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Common carp (*Cyprinus carpio*) Stocked in Cage Culture in Dukan Lake, Kurdistan Region, Northern Iraq: Effects of Stocking Density on Growth Performance, Survival Rate, and Somatic Index

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Abstract

This study examined the effects of stocking density on the growth, survival, and overall health of common carp Cyprinus carpio in net cages at Lake Dukan, in the Iraqi Kurdistan Region. Common carp with an initial weight of 180 ± 5 g were used in nine experimental net cages (7 m × 7 m × 3 m, 147 m^3) for the study. The three different common carp stocking densities (1000, 1250, and 1500 fish/cage, or 6, 8, and 10 fish/m^3) were assessed using three replicates for each treatment. The trial was conducted for 120 days, and the fish were fed commercial floating feed. Fifty fish were taken out of their cages at random every two weeks in order to assess their weight gain and adjust their diet. Total and daily weight, feed conversion ratio, survival rate, and somatic index were measured at the trail's end. The final weight, weight gain, daily weight gain, and specific growth rate (1546 g, 1363.9 g, 11.37 g, and 1.8), respectively, were found to be highest at the lowest stocking density of 1000 fish/cage, and the lowest stocking density had the best feed conversion ratio (1.52). Additionally, the fish applied at 1000 fish/cage had the highest flesh weight index (75.03) and recorded survival rate (96%). It was determined that the condition factor and organ somatic index of cultured fish were unaffected by stocking density. According to our results, stock fish at a density of 6 fish/m^3 with an initial weight of 180 g are suitable for the cage culture of common carp in northern Iraqi lakes.

Key words**:** Biological Parameters, Cage farming, Fish, Weight gain

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Introduction

Fish populations in natural waters declined as a result of overfishing and adverse environmental conditions, which motivated scientists to discover other ways to prevent the reduction in fish water productivity [1]. Fish cultured in cages are seen as an alternative to fish harvested from fisheries and fish produced using water resources. It is promoted as the most suitable production technique to reduce the use of water and land resources and to quickly supply people with huge quantities of food products [2]. According to [3], one of the most significant advancements in cage farming in recent years has been using of floating cages. The most significant benefits of this system are its low cost, efficient use of water, and simplicity in treating and controlling diseases. Water resources in Iraq can supply the essentials needed for successful fish cultivation in cages. A sustainable growth rate may be maintained by the environment for at least ten months. This has prompted financiers and fish farmers to adopt this method and profit from its benefits [4]. There is little research on cage culture in the Kurdistan region of northern Iraq. Recent years have seen a dearth of articles published on some experimental studies. Among these is the research done by [5] in Duhok, where they examined the effects of different protein levels in carp feed on growth and feed conversion. In the Kurdistan Region of Iraq, [6] studied the feeding of common carp fish (*Cyprinus carpio*) on natural feeds in the Tigris River at Mosul Dam/Duhok.

In Iraq and Kurdistan, the common carp is one of the most popular fish to eat. According to [7], common carp is preferred because of its great resilience to difficult environmental circumstances, ease of breeding, availability of a variety of food sources, and great growth range in breeding ponds. Furthermore, [8] clarified that in floating cage fish farming in Europe, Asia, and the Middle East; common carp dominate other fish species. The capacity of a fish to produce income depends strongly on its stocking density. For improved fish growth, physiology, and general development, the ideal stocking density in cage culture is essential [9]. Fish growth rate and behavior are influenced differently by stocking density depending on several factors, such as fish species, size, and culture conditions. Determining the ideal density is necessary since higher stocking densities may have adverse impacts on farmed fish, including elevated stress, disease rate, mortality, and even a declining feed conversion ratio [10; 11]. However, different species, environments, and culture systems will have different ideal stocking densities [12], which will affect fish survival rates [13]. There is, however, no data on how stocking density affects the common carp's ability to grow in cages in Iraq's Kurdistan region. Thus, the main goal of this research was to determine how stocking density affected the common carp cultured in cages on Lake Dukan in the Iraqi Kurdistan region in terms of growth performance, survival rate, and health aspects.

Materials and Methods

1. Study location and cage installation

The study was conducted on a private farm that actively engages in cage fish farming in Lake Dukan, one of the most important lakes in the Kurdistan Region of Iraq. It is a reservoir on the Little Zab formed by the building of the Dukan Dam and is situated near the city of Ranya (Figure 1). Because of the safety and fresh, pure water, the site selection requirements were upheld to create suitable circumstances for cage protection and to preserve the welfare of fish. The study was carried out from July 15, 2023, to November 15, 2023, for a duration of four months. Nine rectangular net cages with a mash size of 1 cm, each measuring 7 m × 7 m × 3 m (L × W × H, 147 m^3), have been placed in the lake for this experiment. The cage framework used to hang these net cages was made from galvanized iron (GI) pipes. A large piece of mesh (3 cm) was placed over the top of the experimental cage to keep birds from snatching the fish and preventing them from jumping out. The spacing between the cages was 0.5 m, and aluminum rafts were positioned atop the cage frame to allow for horizontal movement, which facilitated and intensified the daily observation procedure, feed supply, and experimental fish sample. 200-liter air-filled polyethylene drums were utilized as cage floats to ensure the buoyancy of the cage framework. Cages were positioned 5 meters above the bottom and 30 meters from the beach to provide a complete flow of waste and dissolved oxygen circulation, which promotes the healthy growth and well-being of cultured fish. The cages' water level was maintained at three meters. Dead fish were taken out of the cages every day, and the nets were cleaned every two weeks to ensure that there was enough water flowing through them. Additionally, the cages' conditions were checked out to find out whether or not they were harmed. During the cultural period, no outdoor worker was engaged; the entire farm was handled by local fish farmers.

2. Experimental Fish

Mixed-sex the same race of *Cyprinus carpio*, weighing 180±5 g, were bought from local hatcheries and delivered to the cage location by a special track. Before being utilized in the experiment, they were fed and allowed to adjust to their floating net cages. The seed was conditioned by delaying feeding it by one day before transport.

3. Experimental Procedures

Common carp were used to fill nine experimental cages for the purpose of the study. For each treatment group, we evaluated three replicates of each of the three stocking densities (1000, 1250, and 1500 fish/cage or 6, 8, and 10 fish/m^3) designated as treatments one, two, and three. The fish were hand-fed commercial floating feed (chemical composition in Table 1). Fish samples were taken at random using a scoop net, and 50 fish were taken from each cage every two weeks in order to assess their weight gain and adjust their diet. The fish were then promptly placed back into their cages after being weighed using a digital weighing device. Six days a week for the duration of the 120 days, all the fish were fed at a rate equal to 4% of their biomass for the first two months and 3% of their biomass for the second two months. The portion of feed for each day was split in half and given to fish twice per day. The mobility, colors, infections, and illnesses of the fish were all determined by routinely observing their activity, particularly after feeding them in the morning and evening. Throughout the trial period, no medications or antibiotics were administered. Dead fish were promptly removed, and their survival rates were recorded over the research period (15/7/2023 to 15/11/2023).

Table 1. Formulation and proximate composition of the experimental diet (% dry matter).

Ingredients	Inclusion level (%)	Proximate analysis	
Soybean meal	40	Crude protein (%)	33.5
Yellow Corn	15	Crude fat (%)	7.8
Wheat	32.5	Crude Fiber (%)	18
Fish meal	7.5	Ash (%)	15.8
Oil	1.5	Moisture (%)	4.2
Vitamin premix	2.5		
Mineral	0.8		
Antitoxin	0.2		
Total	100		
Size	4 – 6 mm		

4. Fish growth performance

After 120 days of the experimental period, all the fish were harvested from each cage on the same day. Each cage's harvested common carp were weighed in bulk, and 50 fish were chosen at random for individual weight and length measurements from each cage. Before every sample, the fish were fasted for a full day. Using the following formulas, growth, feed conversion ratio, and survival rate were determined:

- Weight gain (g) = W2–W1
  W2: Fish weight at the end of the experiment
  W1: Fish weight at the beginning of the experiment
- Daily weight gain (g) = W2–W1/ T
  T: the time between W2 and W1 120) (days
- Specific growth rate (SGR) % = (Ln W2 – Ln W1)/ T) x 100
- Feed conversion ratio (FCR) = Total feed fed (g)/ Total wet weight gain (g)
- Survival rate (%) = 100 (final fish number / initial fish number)

5. Biological and health Parameters (Organ somatic Index)

Twenty fish were chosen at random from each cage after the experiment to be utilized for anatomical measurements. Each fish specimen was dissected, and the abdominal cavity was opened to weigh each organ separately. The measurements were calculated as follows:

- Fulton condition (K) factor = 100 (fish weight g / fish length cm^3)
- Viscera somatic index (VSI, %) = 100 (viscera weight g / fish weight g)
- Hepatic somatic index (HSI, %) = 100 (liver weight g / fish weight g)
- Gills somatic index (GI, %) = 100 (gills weight g / fish weight g)
- Spleen somatic index (SSI, %) = 100 (spleen weight g / fish weight g)
- Kidney somatic index (KSI, %) = 100 (kidney weight g / fish weight g)
- Intestine weight index (IWI, %) = 100 (intestine weight g / fish weight g)

Meat and fat index:

- Fish weight index % = (Fish weight without Viscera g / Fish weight g) x 100
- Meat weight index % = (Fish weight without Viscera & Head g / Fish weight g) x100
- Fat index % = (Cavity fat weight g / Fish weight g) x 100

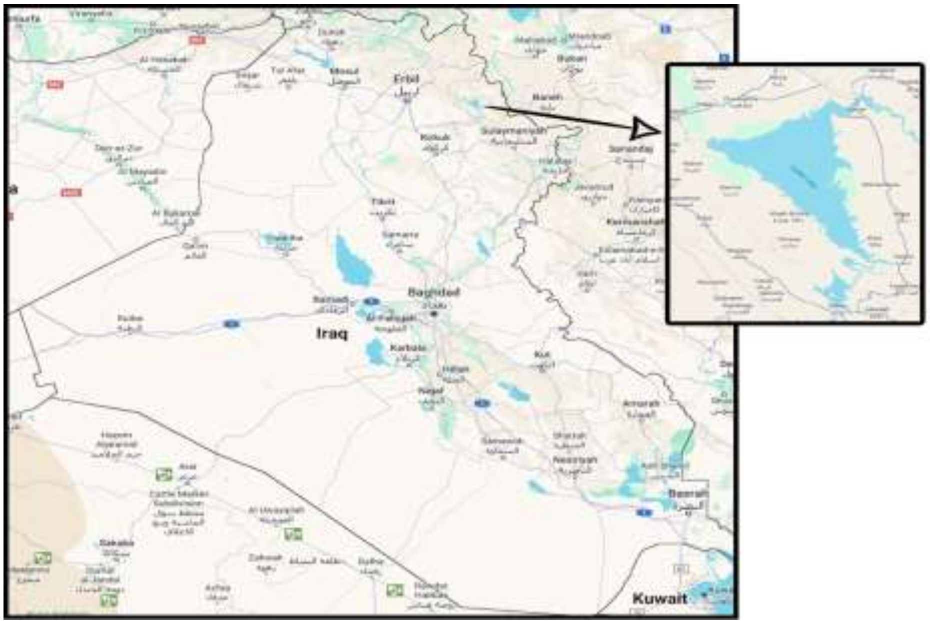

Figure 1: Map of Dokan Lake shows the location of the studied area.

6. Water quality parameters

During monthly fish sampling in the morning (08:00–11:00 h) and evening (15:00–18:00 h) of the experimental period, important water quality parameters that control fish productivity, such as pH, dissolved oxygen (mg/L), and water temperature (^{o}C), were measured at the middle depth of each cage. A thermometer was used to test the water's temperature; an oxygen meter (OAKTON Singapore) was used to find the dissolved oxygen content; and a Germane pH meter was used to assess the pH.

7. Statistical analysis

Data obtained from the various parameters were analyzed with a one-way ANOVA using XLSTAT, Pro 7.5. The differences among means were assessed using Duncan's Multiple Range Test ($p \leq 0.05$). All data are represented as mean±standard deviation (SD).

Results and Discussion

Table 2 summarizes the average values of the water quality variables that were measured in the cages throughout the experiment. In July, the water's highest temperature was 28.2 ^{o}C, while in November; the lowest temperature was 20.8 ^{o}C. The reason for this is variations in the duration of daylight hours and the seasons of the year. The PH range of the water was 7.6–7.3, while the dissolved oxygen was 6.5–6.9 mg/L. Throughout the study, the three treatments' assessed water quality parameters were determined to be within an acceptable range for the culture and welfare of fish kept in floating cages [14].

Table 2: Parameters of the water quality within the cages at various months throughout the culture period.

Parameters	Temperature (°C)	Dissolve oxygen (mg/L)	PH
July	28	6.5	7.6
August	28.2	6.5	7.6
September	26.3	6.8	7.4
October	23.2	6.9	7.3
November	20.8	6.9	7.3

Table 3 displays the results for the common carp growth patterns stocked at three different stocking densities. The fish under study had mean weights of 180g at the beginning. Variations in stocking densities had significant effects (P≤0.05) on the growth characteristics of the fish during the study. At the lowest stocking density of 1000 fish/cage, the final weight, weight gain, daily weight gain, and specific growth rate (1546 g, 1363.9 g, 11.37 g, and 1.8) respectively, were shown to be the greatest. At the maximum stocking density of 1500 fish/cage, there was a significant (P≤0.05) decrease in growth responses. The lowest stocking density had the best FCR (1.52), while medium and high densities showed deleterious FCR values (Table 3). The fish supplied at 1000 fish/cage had the highest recorded survival rate of 96%. Moreover, the survival rate of fish supplied at 1250 fish/cage was 94%, while the survival rate of fish stocked at 1500 fish/cage was 93%.

Table 3: Growth performance, survival rate, and feed utilization of common carp in cages after 120 days of experimental period.

Parameters	Treatment one 1000 Fish/cage	Treatment two 1250 Fish/cage	Treatment three 1500 Fish/cage
Average of initial weight (g)	182.1±0.06	180.6±0.03	181.1±0.04
Average of final weight (g)	1546±0.02 [a]	1344±0.02 [b]	1252.6±0.01 [c]
Weight gain (g)	1363.9±0.03 [a]	1163.4±0.04 [b]	1071.5±0.02 [c]
Daily weight gain (g)	11.37±0.03 [a]	9.7±0.05 [b]	8.93±0.02 [c]
Specific growth rate (SGR) (%)	1.8±0.01 [a]	1.7±0.02 [b]	1.62±0.01 [c]
Feed conversion ratio (FCR)	1.52±0.03 [b]	1.54±0.05 [b]	1.68±0.02 [a]
Survival rate (%)	96	94	93

Note. Means with different letters in the same row are significantly different at P≤0.05. If there are no letters, there are no treatments that vary significantly.

Table 4 shows the biological and health-related outcomes of common carp at various stocking densities. The impact of stocking density on condition factors in cultured fish was found to be not significant (P≥0.05). The treatments with 1000, 1250, and 1500 fish/cage exhibited similar mean condition factors of 1.72, 1.73, and 1.75 respectively. Over a period of four months, there was not a significant effect on the biological performances of common carp, including VSI, HSI, GI, SSI, KSI, and IWI from fish in cages at 1000, 1250, and 1500 fish/cage.

Table 4: Biological and health parameters of common carp after 120 days of experimental period

Parameters	Treatment one 1000 Fish/cage	Treatment two 1250 Fish/cage	Treatment three 1500 Fish/cage
Fulton condition (K) factor	1.72±0.05	1.73±0.02	1.75±0.04
Viscera somatic index (VSI, %)	12.4±0.05	12.83±0.05	12.9±0.06
Hepatic somatic index (HSI, %)	2.7±0.08	2.92±0.28	2.95±0.17
Gills somatic index (GI, %)	2.4±0.07	2.38±0.1	2.4±0.1
Spleen somatic index (SSI, %)	0.2±0.35	0.21±0.36	0.22±0.38
Kidney somatic index (KSI, %)	0.46±0.31	0.5±0.11	0.49±0.06
Intestine weight index (IWI %)	2.04±0.13	2.11±0.14	2.02±0.1

Note. Means with different letters in the same row are significantly different at P≤0.05. If there are no letters, there are no treatments that vary significantly.Using the muscle ratio data, the quantity of meat and fat weight was computed; the findings are shown in Table 5. The results show that while fish in treatment three (1500 fish/cage) had a larger fat ratio in their abdominal cavity, fish in low stocking density (1000 fish/cage) had a significantly higher meat index (75.03 g) than the other two treatments.

Table 5: Meat and fat index of common carp after 120 days of experimental period

Parameters	Treatment one 1000 Fish/cage	Treatment two 1250 Fish/cage	Treatment three 1500 Fish/cage
Fish weight index %	87.4±0.08^{a}	85.99±0.05^{b}	85.89±0.07^{b}
Meat weight index %	75.03±0.02^{a}	72.23±0.01^{b}	71.63±0.01^{b}
Fat index %	2.43±0.18^{b}	2.29±0.29^{b}	3.83±0.28^{a}

Note. Means with different letters in the same row are significantly different at P≤0.05. If there are no letters, there are no treatments that vary significantly.

By making use of natural resources including rivers, lakes, oceans, and reservoirs that would otherwise be unsuitable for traditional aquaculture, cage culture is a great approach to promoting fish culture [15]. Due to social interactions and declining water quality, rearing fish at improper stocking densities may inhibit growth and lower immunological competence. These effects can also have an impact on the fish's feed intake and feed conversion efficiency [16].

During the investigation, the three treatments' assessed parameters for water quality were determined to be within an acceptable range for fish cultivation [14]. Throughout the study, there were no signs of significant physiochemical fluctuations, illness development, handling stress, or declines in the quality of the water in the experimental cages.

The study's findings demonstrate that, as compared to fish placed at greater densities, growth performance was better in fish stocked at a lower density. The current study's findings are consistent with those of [17], [18], and [11], who have shown that raising common carp in floating cages at low density improves growth characteristics. Common carp's lower growth performance at higher stocking densities may be due to voluntary appetite suppression, competition for food and space, and the availability of naturally occurring phytoplankton and zooplankton in the water. Fish stocked at lower densities can easily access these food sources without stiff competition [19]. As fish biomass per unit volume grows, so does the competition for food and space. High stocking density also causes growth inhibition because crowding stress increases energy use, modifies metabolism, reduces starvation and food intake, and ultimately slows down growth [20; 21]. In addition, there is a rise in feed loss in the intensively cultured cages as a result of increased fish-induced water movement [13]. Some studies, such as that conducted by [22], have shown that contrary to our findings, growth responses in some fish species, such as African catfish, increase with increasing density. The variations in each species' biology and environmental needs are likely what led to the differences in the results. Because they breathe air, African catfish can be cultivated at very high densities and are tolerant of low water quality [23]. Phased rearing of carp fish is beneficial for its grow-out culture in cages, according to [24]. The fish can be raised at high stocking densities for up to two months in the fingerling stage; after that, the stock can be thinned to improve growth performance and survival rate.

The primary expenses related to cage culture production are feed and feeding. We used floating pelleted feed in the current study. The increased protein content and less loss while feeding the fish in cages are benefits of using floating pellets. Also in comparison to sinking pellets, floating pellets have shown better results, as proven by fish growth performance and a higher average weight benefit (kg/m^3), as reported by [7].

When assessing the impact of a treatment (stocking density) on how the fish can consume their food, feed conversion ratio parameters are crucial. Feed conversion ratio (FCR) is a measure of how well fish transform food into body meat [9]. Reduced feed conversion ratios (FCR) show that the fish has successfully turned its meal into body meat. The feed conversion in fish may be influenced by a number of variables, such as the kind of raising unit used, temperature fluctuations, feeding rate, and fish size. The ratio in the current study was determined using the same diet and the biomass of each cage. Both the fish's starting size and temperature were maintained at the same levels. As a result, any variation in feed conversion ratio may be connected to the fish's rearing density either directly or indirectly.

In this study, a better feed conversion ratio was observed in the lower stocking density groups, increase in stocking density beyond 1250 fish/cage led to a higher FCR. [25] found that the lowest feed conversion ratio was obtained at the lowest stocking density (10 fish/m^3) of *Puntius sarana* cultured in an open-water cage. [26] reported that the best FCR was found for the lowest stocking density of Monosex Tilapia *Oreochromis niloticus* at 50 fish/m^3, while the highest was at 125 fish/m^3. The results are in agreement with the results of this study. High stocking density caused crowding stress; the change in the metabolic system, such as the rise in basal cortisol value, which was a response signal to chronic stress, was what indicated the higher FCR during conditions of chronic stress in response to stocking density [27]. Furthermore, feed losses during fish feeding may contribute to this, as they rise with increased stocking density [13]. Increased densities of stocking cause water turbulence during feeding, and individuals disturb each other, leading to a rise in feed losses.

The most crucial factors for successful cage aquaculture are weight increase and survival rate since these dictate the system's ability to produce and make money. Fish mortality can raise significantly when stocks are kept above an ideal level, which will lower productivity. High survival rates (more than 90%) were attained in this study for every treatment. The ideal environmental conditions maintained during the experimental period may have contributed to the greater survival rates. Indeed, [28] stated that the ideal physio-chemical conditions of the water body where the fish are being raised may be associated with improved survival rates in fish. Also, this study's notable survival rate can be attributed to the fish's proper conditioning and acclimation before the trial.

However, fish survival was shown to be impacted by stocking density in this study. Because the treatments with the lowest density and best growth performance had the highest survival rates, survival declined as stocking density increased, most likely as a result of the increased need for oxygen and competition among individual fish for food and swimming space. The results of this study are also in agreement with [29], who reported that higher stocking density has a negative influence on the survivability of *Labeo rohita* and might affect fish welfare. This is in contrast to research by [30], which demonstrated that the survival rate of *Oreochromis niloticus* in a cage culture system is unaffected by stocking density. Therefore, *O. niloticus's* excellent survival rate at high densities suggests that it is amenable to intensive cultivation practices.

The condition factor is a quantitative measure of the fish's health and how it affects growth, reproduction, and survival that is calculated using length-weight data [31]. It is essential for understanding feed intake and provides information on the environmental compatibility for the growth and survival of fish species [32]. According to [33], fish species' overall fitness is indicated by CF values that are near 1. The fish in this study were in good condition and reflected the environmental quality criteria of the culture environment, as indicated by the condition factor values ranging from 1.72 to 1.75 for all treatments. The results of this study were similar to the outcomes of research done by [2], who indicated that rearing common carp in floating cages located on irrigation canals with four different stocking densities (130, 150, 170, and 190 fish/cage) had a condition factor ranging from 1.74 to 1.8. Overall, our research indicates that fish welfare was not affected by varying densities of culturing, and K values near 1 indicate that the reservoir environment is suitable for cage culture. Moreover, the K factor stayed constant, demonstrating that variations in body mass are linked to the growth of muscles and bones rather than the buildup of fat or water [34].

The biological indicator is a useful method for determining the overall impacts of stress on fish. The organosomatic index, on the other hand, could offer more precise details on the chosen organ's function. The organosomatic index, which changes in size more quickly than animal weights and lengths, displays the relative sizes of the organs and the state of the organ systems [35]. The research's examination of somatic indicators showed no differences across all treatments. This conclusion was consistent with that of [36], who discovered no difference in somatic index (VSI, HSI, SSI, KSI, and GI) while growing common carp in varying population densities. These findings show that the fish successfully adjusted to the applied density. In contrast to what we found, other studies [37; 38] discovered that the fish group with the highest stocking density had the lowest values for VSI, KSI, HSI, and SSI. Their findings may be explained by the fish group with a reduced stocking rate having better growth performance and welfare, which will then increase the fish's organ somatic index.

Fish nutritional status may be determined indirectly using the hepatosomatic index, which calculates amounts of glycogen and carbohydrates [39]. The different stoking cultures did not impact the liver state of common carp since there were no variations found for the HSI parameter among the treatments. [40] observed HSI decline at high stocking densities for Cyprinus carpio, which is in contrast to our findings. The authors relate this observation to the reduced overall accumulation of hepatic lipid and glycogen stores in high-stoking fish cultures. Because the viscerosomatic index and lipid levels are positively connected, VSI is a sign of a lipid deficit [39]. [41] found that the VSI of Oncorhynchus mykiss was significantly higher at high stocking densities. While [42] found that high stocking density caused a decrease in the VSI of juvenile Gurami Sago. These findings imply that the stress of increased density can cause viscerosomatic mass growth and energy storage mechanisms, which could slow fish growth [41]. The fish's hematopoietic capacity and immunological condition are both reflected in the spleenosomatic index [39]. The higher-density Rainbow Trout had a much higher SSI, according to [43]. This may be the result of fish weight gain decreasing when stocking density rose rather than an increase in spleen size. Numerous essential physiological processes are carried out by the gill epithelium in fish, including gas exchange, ionic control, acid-base balance, and the excretion of nitrogenous waste [44]. The current study's findings did not reveal any variations in the gillsomatic index across the treatments, suggesting that the varying rearing densities did not affect the gills. The non-significant difference between the values of the intestinosomatic index and the kidney somatic index indicated that the increased density did not have a corresponding effect on the weight of the intestine and kidney. It has not been as extensively studied as VSI and HSI, but certain endogenous and exogenous factors are known to affect them.

The disparities seen in the findings of several types of research might potentially be attributed to various factors such as fish species, life stage, age, nutrition, reproductive stage, health condition, water exchange rate, stocking density levels, social behavior, and environments [45]. Furthermore, the internal organs' blood distribution may be altered by the stressed fish's hypersecretion of cortisol. Accordingly, the volume of the highly irrigated organs may decrease due to a decrease in blood volume [46].

The literature is filled with observations on the effects of varying population densities on different species of fish, but there are very few on how these densities affect the meat and fat indexes of fish. The meat index, which is based on fish weight, can be used to identify potential organ enlargements as well as to evaluate the overall health of the fish. Due to the slower growth of fish at higher rearing densities, the different stoking densities tested in this study indicated a significant decrease in the flesh weight index among fish stoked at high densities. Fish with the greatest visceral fat index underwent the highest stocking density compared to other treatments. This could be because fish weight gain decreased as stocking density rose rather than because visceral fat weight increased [29]. However, stocking density had no influence on the visceral fat index in juvenile Osphronemus goramy raised in the synthetic sheet pond, according to [42]. Furthermore, Tambaqui production in RAS at various stocking densities was shown to have no significant impact on the visceral fat index [47].

However, it should be noted that this is the only study that has been conducted on Dukan Lake; therefore, more research is needed to determine the ideal and profitable stoking density with a variety of fish sizes. Nowadays, fish farmers are increasingly using this area to place more cages inside of it and turn it into a profitable location for raising common carp, a fish that is consumed throughout Iraq. As a result, further research will be required in the future to determine how these cage farms affect the quality of lake water.

Conclusion

The study's findings showed that, compared to greater stocking densities, common carp cages containing 1000 fish at an initial weight of 180 g had superior growth performance and survival rates. The study also shows that the water quality parameters at the cage location are within ranges that are suitable for the culture of Cyprinus carpio. Thus, for the effective cage culture of common carp in Dukan Lake, a stocking density of 6 fish/m^3 and an initial weight of 180 g could be recommended.

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KIRKUK UNIVERSITY JOURNAL FOR AGRICULTURAL SCIENCES

الكارب الشائع (*Cyprinus carpio*) المربى في الأقفاص في بحيرة دوكان، إقليم كردستان، شمال العراق: تأثير كثافة التربية على أداء النمو ومعدل البقاء والمؤشرات الجسدية

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الملخص

تناولت هذه الدراسة تأثير كثافة التربية على النمو والبقاء والصحة العامة لسمك الكارب الشائع *Cyprinus carpio* في الأقفاص الشبكية في بحيرة دوكان، في إقليم كردستان العراق. تم استخدام الكارب الشائع بوزن أولي 5 ± 180غ في تسعة أقفاص شبكية تجريبية (7 م × 7 م × 3 م، 147 م^3) للدراسة. تم تقييم الكثافات الثلاثة المختلفة لسمك الكارب الشائع (1000، 1250، 1500 سمكة/قفص، أو 6، 8، و10 سمكة/م^3) باستخدام ثلاث مكررات لكل معاملة. واستمرت التجربة لمدة 120 يومًا، وتم تغذية الأسماك بالأعلاف العائمة التجارية. تم إخراج خمسين سمكة من أقفاصها بشكل عشوائي كل أسبوعين لتقييم زيادة وزنها وتعديل نظامها الغذائي. تم قياس الوزن الكلي واليومي، نسبة التحويل الغذائي، معدل البقاء على قيد الحياة، والمؤشر الجسدي في نهاية التجربة. وجد أن الوزن النهائي والزيادة الوزنية والزيادة الوزنية اليومية ومعدل النمو النوعي (1546 غ، 1363.9 غ، 11.37 غ، و 1.8) على التوالي، هي الأعلى عند أدنى كثافة تخزين تبلغ 1000 سمكة/قفص، أقل كثافة تخزينية كانت لها أفضل نسبة تحويل غذائي (1.52). بالإضافة إلى ذلك، كانت الأسماك التي تم تطبيقها عند 1000 سمكة/قفص تحتوي على أعلى مؤشر لوزن اللحم (75.03) ومعدل البقاء المسجل (96%). وقد تبين أن عامل الحالة والمؤشر الجسدي للأسماك المستزرعة لم يتأثرا بكثافة التخزين. وفقاً للنتائج التي توصلنا إليها، فإن الأسماك ذات الكثافة 6 سمكات/م^3 والوزن الأولي 180 غراماً مناسبة لتربية الكارب الشائع في أقفاص البحيرات شمال العراق.

الكلمات المفتاحية: العوامل البيولوجية، تربية الأقفاص، الأسماك، زيادة الوزن.