DETERMINATION OF STOCKING DENSITY FOR CARP REARING (*Cyprinus carpio, Linnaeus 1758*) IN FLOATING CAGES LOCATED ON IRRIGATION CANAL

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Abstract

The purpose of this experiment was to determine the stocking density and evaluate its influence on the growth performance of carp (Cyprinus carpio) reared in floating cages located on an irrigation canal. The experimental period lasted 90 days. A number of 600 carp specimens were distributed in four floating cages so as to form different stocking densities, namely: Experimental variant 1 (V1) with 130 specimens and an average weight of 215 g/ex; Experimental variant 2 (V2) with 150 specimens and an average weight of 151 g/ex; Experimental variant 3 (V3) with 170 specimens and an average weight of 142 g/ex; Experimental variant 4 (V4) with 190 specimens and an average weight of 89 g/ex. The fish were fed three times a day with extruded feed containing 30% crude protein and 9% fat. At the end of the experiment, the fish growth performance was evaluated by calculating the productive bioindicators. Better results were obtained for the experimental variant V3. In conclusion, the species Cyprinus carpio presents a growing interest for rearing in floating caged located on an irrigation canal, that support a high level of intensity in aquaculture.

Key words: carp, stocking density, floating fish cages

INTRODUCTION

In aquaculture, efforts are increasingly being made to make fishery resources available to the population, especially the most vulnerable, at a lower cost while ensuring the efficient use of water resources [8].

Floating cage farming is considered an alternative to obtaining fish from fisheries and to utilising water resources for fish production. It is presented as the most appropriate production method to minimize the use of land and water resources and to provide large quantities of food products to the population in record time. This production method gives fish a variable zootechnical expression depending on the ecological quality of the water body, its importance, its depth and its renewal potential [9], [12], [17], [19], [2].

Floating cage aquaculture is an excellent way of fish culture by utilizing natural resources like rivers, lakes, flood plain areas, estuaries, seas, and reservoirs otherwise unworthy for traditional aquaculture [7]. This profitable fish culture technique is most important to the landless people as they can use communal water bodies for fish culture in cages [4].

The activity of aquaculture in cages requires first of all the knowledge of the aquatic environment specific to the irrigation canal where the floating fish cages will be located, of some environmental aspects and at the same time the biology of the cultivated species. The main advantages of this technology are: relatively fast recovery of water in cages (depending on their size) without costs; lower initial investments than on land technology; lower frequency of fish health problems; increased fish production (due to the high level of dissolved oxygen in the water stream of irrigation channels that stimulates the metabolism and the assimilation process of fish that materializes in a good growth spurt); increased production of vegetable crop biomass (by feeding it with

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water loaded with organic substances and nitrogen compounds from fishing activity) and last but not least avoiding environmental pollution by recirculating and using wastewater in the aquaponics system [22].

In cage aquaculture, stocking density has a direct inverse relationship with growth performance, specific growth rate, survival rate, food conversion ratio, body composition, and production of fish [25], [20].

Determination of optimum stocking density is prerequisite for the maximization of carp production in floating cage. The aim of this present study was to explore the suitable stocking density of carp, *Cyprinus carpio* as a potential culture species in floating cage culture in an irrigation canal CM Lunca, Galați.

MATERIAL AND METHODS

The experiment on determining the stocking density of carp reared in floating ponds was performed by mounting four units of this type on the CM Lunca irrigation canal, described by Nistor et al., 2020. The floating ponds used have a capacity of 2 m^3 and their description is presented by Nistor et al., 2020 with the difference that the diameter of the mesh used is 20 mm, estimated depending on the age and size of the carp (figure 1).

Fig. 1 Floating cages located on the irrigation canal

The biological material used in this experiment is represented by the carp species (*Cyprinus carpio, Linnaeus 1758*) from the Brateș Experimental Laboratory for Agro-Fisheries Research, Research - Development Institute for Ecology Galați - Romania. A number of 600 carp specimens were distributed in four floating cages so as to form different stocking densities, namely:

I. Experimental variant 1 (V1) with 130 specimens and an average weight of 215 g/ex;
II. Experimental variant 2 (V2) with 150 specimens and an average weight of 151 g/ex;
III. Experimental variant 3 (V3) with 170 specimens and an average weight of 142 g/ex;
IV. Experimental variant 4 (V4) with 190 specimens and an average weight of 89 g/ex.

The experimental period took place over 90 days (18.05.2021 - 18.08.2021), during which the aim was to determine the optimal stocking density for this intensive growth system.

The frequency of food administration was at 8 hours with 3 meals/day, the food was administered manually. In experimental period was administered a ratio of 3.5% of biomass (BW)/day. The fish were fed three times a day with extruded feed (the diameter of the granule is 4 mm) containing 30% crude protein and 9% fat. The biochemical composition of the feed used is presented in the table 1:

Table 1 The biochemical composition of *AQUA VITAL SWIM*

Composition	Quantity
Crude protein %	30.0
Crude lipid %	9.0
Crude cellulose %	3.5
Phosphorus %	1.10
Vitamin A (UI)	10000
Vitamin D3 (UI)	1750
Vitamin E (mg)	175
Vitamin C (mg)	165
Digestible energy (MJ/kg)	16.3

The assessment of water quality in the culture system was performed by daily monitoring of temperature, oxygen and pH using portable oxygen meter HACH HQD Field Case 58258-00, respectively by periodic determination of nitrates, nitrites, ammonium, chlorine and dissolved organic matter by the colorimetric method with the help of the DR 2800 spectrophotometer, the values thus determined were compared with those optimally admissible for the crop species.

RESULTS AND DISCUSSIONS

Intensive aquaculture technologies, ensure the complete utilization of space in a production system, improve the fish production and profitability by stocking high number of fish per cubic area. Fish growth and stocking density are negatively correlated owing to the competition for food and space resulting in stress, causing the growth reduction and compromising immunity [18]. Cost effective production should ensure maximum production with minimum physiological stress and disease incidence [13].

Water quality parameters (temperature and oxygen) were monitored daily at 8:00 a.m., 2:00 p.m., 8:00 p.m. The water temperature varied between 15.1-29.7^{0}C, being lower in June and reaching a maximum of 29.7^{0}C in July. The average values recorded both inside each floating cages and outside (irrigation canal) are shown in Figure 2.

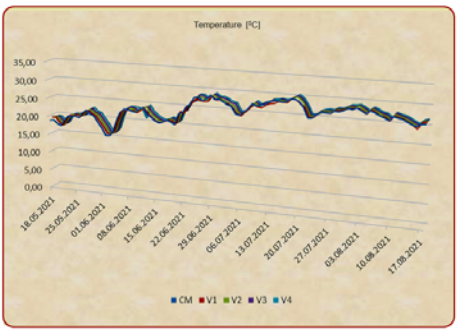

Fig. 2 Dynamics of temperature in irrigation canal (floating cages)

Dissolved oxygen registered significant variations, that range being between 4.37 - 18.20 mg/l. Since the water in the irrigation canal has a permanent dynamic due to meteorological phenomena (wind speed, precipitation), irrigation regime (days when no irrigation was carried out - weekend or periods when rainfall is abundant), algal flowering or massive development of aquatic vegetation. All these aspects lead to characteristic oscillations of dissolved oxygen in the water of the irrigation canal. These fluctuations are shown as average values of dissolved oxygen in Figure 3, where a significant decrease was observed at the end of the experimental period when the water temperature increased, and the eutrophication phenomenon occurred, affecting the crop biomass and requiring additional oxygenation with aerators.

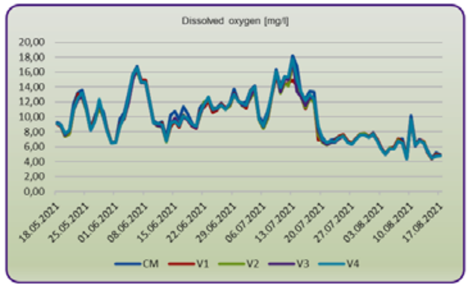

Fig. 3 Dynamics of dissolved oxygen in irrigation canal

The water level in the irrigation canal was measured daily with the help of the Secchi disk, and the recorded values are illustrated in figure 4, where a variation between 2.35-3.15 m can be observed, depending on the environmental factors and the irrigation regime.

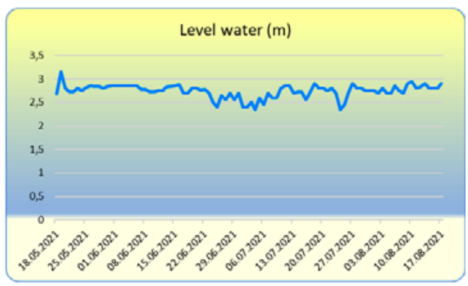

Fig. 4 Variation of level water in irrigation canal

The physico-chemical parameters of the water from the CM irrigation canal were monitored weekly, and the recorded values are shown in table 2, where it is observed that these parameters were within the specific gap of the crop species.

High storage densities can affect the digestion and absorption of feed [1], reduce the growth performance of fish, their survival, size variation, health, and mortality [21], [16]. Under the conditions in which the same feed ration was applied (3.5%), the growth performance differed in all experimental variants. This phenomenon may be due to the larger space and lower competition for food in the lower density variant compared to the higher stocking densities. The biomass growth for the experimental period varied between 64.87 kg/m^3 (variant V1) - 77.54 kg/m^3 (variant V4) and the best growth was obtained in variant V3 of 80.90 kg/m^3, where the stocking density was 170 specimens/floating cages (table 3). During the experimental period, the growth rate registered a positive evolution in the four experimental variants being illustrated in figure 5.

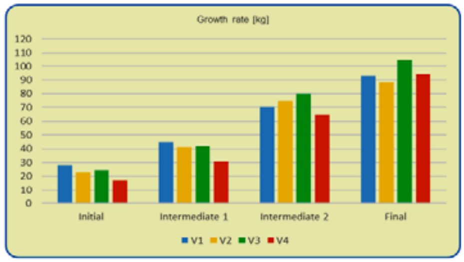

Fig. 5 Evolution of the carp growth rate in floating cages

According to a study by Firas et al. (2020) [11], at higher stocking densities, fish spent more time feeding and swimming and less rest time, which can negatively affect their growth. On the other hand, lower population densities can reduce the total production obtained [3], causing economic losses.

Table 2 The physicochemical parameters of water in floating cages (irrigation canal)

The physicochemical parameters	Units of measurement	Determined values			Maximum allowed values
		minimum	average	maximum	
pH	units pH	7.40	8.08	8.65	6.5-8.5
Organic matter	mg $KMnO_4$/l	46.13	73.07	97.8	60
Chemical oxygen consumption CCO-Mn	mg O_2/l	11.67	14.30	18.5	15
Calcium Ca^{2+}	mg/l	52.1	66.79	88.17	160
Magnesium Mg^{2+}	mg/l	7.29	29.16	48.6	50
Ca^{2+}/Mg^{2+}	Report	1.07	5.02	12.09	5
Total hardness	^{0}D	14.02	16.07	18.51	20
Nitrites NO_2^-	mg N/l	0.005	0.017	0.025	0.2
Nitrates NO_3^-	mg N/l	0.661	0.85	0.973	5
Chlorides Cl^-	mg/l	12.76	12.76	12.76	40

Table 3 Biotechnological indicators of farmed carp in floating cages

Experimental variants / Indicators	Floating cages			
	V1	V2	V3	V4
Initial number of fish	130	150	170	190
Final number of fish	120	140	160	180
Survival rate [%]	92	93	94	95
Initial biomass [g]	28010	22584	24218	16959
Initial biomass [kg/m^3]	28.01	22.58	24.22	16.96
Final biomass [g]	92880	88200	105120	94500
Final biomass [kg/m^3]	92.88	88.20	105.12	94.50
Biomass gain [g]	64870	65616	80902	77541
Biomass gain [kg/m^3]	64.87	65.62	80.90	77.54
Average initial weight [g/ex]	215	151	142	89
Average final weight [g/ex]	774	630	657	525
Individual weight gain [g]	559	479	515	436
Specific growth rate [%/day]	1.33	1.51	1.91	1.63
Fulton condition factor [K]	1.74	1.78	1.88	1.80

CONCLUSION

Survival rate and growth rate are the main problems for aquaculture in floating cages, as they determine the performance and profit of the production system.

The different stocking densities applied to the carp reared in floating cages located on the CM Lunca irrigation canal were evident in the final growth rate and the individual weight of the crop biomass.

The best stocking density obtained from the biomass growth analysis was obtained in the experimental variant (V3), where it was initially populated with 24.22 kg/m^3 and resulted in 105.12 kg/m^3 carp.

However, the results obtained were satisfactory, but the present study recommends further research on the determination of the optimal stocking density for rearing the biological material in floating cages, to maximize the final production.

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