond, original photo)



Acknowledgement: This research work was carried out with the support of the Fish Culture Research and Development Station Nucet and Faculty of Animal Productions Engineering and Management, University of Agronomic Sciences and Veterinary Medicine of Bucharest.