Iraqi Journal of Agricultural Sciences –2026:57(8):2234-2244
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/f3fec434

Effects of Stocking Density on Growth Performance and Profitability of Cyprinus Carpio Fry Reared in Floating Cages at Tigris River Central Iraq

H.A Al-Hilali[1,2] , A. R. Lozovski, M. S. Al-Khshali[3] , H.A. Hamad[2,4]

[1]Astrakhan State University, Astrakhan, Russia. [2]Min. of Agric. ,Iraq , [3]Coll.Agric. Eng. Sci.,University of Baghdad, Baghdad ,Iraq, [4] Astrakhan State Techn. University, Astrakhan, Russia.

ABSTRACT

This study assessed the effect of stocking density on growth performance, survival rate, and profitability of common carp (Cyprinus carpio) fry in floating cages along the Tigris River, Al-Sewairah, Iraq. The 63-day experiment, conducted from April 15 to June 17, 2024, used three stocking densities: 100, 200, and 300 fry/m³ (G1, G2, and G3), with two replicates per group. Key parameters, including growth rates, feed conversion ratio (FCR), survival rates, and economic returns, were evaluated. Water quality remained optimal. Results showed significant differences ($P \leq 0.05$) in growth rates (7.89%/day for G1, 8.03%/day for G2, and 7.14%/day for G3), survival rates (81.6%, 80.25%, and 76.75%), and FCR (3.64, 2.69, and 6.0). Economic analysis revealed G2 had the highest net profit and benefit-cost ratio (BCR=1.6), suggesting it as the optimal density for maximizing productivity and profitability. These findings support floating cage aquaculture for sustainable common carp production in Iraq and similar areas.

Key words: economic Analysis , fry Development, production Efficiency, fish stocking Density, fish cage farming, freshwater fishes.

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Received: 23/1/2025, Accepted: 13/4/2025, Published: 31/8/2026

INTRODUCTION

Common carp *Cyprinus carpio* is one of the most widely distributed freshwater fish species globally, thriving in diverse environments from Scandinavia to Indonesia and from North America to Japan (Minns, & Cooley, 2000) In Iraq, carp inhabit fish farms, the Tigris and Euphrates rivers, and even their drainage systems (Anonymous, 2022.). Carp farming holds significant social, cultural, and economic importance, especially in regions where river fish is a staple food ,despite its relatively recent emergence in Iraq, carp farming has become an integral part of the aquaculture sector, driven by rising demand for aquatic products and the adoption of modern techniques such as cages (Naylor, et al. 2021). Aquaculture using Floation Cages aquaculture, characterized by its efficiency and adaptability, is a growing trend worldwide, with its benefits well-documented in Asia (Araujo, et al. 2022). In Iraq, this practice began as a low-cost solution for landless communities and later expanded into commercial-scale operations utilizing large cage systems (Soltan, et al. 2015). Floating cage systems, especially in flowing water, provide distinct advantages, including enhanced oxygen supply, waste removal, and nutrient availability (Soltan, et al. 2015). While growing carp to adulthood in ponds with limited water exchange is common, rearing larvae and fingerlings in floating cages remains relatively unexplored in Iraq's river systems. This study is one of the first to investigate the rearing of advanced carp larvae to fingerlings in floating cages under the environmental conditions of the Tigris River. The research focuses on the optimization of stocking densities, growth performance, and survival rates, aiming to establish standardized protocols for sustainable carp farming. Previous studies have highlighted the importance of optimal water temperatures (20–28°C) and stocking densities for maximizing growth and survival (Bhatnagar, &, Devi, 2013., Mocanu, et al. 2015, Mohale, et al. 2020). By addressing these factors, this

Iraqi Journal of Agricultural Sciences –2026:57(8):2234-2244
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI:

research contributes to advancing cage-based aquaculture in Iraq, offering a scalable solution for producing high-quality carp fingerlings directly in river systems for growing common carp in cages. These protocols can become the basis for the introduction of this species into the cage farming on the rivers of Iraq. Additionally, we aimed to assess the impact of stocking density on the growth rates, feed utilization, and survival rate of common carp, a potential species for diversification in floating cages. This study is one of the first Research on the cultivation of fry in cages and will be valuable for optimizing the technology of growing this important species under the environmental conditions of Iraq.

MATERIAL AND METHODS

The aim of this research was to experiment with various methods of growing carp fry. The goal was to produce fingerlings that could grow and fatten in the cages of commercial fish farms. One of the most a modern and effective method for growing and fattening fish was chosen: floating cages in natural water bodies. six floating cages were selected and rented from a private fish farmer's floating cage farm on the Tigris River in the Al-Sewairah area\Wasit government , near the Central Fish Hatchery (32°59’51”N 44°46’59”E) (fig. 1). The experiment was conducted from April 15 to 17 June, 2024. The growth and survival of the carp fry was conducted in six floating cages, sizes of each were 3 x 3 x 2 m (L * W * H =18 m3). The floating structure constructed from metal and wooden frames, the nets part (mesh size 2mm) is a cubic bag, the length and width of which coincide with the dimensions of the floating frame, the depth is 2 meters. They were installed in the shore of Tigris River with 4 meters depth and moderate water flow (0.4-0.6 m./ second). There were 3 treatments were carried out with stocking densities of 100, 200 and 300 grown larvae per m^3, each having double replications, then it will be referred to as; G1, G2 and G3. Undergrown larvae at the age of 35 days with average body weight of 1.25 g purchased from central state hatchery and were cultured in all net cages. The water samples were collected weekly from sub-surface of the cages at 8.00 am and chemical parameters such as dissolved oxygen were analyzed by using Hack kit box (HACK Kit, FF-2 USA). Water temperature, transparency, pH etc. were recorded by using Celsius thermometer, Secchi disc and pH meter respectively. In our experiment, dry granular feed with high protein content (Grower Food) imported from the Iranian Chineh Company was used to feed the fry at all stages of growth. The grain structure of the feed had a size of 0.5 mm. According to the results of our own analyses, the content of the main nutrients in this feed was: Crude protein: 39.80%, Crude lipids: 10.23%, Crude fiber: 4.22%, Ash: 11.54%, Moisture: 10.28%, Nitrogen-free extract: 23.93%. In addition, premixes were included in the feed. The amount of feed needed to feed the fry was determined at the rate of 6% of their current body weight. Every seven days, this amount was adjusted depending on the total biomass of fish, which was determined as part of growth monitoring. The fish were fed thrice a day: at 8 a.m., at 1 p.m. and at 6 p.m., in three equal portions. The latter action was to reduce the risk of being carried out of the cage by the river current. The feed was distributed over the surface of the water into a cage. Sampling was carried out seven, fourteen, twenty-one, twenty- eight and thirty- five days after planting. On each selection day, 25 fish were taken from each cage. Fish samples were randomly selected using a cage bench for catching fry, which had a suitable mesh size. Whole body weight (BW) of each fry was recorded with an electronic balance to the nearest 0.01 gram. The standard length (SL) of each individual was recorded to the nearest 0.5 millimeter. The length-weight relationship of the planted advanced larvae and harvested fingerlings was calculated using the following equation: $W = aSL^b$, where W is the dependent variable (body weight) and the independent variable (TL), (a) is the intercept and (b), the growth coefficient. Fulton’s condition factor (K) was calculated according to equation as per formula given below:

$K = W/ L^3 x\ 100$, where, W=weight of fish (g), L=Length of fish (cm).

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Figure 1. Location of experimental cages of carp fry rearing in Tigris River at Suwera district, Kut province, Iraq, (32° 52′42″N, 44° 46′59″E).

At the end of the trial period, we recorded the final weight of the fry (in grams), their specific growth rate (SGR), the feed conversion rate (FCR), and their survival. These parameters were used to evaluate the effectiveness of fry growth:

Daily weight gain (DWG) = (W2 - W1) / T

Specific growth rate (SGR) = (Ln W2- Ln W1) /T x100.

Condition factor value **(**Soltan, et al. 2015**)** (K) = (W / L^3) x l00

Where: W = weight of fish in grams. L = length of fish in centimeters

The survival rate was measured after the end of the experiment:

S.R. (%) = [number of fry caught / number of fry planted] x 100

An economic analysis was carried out to calculate the economic costs and economic efficiency of fingerling production. The profit, the total return on total variable costs (operating costs) and the total cost of fry were analyzed. Variable costs include the cost of larvae, fertilizers and feed needed for development, the gross profit margin was measured based on the current market price, and the gross yield was calculated based on the products sold. Gross profit margin, variable costs and total revenue were calculated using the following formula:

Investment Cost Analysis (ICA) =Cost of feeding (N) +The cost of keeping fry (N), all in Iraqi dinars (ID).

Net production value (NPV) = Average fish weight gain (g) × Overall survival rate (n) × Cost per piece (ID).

Gross profit (GP) = NPV – ICA

Benefit-Cost Ratio (BCR) = Total Sales/ Total Expenses

Margin %= (Selling Price — Cost) / Selling price × 100

All experimental data are presented as an average ± standard deviation.

All the descriptive statistics of the data was calculated by using Ms excel-2016.

Statistical analysis was performed using the t-test; the effect was considered significant at $p < 0.05$.

Before starting the experiment and to monitor the accuracy and nature of the larval production process and their development during the hatching, incubation and development period, the production process was directly observed inside the hatchery itself for 30 days, which is the period of integration of body development and undergrown larval growth to meet the conditions of meshed net of the floating cage.

RESULTS AND DISCUSSION

During this experiment, the water temperature varied from 19.5°C to 24.7°C. The minimum concentration of dissolved oxygen was 6.65

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mg/ l; the maximum was 8.82 mg/ l. The pH values were fixed at 7.01 – 8.32 units. The content of nitrogenous compounds in water changed over time. The minimum and maximum concentrations of nitrates, nitrites, and ammonium were as follows: Nitrates: between 0.35 mg/l and 1.48 mg/l; Nitrites: between 0.005 mg/l and 0.08 mg/l; Ammonium: between 0.34 mg/l and 0.62 mg/l (table 1). However, no significant differences were found in the average values of water quality parameters among the treatments ($p > 0.05$). This means that there was no deterioration in water quality due to differences in stocks during the different treatments. This is not surprising because the cages are closely connected and in the same conditions (fig.1). The water changes naturally: due to the flow, the wind mixing the water, and the active movement of the fish in the cages, It's current under the complex was on average 0.4- 0.6 m / sec and varied within 0.75 – 0.92 m / sec. The results revealed that during 63 days of cultivation in floating cages on the bank of the middle course of the Tigris River, the average weight of carp fingerlings in G1, G2 and G3 reached 19.52 ± 0.16 g with an average daily increase of 0.52 g of fish, 20.96 ± 0.09 g with an average daily increase of 0.56 g of fish and 15.23 ± 0.10 g with an average daily increase of 0.46 g of fish per day; the specific growth rate (SGR) was 7.89, 8.06 and 7.14 at the three densities indicated above, respectively (Table 2). The feed conversion rates (FCR) in the three sets of duplicated cages with increasing density were 3.35, 2.92 and 5.07, respectively.

Table 1. Mean values of physico-chemical parameters during the period of common carp fry growing

Parameters	30 day old larvae planting day	Sampling periods (age), days					Averages and range of parameters
		7 (42)	21 (56)	35 (70)	49 (84)	63 (98)	
Water temperature ^{0}C	G1	19.7	19.4	20.2	25,3	26.6	22.24 ± 0.45/ 19.7 – 26.6
	G2	20.2	20.2	21.1	24.8	26.8	22.32 ± 0.31/ 20.2 – 26.8
	G3	19.2	20.2	21.0	23.9	26.4	22.17 ± 0.23/ 19.2 – 26.4
water flow (0.4- 0.6 m/ second							0.4- 0.6 m/ second
Sg		Ns	Ns	Ns	Ns	Ns	
pH	G1	8.7	8.5	8.7	7.9	8.8	8,5±0.06/7.9 – 8.8
	G2	8.8	8.7	8.3	8.5	8.5	8.5±0.13/ 8.3 – 8.8
	G3	7.9	7.9	8.4	8.7	8.8	8.3±0.05/ 7.9 – 8.8
Sg		Ns	Ns	Ns	Ns	Ns	
DO, mg/l	G1	8.8	7.8	8.3	8.4	7.9	8.5/ 7.8 – 8.8
	G2	8.8a	7.8	8.6	8.6ab	8.0	8.4/ 7.8 – 8.8
	G3	8.2	8.1	8.4	8.1	7.9	8,2/ 7.9 – 8.4
Sg		*	Ns	Ns	*	Ns	
Ammonia–nitrogen (mg NH_3-N/L)	G1	0.39b	0.5b	0.78a	0.88c	0.98b	0.78/0.39 – 0. 98
	G2	0.45b	0.64b	0.88b	0.75b	0.86b	0.45/ 0.45 – 0.88
	G3	0.45a	0.63b	0.71c	0.77a	0.81a	0.45/ 0.45– 0.81
	G contr.	0.41a	0.62a	0.79a	079ab	0.85a	0.41/ 0.41 – 0.85
Sg		*	*	*	*	*	

The highest net production of fish mass occurred when the stocking density was 300 fish per m^3. This was due to that the number of survived fingerlings was higher although the final mass of an individual fish was lower at 15.23 grams compared to 19.67 grams and 21.05 grams at stocking densities of 100 fish and 200 fish per m^3, respectively. However, in the case of stocking density was 300 fish per m^3, the feed conversion rates (FCR) was higher, about 5, compared to about 3 at other densities (table 1). Therefore, stocking density

Iraqi Journal of Agricultural Sciences –2026:57(8):2234-2244
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had a significant effect ($p < 0.05$) on Specific growth rate, final weight, percentage of weight gain, feed conversion rate and productivity (Table 1). The survival rate of fingerlings decreased as the stocking density increased, but it remained within acceptable limits for all three groups. The G1 group had a relatively high survival rate of 81.6 %. The G2 group showed a slightly lower survival rate of 80.25%, and the lowest survival rate was recorded in the G3 group with 76.75. %. This indicates that fish survived better when stocking at a lower density. As the density increased, more fish competed for food, which led to an increase in mortality. There was no significant difference ($P<0.05$) in the initial weight of fries under various treatments (Table 2). At the same time, the difference in the average final weight and average weight gain of fingerlings at different stocking densities was significant ($p<0.05$). The specific growth rates (SGR) for G1, G2 and G3 treatments were 7.89±3.13%, 8.03±2.04%, 7.14±2.49% accordingly. There was no significant difference ($p<0.05$) between G1 and G2, but the significant ($p<0.05$) was between them and G3. After 65 days of the experiment, the survival rates were given as means at the level of 81.6±4.017, 80.25±3.38 and 76.75±4.29 at G1, G2 and G3, respectively. The highest value was obtained at G1, and the lowest - at G3. There was no significant difference ($p<0.05$) in the survival rates of carp fingerlings of G1 and G2; G3 differ significantly from two other options.

Table 2. The growth parameters of common carp during the study periods

Parameters	**Cage area- 18m^3 (3 x 3 x 2 meter) (reared for 63 day)**					
Experimental groups	group one - 100/m3		group two - 200/m3		group three-300/m3	
Number of planted undergrown larvae (30 day age)	1800	1800	3600	3600	5400	5400
Cage number (duplicate)	Cage 1	Cage1 +	Cage 2	Cage 2+	Cage 3	Cage 3+
Initial weight (g fish^{-1})	1.25±0.01	1.23±0.01	1.25±0.01	1.25±0.01	1.24±0.01	1.26±0.01
Total initial weight, kg	2.25	2.21	4.5	4.5	6.7	6.9
Av. Final weight (g fish^{-1})	78,22±0.28a		82,63±0.28b		73,52±0.36c	
Av. Individual weight gain	76,68± 0.25b		81,44±0.26a		73.37±0.35c	
SGR (% day)	6.57a		6.65a		6.47b	
Number of survived fingerlings	1463	1419	3321	3067	4147	4071
Pure Fish production, kg	112,18	108,81	230,56	225,35	195,02	166,18
Total consumed feed, kg	376,92	346,02	571,79	581,403	1002,40	872,45
FCR	3.36a	3.18a	2.48b	2.58b	5.14c	5.25c
Survival rate (%)	80.05 ± 0.24a		88.72 ± 0.32a		76.09 ± 0.29c	
Value representing same superscript horizontally do not differ significantly (P< 0.05)						

The survival rate (%) was significantly varied ($P< 0.05$) among different treatments; G1 had a considerably better average survival rate (81.6 ± 0.15) than G2 (80.25 ± 0.12) , and G3 (76.75 ± 0.20). The FCR were significantly ($P<0.05$) varied, with best values in G1 (3.460±0.05) than G2 (2.54±0.25) and G3 (5.69 ± 0.38). The specific growth rate (SGR, % day-1) was significantly ($P< 0.05$) higher in G2 (8.03 ± 0.13) than G1 (7.89 ± 0.04) and G3 (7.14±0.05). Growth patterns are shown in Fig.2. Thus, there is no doubt that during the treatment period of up to 28 days, there were no significant differences in growth, as measured by average weight ($p > 0.05$). owever, the growth did show significant differences ($p < 0.05$) among different treatments only towards the age of 56 days (Figure 2) and after that.

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P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
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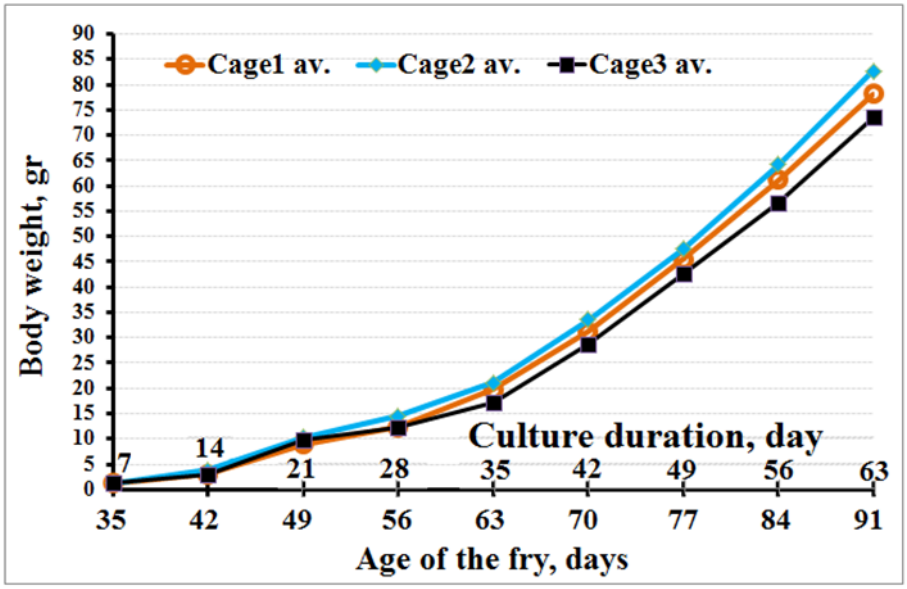


Figure 2 . Weight gain of common carp during study period**.**

The growth patterns of advanced larvae and the fingerlings expressed by the b value which were 0.35 and 1.15 respectively. For advanced larvae and fingerlings,and regression parameters *a* and *b* for these were within the range of Bayesian LWR predictions (Froese, Rainer, et al.2016.). The correlation coefficients (r) between the length and weight of advanced larvae (0.987) and the fingerlings (0.965) were not significantly differ (Figure 3, a, b).

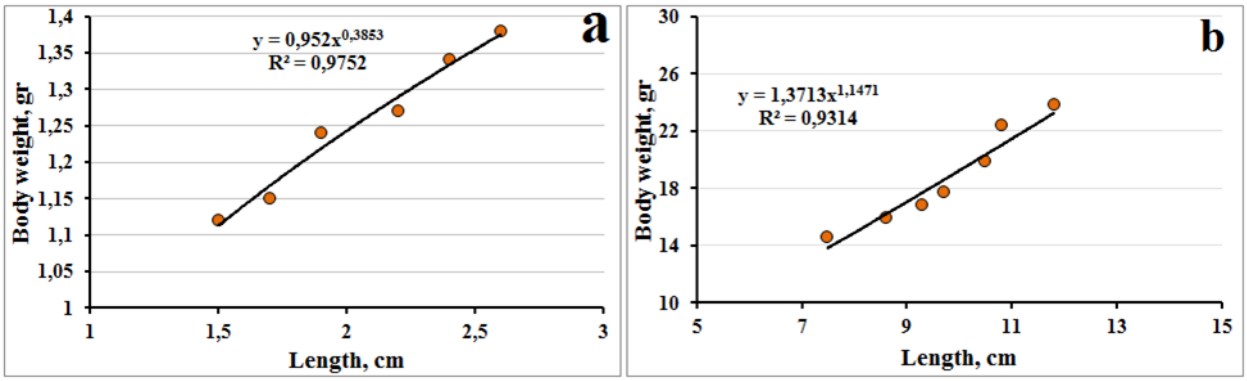


Figure 3. The length-weight relationship of the planted advanced larvae (a) and harvested fingerlings (b)

Correlation coefficient (r) suggest strong length weight relationship with ‘b’ value of around 1 which indicated negative allometric growth , meaning that the increase in body length was faster than the increase in body weight. The overall expense of fingerlings growing with varying densities was discovered to be lower in G1 compared to G2, and the highest in G3. Despite the overall cost of production, the greatest net profit was achieved with G2, surpassing those of G1 but not much higher than G3. (Table 3). Moreover, the individual weight was the highest in the treatment G 2 - 81,44 grams and the lowest in G 3- 73.37 grams which led to a decrease in the selling price of the fingerling and net return. All this appeared to be related with higher densities in G3 and increased the food conversion ratio. As can be seen from the growth rate pattern (Fig. 2), all options do not differ so much from each other. This is more likely due to the same growing conditions in floating cages of the same construction

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P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
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Table 3 Economic analysis of common carp in different treatments

Item	G1	G2	G3
1. Variable cost :			
Price of fry (approx. 20 ID/ fry)	72000	115560	216000
FCR	3.22±0.07	2.47±0.11	5.15±0.10
Mean final fingerling weight, gr	78,22±0.28	82,63±0.33	73,52±0.25
Mean Weight gain of fish (g)	76,68±0.25	81,44±0.26	73.37±0.35
Consumed feed, kg	722,94	1153,19	1874,85
Number of survived fingerlings	2882	6388	8218
Pure Fish production, kg	220.99	520.24	602.95
Feed cost (ID 1350/ kg) (% of TC)	975969 (66.5%)	1556806.5 (81.6%)	2531047.5 (40.8%)
Cages Rental + services (labors)	350000	350000	350000
Miscellaneous (5% var. cost)	69898.45	232937	127632.35
Total variable cost (TVC)(ID)	1117867.45	1556806.5	2680279.35
Fixed cost (cages rental) (ID)	350000	350000	350000
Total cost (TC) (ID)	1467867.45	1906806.5	3030279.35
Production:			
Total survival (wt. 75 – 80 gr)	2882x600 ID	6388x600ID	8218x 600 ID
Selling finger. (600 ID/fing.)	1729200	3832800	4930800
Net return (ID)	261332.55	1925993.5	1900520.65
Margin %	1.18%	50.3%	38.54%
benefit–cost ratio (BCR)	1.18a	2.01b	1.63a

A review of scientific literature has highlighted the importance of finding the ideal number of carp to place in mesh cages (Demétrio, et al. 2012; Wang, et al 2013). (Demétrio, et al. 2012;& Naylor, et al. 2021) found that there is an inverse relationship between the density of fish and their growth rate. As the stocking density increases, the production of fish also increases, but the individual weight of each fish decreases. Latter was confirmed by the present study where fish production in the different groups at the end of the experiment: G100 –, G200 – and G300, the individual weight gain was as follows: 78.22 g, 82.63 g and 73.52 g. In the field of aquaculture, the growth rate of fry plays a key role. The presence of fast-growing individuals makes it possible to significantly reduce the growing period, which, in turn contributes to increased production efficiency. However, the growth rate of a fish depends on the external environmental conditions in which it lives. The term 'environment' in this context covers not only the physical and chemical characteristics of the nutrient medium, but also factors such as the growing system, stocking density, type of feed and other conditions that affect the fish body. Water quality and stocking density have direct impact on the survival rate, growth, behavior, health, feeding habits, and production of fish (Huang, et al. 2008).The nutritional needs of farmed fish differ greatly depending on several factors, including the species, size of the fish, and other environmental parameters such as water temperature, physiological situation, stress levels, and the quality of the food provided (Schram, et al. 2006). Many researchers around the world have found that the optimal water temperature for growing common carp ranges between 18 and 28 degrees Celsius (Naylor, et al. 2021). It has also been suggested that the ideal water temperature range for carp cultivation in cages is between 22 and 28 degrees Celsius (Bhatnagar, & Devi, 2013; Mocanu, et al. 2015; Oprea, et al. 2015) Growing fingerling in such cages in local rivers and reservoirs can help solve the problem of high-quality advanced stocking material in order to become deficiency a source of additional income for fishermen with limited land and resources (Leroy, et al. 2019). In our current experiment, most of the environmental factors were optimal for growth. The fact that there were no significant differences in the water quality indicators of the analyzed cage location over the study period suggests that the cultivation system was well operated. The density of fish populations is a crucial factor that affects the growth and

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development of both wild and farmed fish species. Along with food supply, hereditary qualities, and natural conditions, this factor plays a significant role (eroy, et al. 2019). The higher density of fish in the cages may have caused them to experience stress, which in turn may have hindered their growth at the highest density tested. It is possible that the deterioration of water quality contributed to this stress. Additionally, the increased density of fish leads to competition for space, food, and oxygen, as well as increased activity levels, which results in higher metabolic rates and a decrease in growth (Ellis, et al. 2002). In a controlled environment, fish must swim faster to obtain food, and these activities require energy, which increases due to aggressive interactions (Thorarensen, & Farrell, 2011.). According to 8 , the number of fish for yearling carp farming should be 500 m. The higher stocking density of fish increased mortality rates (Wang, et al. 2013). 10 reported a negative relationship between stocking density and growth rate of fish. Fish production increases in parallel to stocking density, but at the expense of lower individual weight of fish (Nikolov, 2013.). Some researchers believe that the increase in stocking density up to 400/m could have a negative effect on growth intensity and alter the metabolism of fish as a result of higher stress levels (Braun, et al. 2010). This could result in lower production rate and even death of the farmed species (Kristiansen, et al. 2004; Schram, et al. 2006; Boscolo, et al. 2011). The financial success of aquaculture production management is largely determined by the affordability of feeding expenses. One method to decrease the cost of feeding is to assess the daily ration and develop a feeding plan that is tailored to the local farming environment. To maximize financial gain, it is essential to maintain the ideal stocking density in ponds for the desired growth and survival of fry. Therefore, this research was conducted to investigate the impact of stocking density on the growth, yield, and profitability of carp fry raised in floating cages. (Nistor, et al. 2021) In our study, raising of common carp fingerlings in cages and feeding them high-protein diets resulted in significantly higher growth rate in short time, even at much higher stocking densities compared to ponds. This also led to a higher rate of daily weight gain and cost effective. Farther, the economic success of production control in aquaculture depends to a large extent on reasonable feeding costs. One way of reducing feeding costs is to estimate the daily ration and formulate a feeding chart that will best suit local farming conditions.

CONCLUSION

- The study evaluated the effect of stocking density on the growth, survival, and profitability of Cyprinus carpio fry reared in floating cages on the Tigris River.
- The experiment demonstrated significant differences in specific growth rates (SGR), survival rates, and feed conversion ratios (FCR) among different stocking densities.
- The highest growth performance and survival rates were observed at a stocking density of 200 fish/m³ (G2), with the highest economic profitability achieved for this group.
- The group with 200 fish/m³ showed the best combination of growth performance, survival rate, and feed conversion efficiency, indicating that this is the optimal stocking density for maximizing productivity and profitability in the context of floating cage aquaculture systems in river environments.
- The study suggests that floating cage aquaculture is a viable and sustainable method for rearing common carp in river systems, offering an opportunity for scaling up production in Iraq and similar regions.
- Furthermore, this research provides important insights into optimizing stocking densities for carp farming, contributing to more efficient fish production and enhancing the economic viability of aquaculture in riverine environments.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

REFERENCES

Anonymous, 2022. Yearly fishery statistics of the Ministry of Agriculture in Iraq, the General

Iraqi Journal of Agricultural Sciences –2026:57(8):2234-2244
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI:

Directorate of Animal Resources, Fish Resources Directorate.

Araujo, G. S., J. W. Silva, A. D., Cotas, J. & L., Pereira, L., 2022. Fish farming techniques: Current situation and trends. Journal of Marine Science and Engineering, 10(11), 1598. https://doi.org/10.3390/jmse10111598

Bhatnagar, A. & P., Devi, 2013. Water quality guidelines for the management of pond fish culture. International Journal of Environmental Science, 3,1980–2009.

Boscolo, C. N. P., R. N. Morais, & E. Goncalves-de-Freitas,, 2011. Same-sized fish groups increase aggressive interactions of sex-reversed male Nile tilapia (GIFT strain). Applied Animal Behaviour Science, 135, 154–159. https://doi.org/10.1016/j.applanim.2011.10.003 .

Braun, D. R., J. W., Harris, N. E., Levin, J. T., McCoy, A. I., Herries, M. K., L. C., B. G. Bamford, Bishop, Richmond, & M., Kibunjia, 2010. Early hominin diet included diverse terrestrial and aquatic animals 1.95 Ma in East Turkana, Kenya. Proceedings of the National Academy of Sciences of the United States of America, 107(22), 10002–10007. https://doi.org/10.1073/pnas.100218110 7.

Das, A. K., D. K. Meena, & A. P., Sharma, 2014. Cage farming in an Indian reservoir. World Aquaculture, 45(3), 56–59.

Demétrio, J. A., L. C., Gomes, J. D. Latini, & A. A., Agostinho, 2012. Influence of net cage farming on the diet of associated wild fish in a Neotropical reservoir. Aquaculture, 330–333, 172–178.

Ellis, J., V., Cummings, J., Hewitt, S. Thrush, & A.,Norkko, 2002. Determining effects of suspended sediment on the condition of a suspension-feeding bivalve (*Atrina zelandica):* Results of a survey, a laboratory experiment, and a field transplant experiment. *Journal of* Experimental Marine Biology and Ecology, 267(2), 147–174. https://doi.org/10.1016/S0022-0981(01)00355-0

Froese, Rainer, et al.2016. "Revisiting safe biological limits in fisheries." Fish and Fisheries 17.1: 193-209.

Huang, C. C., H. J. Tang, & J. Y., Liu, 2008. Effects of waves and currents on gravity-type cages in the open sea. Aquacultural Engineering, 38(2), 105–116. https://doi.org/10.1016/j.aquaeng.2008.01.003

Kristiansen, S., A., Ferno, C. Holm, , L.,Privitera, S. Bakke, & E., Fosseidengen, 2004. Swimming behaviour as an indicator of low growth rate and impaired welfare in Atlantic halibut (Hippoglossus hippoglossus L.) reared at three stocking densities. *Aquaculture*, 230, 137–151 https://doi.org/10.1016/S0044-8486(03)00436-8

Kunda, M., M. A.,Kawsar, D., Adikari, S. T., Rishan, A. Harun-Al-Rashid, & D., Pandit, 2024. Investigation of the pangas (*Pangasianodon hypophthalmus*) cultivation sustainability in cages at the Ratargul Freshwater Swamp Forest of Bangladesh. Aquaculture, Fish and Fisheries, 4(4), e193. https://doi.org/10.1002/aff2.193.

Leroy, B., M. S Dias,., E., Giraud, B., Hugueny, C. Jézéquel, , F. Leprieur, & P. A.Tedesco,, 2019. Global biogeographical regions of freshwater fish species. Journal of Biogeography, 46(11),2407–2419. https://doi.org/10.1111/jbi.13674

Malik, A., H., Kalhoro, S. A. Shah, & I. B. Kalhoro, 2014. The effect of different stocking densities on growth, production, and survival rate of pangas (*Pangasius hypophthalmus*) in cemented tanks at Fish Hatchery Chilya, Thatta, Sindh-Pakistan. International Journal of Interdisciplinary and Multidisciplinary Studies, 1(10), 129–136.

Minns, C. K. & J. M., Cooley, 2000. International introductions: Are the incalculable risks worth it? In: Non-indigenous Freshwater Organisms. Lewis Publishers, New York, pp. 57–60.

Mocanu, M. C., T.,Vanghelie, , P. G., L. SanduDediu, & L., Oprea, 2015. The effect of supplementary feed quality on growth performance and production of common carp (*Cyprinus carpio L.*) at one summer of age, in pond aquaculture systems. AACL Bioflux, 8(4), 602–610.

Mohale, H. P., N. Sarang, & A. Y., Desai, 2020. The common carp and its culture system management.

Naylor, R. L., R. W., Hardy, S. R Buschmann, L. Bush, , D. H Cao, Klinger,. & M. Troell,

2021. A 20-year retrospective review of global aquaculture. Nature, 591(7851), 551–563. https://doi.org/10.1038/s41586-021-03308-6

Nikolov, G., 2013. Russian sturgeon (*Acipenser gueldenstaedti*) farming in a recirculation system at different stocking densities. *PhD Thesis*, Trakia University, Stara Zagora.

Nistor, V., Sîrbu, E., Dima, F. M., Patriche, N., L. B. Athanasopoulos, & others, 2021. Determination of stocking density for carp rearing (C*yprinus carpio, Linnaeus 1758)* in floating cages located on irrigation canals. Scientific Papers-Animal Husbandry Series, 74, 139–145. http://www.uaiasi.ro/firaa/Pdf/Pdf_Vol_76/Vet a_Nistor.pdf

Oprea, L.,M. C.,Mocanu, T., Vanghelie, P. G. Sandu, & L., Dediu, 2015. The influence of stocking density on growth performance, feed intake, and production of common carp (*Cyprinus carpio L*.) at one summer of age in pond aquaculture systems. AACL Bioflux, 8(5), 632–639.

Piska, R. S. & S. J. K., Naik, 2013. Introduction to freshwater aquaculture. *Intermediate Vocational Course, State Institute of Vocational Education and Board of Intermediate Education. Department of Zoology, University College of Science, Osmania University, pp.305

Schram, E., J. W., Van der Heul, A. Kamstra, & M. C. J., Verdegem, 2006. Stocking density-dependent growth of Dover sole (*Solea solea*). Aquaculture, 252(2–4), 339–347. https://doi.org/10.1016/j.aquaculture.2005.07.011

Soltan, M. A., M. M., Abdella, G. A El-Sayaad,. & M. H., Abu-El Wafa, 2015. Effect of some over-wintering regimes on survival and growth performance of Nile tilapia (*Oreochromis niloticus)*. Biological and Chemical Research, 2, 362–374.

Thorarensen, H. & A. P Farrell,., 2011. The biological requirements for post-smolt Atlantic salmon in closed-containment systems. Aquaculture, 312(1–4),1–14. https://doi.org/10.1016/j.aquaculture.2010.11.043

Wang, X., W., Dai, M., Xu, B., Pan, X.Li, & Y., Chen, 2013. Effects of stocking density on growth, nonspecific immune response, and antioxidant status in African catfish (*Clarias gariepinus*). Journal of Aquaculture-Bamidgeh, 65(6).

Iraqi Journal of Agricultural Sciences –2026:57(8):2234-2244
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI:

تأثير كثافة الاستزراع في أداء النمو وربحية إصبعيات أسماك الكارب الشائع (Cyprinus carpio) المُرباة في أقفاص عائمة في نهر دجلة وسط العراق

حسن علي الهلالي، اليسكندر روبيرتوفيش لوزوفسكي، محمد شاكر الخشالي ، حيدر عباس حمد

المستخلص

هدفت هذه الدراسة إلى تقييم تأثير كثافة الاستزراع على أداء النمو، ومعدل البقاء، وربحية صغار السمك من النوع الشبوط (Cyprinus carpio) التي تم تربيتها في الأقفاص العائمة على نهر دجلة في منطقة السويرة، العراق. تم إجراء تجربة لمدة 63 يومًا من 15 أبريل إلى 17 يونيو 2024 باستخدام ثلاث كثافات استزراع: 100، 200، و300 سمكة/م^3 (G1، G2، وG3)، مع تكرارَين لكل مجموعة. تم تقييم المعلمات الرئيسية، بما في ذلك معدلات النمو، ونسبة تحويل العلف (FCR)، ومعدلات البقاء، والعوائد الاقتصادية. ظلت جودة المياه ضمن النطاقات المثلى طوال فترة الدراسة. أظهرت النتائج اختلافات معنوية ($P\leq0.05$) في معدلات النمو النوعية (7.89%/يوم لـ G1، 8.03%/يوم لـ G2، و7.14%/يوم لـ G3)، ومعدلات البقاء (81.6%، 80.25%، و76.75%)، و3.64) FCR، 2.69، و6.0). أظهرت التحليل الاقتصادي أن G2 حققت أعلى ربح صافي ونسبة الفائدة إلى التكلفة (BCR=1.6)، مما يشير إلى أنها الكثافة المثلى لتحقيق أقصى إنتاجية وربحية. تدعم هذه النتائج استخدام أنظمة الأقفاص العائمة للاستزراع السمكي المستدام لشبوط النهر في العراق والمناطق المماثلة.

الكلمات المفتاحية : التحليل الاقتصادي، تطور اليرقات ، الأقفاص العائمة، الإنتاجية المتحققة، كثافة الاستزراع.