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.

Keywords: aquatic organisms, IMTA, manure, ponds, productivity, valorify

1. Introduction

At present, aquaculture farming technologies are based on a feeding system based on the use of both live feed and granular feed [1, 2]. 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 [3, 4], 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 [5]: stocking formulas, feed formulas, pond fertilization, water

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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 [6, 7]. 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. This experiment aims at how to achieve an increase in the natural productivity of the studied ponds by applying an effective manure combination. After obtaining the cultures of aquatic organisms, a study is carried out on the populations developed in the ponds and the efficiency of the technological operations applied is determined.

2. Materials and methods

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 have been carried out to establish the optimal period of growth of aquatic microorganisms. In order to fully exploit the productive capacity of the ponds, it was necessary to determine the groups of organisms that contributed to the final fish production and to identify the factors that contributed to its achievement. The development of a zooplankton culture involved the prior preparation of ponds for culture initiation by administering various 'ingredients' that were used to feed the aquatic organisms. In the first stage, the ponds under study were prepared (two ponds with a surface area of 1400 m^2, with the same depth and identical construction, called BE6 - experimental pond number 6 and BE7 - experimental pond number 7) (Figure 1, Figure 2).

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

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

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

Their preparation consisted of complete emptying and leaving them on dry land for 10 days, chlorinating them by distributing 80 kg/ha of calcium chloride with the aim of disinfecting, distributing as evenly as possible on the slopes and their platform 300 kg/ha of unrefined calcium to improve the calcium levels in the soil (with the aim of increasing the quality and quantity of plankton), 3 t/ha of manure was uniformly distributed, vegetation on the basin platforms and slopes was cleared and soil homogenization work was carried out to a recommended depth of 30 cm.

Prior to the pond flooding stage, manure piles (of known origin, of different types, depending on the specific needs) of about 150-200 kg (total quantity for one hectare, 3 t) were strategically placed, water supply and discharge were stopped, so as not to recirculate the water, flooding took place gradually leaving a period of 10-12 days until the stimulation of aquatic organisms was achieved, then brewer's yeast was distributed daily for 7-9 days 3 times a day 0.5 kg/meal + 0.5 kg/mass rice flour, these were diluted in 10 l water.

After flooding was carried out at short notice, to avoid the development of aquatic vegetation and *Spirogyra algae*, 1 mm mesh-side sieves were fixed in the feeding area and 3 mm mesh-side sieves were fixed at the outlet. To maintain the habitat during the growing season, *Spirogyra algae* and submerged vegetation were removed, and a permanent maintenance water flow of 10 l/s/ha was ensured, and where necessary mechanical aeration of the water was carried out at dawn and during hot periods using aerators. The surface of one of the two ponds (BP6) was covered with 15 cm side mesh for protection against hythiophagous birds, which was fixed along the dikes on iron and wooden posts.

The method of determining plankton biomass is that of filtering a quantity of water collected from the pond (Figure 3) and using a counting chamber both numerical and qualitative determination takes place [8].

3. Results and discussion

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 fertilizers and is used to regenerate humus, (the component of soil that is necessary for the growth of animal and plant organisms)

Table 1. Manure chemical composition (%)
(Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.icpa.ro/documente/CBPA2019.pdf)

Manure type	Water	Organic material	N	P	K	Ca
Fresh manure	75	21	0.50	0.25	0.60	0.35
Horse manure	71	25	0.58	0.28	0.63	0.21
Cattle manure	77	20	0.45	0.23	0.50	0.40
Sheep manure	64	31	0.83	0.23	0.67	0.33
Swine manure	72	25	0.45	0.19	0.60	0.18
Fermented manure 3-4 months	77	17	0.55	0.25	0.70	0.70
Completely fermented manure (middlings)	79	14	0.98	0.58	0.90	0.88

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 [9].

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 (original)

Sampling interval	Density (unit/ml)	Cyanophyta (%)	Chlorophyta (%)	Bacilloriophyta (%)
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 (original)

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

Tables 2 and 3 show the proportions of phytoplankton populations resulting from hydrobiological analyses carried out in the S.C.D.P-Nucet laboratory in 2023, in both studied basins, collected following the same working protocol and expressed in percentages. In the months in which the samples were taken, the monthly water temperatures were averaged (recorded in 3 intervals of days) and the result was that: in May the average water temperature was 21.8℃, in June 26.4℃, in July 27.9℃, in August 26.7℃, and in September 21.1℃. The influence of temperatures recorded in the water in the arrangement have direct influence on the growth and development of algal biomass can change the period of their life cycle. The qualitative and quantitative structure of the zooplankton obtained was also determined, with only 8 categories being observed, their density varying between 180 and 314 ex/l in the case of the BE6 pond, and 159 to 298 in BE7. The maximum development was captured in August in the case of BE6 and in the other pond in May. However, the average temperature in May was approximately the same as in September and the zooplankton populations showed different structures in proportion to the dominant category in both ponds.

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

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 (original)

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

Of the zooplankton categories encountered, copepods were most abundant in May and August in the BE6 pond, while in the other pond they were dominantly present in July and September. From the copepod category the representative species was *Macrocyclops* and their nauplii at different stages of development. Rotifers present in both ponds studied had the highest proportion in the months of June, July and August in BE6, while in BE7 they were mostly found in the months of May, July and August, represented by the following species: *Kellicotia longispina, Keratella cochlearis, Brachionus angularis and calicyflorus.* In June and July, cladocerea, represented by species of the *Daphnia* genus, *Bosmina and Moina*, were also abundant in BE6.

In contrast, they were present in BE7 only in a small proportion in July, about 8%. The manure distributed in both ponds had the following composition: in BE6 sheep manure was introduced mixed with complete fermented manure (middlings) in the ratio of 60% fermented manure and 40% sheep manure; in BE7 3-4 months old fermented manure and horse manure was introduced in the ratio of 60% fermented manure and 40% horse manure. The manure distribution was done in stages, strategically placing the manure piles along the edges of the ponds, quantitatively they were identical except for the piles positioned near the water supply to stimulate the formation of aquatic organisms so that due to the flow of water they could migrate to the rest of the surface [10-12]. In order to compensate for the low amount of calcium contained in sheep manure (0.33%) and phosphate (0.23%), the mixture was made with a higher percentage of fermented manure (60%) containing double the amount of these constituents, in the case of the BE6 pond. In the other pond studied, three to four month fermented manure was added due to the higher percentage of phosphate (0.25%), potassium (0.70%) and calcium (0.70%) to supplement the lower ratio of horse manure [13,14]. When using horse manure, the organic 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 [15, 16]. 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 [17-22].

4. 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 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.

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