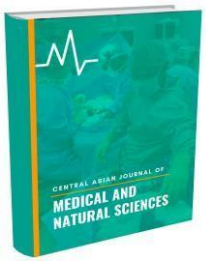

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Article

Seasonal Growth Dynamics of Common Carp (Cyprinus Carpio) Under Varying Stocking Densities and Hydrochemical Conditions

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Abstract: This study evaluates the impact of seasonal fluctuations and hydrochemical water parameters on the body weight gain of common carp (Cyprinus carpio) in intensive aquaculture. The study was conducted on 1-hectare ponds that had two different stocking levels (5,000 and 7,000 fish/ha). The results show that the growth rates considerably slowed down after mid-summer, and weight gain slowed down to 63.7% in May to 8.6-12.0 in September, which was mainly due to thermal stress and hypoxia. The research scientifically establishes the optimal levels of thresholds to maximize productivity: ammonia (NH3) and dissolved oxygen @ above 5.0 mg/L and water temperatures between 18.6-22.0 C. Moreover, it examines the use of water hardness as a buffering agent against ammonia toxicity.

Keywords: Common carp (Cyprinus carpio), growth dynamics, seasonal, stocking density, water quality, dissolved oxygen, free ammonia, water hardness, hydrochemical regime, intensive aquaculture.

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Introduction

Aquaculture has become one of the most rapidly developing industries of food production globally and it is a significant contributor towards satisfying the world demand on high quality protein of the animal world. In Uzbekistan, a prominent fish in fresh water aquaculture is the common carp (Cyprinus carpio) due to its high adaptability, swift development combined with high market price [1]. Nonetheless, it has been difficult to maintain a record high level of productivity in intensive pond systems mainly due to the fact that fish growth is highly affected by seasonal changes in the environment as well as by water hydrochemical conditions [2].

Increase in stocking density may occur in most modern intensive aquaculture practices in order to maximise productivity per unit area. On the one hand, this method may improve production, but, on the other hand, it is the way to add a greater amount of

chemicals to the aquatic environment [3]. This may cause deficiency of oxygen and the build up of the nitrogenous waste product, including the free ammonia (NH3). It may also cause extreme water temperature and pH seasonality. Past research has shown that high concentration of ammonia and low level of dissolved oxygen can severely retard metabolic processes and growth performance in cyprinid species [4]. These adverse impacts are especially noticeable in the summers in the regions with continental climates, as in the Uzbekistan where temperatures of water shoot up, and the solubility of oxygen is reduced [5].

Another buffering factor that has been identified as having significance in alleviating ammonia toxicity is water hardness, especially in warm temperatures. Although common carp farming has economic significance in Uzbekistan, specific local information on interaction of various stocking density and seasonal hydrochemical dynamics on fish growth is still unavailable [6].

Most existing research has focused either on disease aspects such as saprolegniosis or on general hydrobiological parameters, while comprehensive studies combining stocking density, seasonal growth patterns, and key water quality indicators (temperature, dissolved oxygen, free ammonia, and hardness) are still limited [7].

The present study was conducted during 2023–2024 at the experimental ponds of Samarkand State University of Veterinary Medicine, Livestock and Biotechnologies to evaluate the seasonal dynamics of body weight gain in yearling common carp reared at two stocking densities (5,000 and 7,000 fish/ha) [8]. Particular attention was paid to the influence of critical hydrochemical parameters — water temperature, dissolved oxygen, free ammonia concentration, and total hardness — on fish growth performance throughout the growing season . The main objective was to identify optimal hydrochemical thresholds that support maximum growth and to provide practical, science-based recommendations for sustainable management of intensive carp aquaculture under local climatic conditions [9].

Materials and Methods

The research was conducted during 2023–2024 at the experimental ponds of Samarkand State University of Veterinary Medicine. Two groups were established in 1-ha ponds:

Group 1: 5,000 fish/ha

Group 2: 7,000 fish/ha

Methodology

Temperature and dissolved oxygen (O_2) were monitored daily (8:00 and 17:00) using an "OxyGuard" thermo-oximeter. pH and total hardness were determined via standard complexometric methods.

Free ammonia (NH_3) was measured colorimetrically using Nessler's reagent.

Monthly sampling (50–100 fish per group) was conducted using control nets. Weight was recorded with a precision of ±0.1 g.

Data were processed in Microsoft Excel using Student's t-test ($P<0.05$). Growth rate (W) was calculated as:

$W=W1W2−W1×100\%$

Research Object. The research was conducted during the 2023-2024 period at the educational-scientific farm of the Samarkand State University of Veterinary Medicine, Livestock, and Biotechnologies, as well as in local fish farms.

The objects of the study included yearling carp (Cyprinus carpio) and their habitat (water). The experiments were carried out in two ponds with a total area of 1 hectare, using different stocking densities:

Group 1: 5,000 fish per hectare;

Group 2: 7,000 fish per hectare.

Research Methods: Hydrochemical Analyses: To assess water quality and ecological conditions, water temperature and dissolved oxygen (O_2) levels were measured daily at 8:00 AM and 5:00 PM using oxy-thermometers. The waters pH value and how hard it is were found out using the methods that involve complex things.

Hydrobiological and toxicological methods: The amount of ammonia in the water was found out using a special tool called Nesslers reagent and a method that looks at the color. This method is really good, at finding small amounts of ammonia which helps us see how bad it is for fish to grow.

Ichthyometric measurements: To see how the weight of the fish changes we checked on them in the middle of every month. Samples of 50–100 fish from each group were taken and weighed using an electronic scale (accuracy ±0.1 g).

Statistical Methods: The collected data were processed using variational statistics (Student's t-test). Mathematical analyses were applied to ensure the statistical significance and reliability of the results ($P<0.05$).

Results and discussion

The conducted studies demonstrated that the body weight gain of common carp is directly dependent on seasonal hydrochemical changes and stocking density. The findings are summarized in the following data and Table 1.

It was observed that starting from mid-summer, the rate of body weight gain in carp began to decrease. This process is attributed to the biological characteristics of the fish and their rearing conditions [10]. To achieve high weight gain in yearling carp during the summer, special attention must be paid to creating optimal hydrochemical conditions in the habitat, in addition to an optimal feeding regime [11].

Group 1 (Stocking density: 5,000 fish/ha):

May: At a water temperature of 19.0°C, with an oxygen concentration of 5.6 mg/l, an ammonia concentration of 0.06 mg/l and a water hardness of 3.0 mg-eq/l, the average weight gain was 63.7%.

June: (23.2°C, O_2: 5.3 mg/l) — weight gain was 60.9%.

July: (23.5°C, O_2: 5.1 mg/l) — weight gain was 38.0%.

August: (24.1°C, O_2: 5.2 mg/l) — weight gain was 32.0%.

September: (20.3°C, O_2: 4.8 mg/l) — weight gain was 12.0%.

Group 2 (stocking density: 7,000 fish/ha):

May: At a water temperature of 19.7°C, an oxygen concentration of 5.3 mg/l, an ammonia concentration of 0.06 mg/l and a water hardness of 3.1 mg-eq/l, the average weight gain was 54.4%.

June: (23.1°C, O_2: 4.9 mg/l) — weight gain was 36.8%.

July: (23.6°C, O_2: 5.1 mg/l) – weight gain was 34.6%.

August: (26.4°C, O_2: 4.8 mg/l) – weight gain was 26.4%.

September: (20.5°C, O_2: 4.9 mg/l) – weight gain was 8.6%.

Table 1. Seasonal Dynamics of Growth and Hydrochemical Parameters.

Stocking Density (fish/ha)	Month	Weight Gain (%)	Free Ammonia (NH_3, mg/l)	Temperature (°C)	Dissolved Oxygen (O_2, mg/l)	Water Hardness (mg-eq/l)
Group 1	May	63.7	0.06	19.7	5.6	3.0
(5,000/ha)	June	60.9	0.05	23.2	5.3	3.2

Group 2 (7,000/ha)	July	38.0	0.05	23.5	5.1	3.3
	August	32.0	0.03	24.1	5.2	3.7
	September	12.0	0.04	20.3	4.8	3.3
	May	54.4	0.06	19.7	5.3	3.1
	June	36.8	0.07	23.1	4.9	2.6
	July	34.6	0.06	23.6	5.1	2.8
	August	26.4	0.05	23.9	4.8	3.6
	September	8.6	0.04	20.5	4.9	2.9

The study found that optimal body weight gain in common carp is closely linked to specific water quality parameters. The highest growth rates were observed in ponds where ammonia levels remained between 0.04–0.06 mg/l, dissolved oxygen was at least 4.5–5.6 mg/l, water temperature ranged from 19.7–23.0°C, and water hardness was 3.0 mg-eq/l or higher. Based on the synthesis of results across different stocking densities, the following conclusions were drawn:

Ammonia is present in all aquaculture ponds throughout the season, with its concentration influenced by pH, temperature, dissolved oxygen, and water hardness [12]. The rearing season can be divided into three distinct periods:

Characterized by peak ammonia concentrations (up to 0.40 mg/l), high dissolved oxygen (17.0–20.0 mg/l), and pH values between 8.0–8.5. During this time, the temperature remains below 18.6°C and the minimum hardness is less than 3.0 mg-eq/l. Ammonia levels decrease to 0.30 mg/l or lower. There is a significant decrease in oxygen concentration (often below 4.0–4.5 mg/l) and a fall in pH (to 6.3–6.5). Temperatures then rise to between 23.0 °C and 25.0 °C and water hardness reaches 3.7 mg-eq/l or more.

This is characterised by a decrease in pH and temperature, which leads to reduced ammonia levels and a decline in the severity of gill damage in fish [13].

Optimal Requirements for Maximum Growth: To ensure maximum fish growth throughout the season, the following water quality standards should be maintained:

Ammonia (NH_3): leq 0.07 mg/l

Dissolved Oxygen (O2): geq 5.0 mg/l

pH Level: 7.5 – 8.5

Temperature: 18.6 – 22.0°C

Water Hardness: geq 3.0 mg-eql

Toxicity Risk Factors: Fish can tolerate ammonia concentrations of 0.10 mg/l or higher for only a few days, provided that oxygen is at least 5.0 mg/l, temperature does not exceed 20.0°C, and hardness is at least 2.0 mg-eq/l. When temperatures exceed 20.0°C, the proportion of free (toxic) ammonia increases, and its harmful effects are intensified in soft water [14]. Therefore, constant monitoring of ammonia levels is of great practical importance for aquaculture management.

The data proves that water hardness plays a critical buffering role. At temperatures above 20°C, the toxicity of free ammonia increases; however, in ponds with hardness levels ≥3.0 mg-eq/l, the growth inhibition was less severe compared to soft-water environments [15].

Conclusions

The present study clearly demonstrates that the seasonal growth dynamics of common carp (*Cyprinus carpio*) in intensive pond aquaculture are strongly influenced by the complex interaction between stocking density and hydrochemical parameters. Growth performance exhibited a distinct seasonal pattern, with the highest weight gain observed in May (54.4–63.7%) and a sharp decline toward September (8.6–12.0%). This deceleration

was primarily associated with rising water temperature, decreasing dissolved oxygen levels, and increasing free ammonia (NH_3) concentrations during the summer months.

A higher stocking density of 7,000 fish per hectare resulted in a consistent 10–15% reduction in weight gain compared to a lower density of 5,000 fish per hectare, mainly due to the accelerated deterioration of water quality. The results confirm that concentrations of free ammonia above 0.07 mg/L, dissolved oxygen below 5.0 mg/L and water temperatures above 22.0°C act as critical limiting factors for carp growth. Conversely, water hardness of at least 3.0 mg-eq/L played a significant buffering role, reducing the toxic effects of ammonia, particularly during periods of high temperature.

These findings allow us to establish scientifically grounded optimal hydrochemical thresholds for maximizing productivity in common carp farming under semi-intensive and intensive conditions:

- Free ammonia (NH_3) ≤ 0.07 mg/L
- Dissolved oxygen (O_2) ≥ 5.0 mg/L
- Water temperature 18.6 °C –22.0 °C
- pH 7.5–8.5
- Total hardness ≥ 3.0 mg-eq/L

The study also highlights the practical importance of continuous monitoring and proactive management of hydrochemical parameters, especially during the critical summer period when thermal stress and hypoxia become pronounced. Maintaining adequate water hardness appears to be a cost-effective strategy for mitigating ammonia toxicity without requiring expensive technological interventions.

From a broader perspective, the obtained results contribute to the optimization of carp aquaculture practices in regions with continental climates similar to Uzbekistan, where pronounced seasonal temperature fluctuations pose significant challenges to intensive fish farming. Using the water quality standards for carp can really help them grow faster stay healthy and make the whole process more cost effective. This is also good for the environment.

Future studies should look at how things, like biofloc technology or periphyton-based systems work to keep the water clean when there are a lot of carp in a small space. They should also check ways of adding oxygen to the water to keep it healthy for the carp.

Furthermore, long-term studies investigating the physiological stress responses and immune status of carp in response to varying hydrochemical conditions would provide valuable insights into the sustainable intensification of carp aquaculture.

In conclusion, successful intensive carp farming requires optimised feeding regimes and precise, continuous control of the hydrochemical environment. Adopting the hydrochemical thresholds identified in this study could serve as a practical guideline for fish farmers and researchers aiming to achieve high, stable productivity in common carp farming despite seasonal climatic variations.

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