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Article

Effects of Pond Water Quality Indicators on Fish Body Weight Gain and Their Optimal Standarts

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Abstract: This study investigates the correlation between hydrochemical parameters and the body weight gain of yearling common carp (Cyprinus carpio) in ponds with different stocking densities (5,000 and 10,000 fish/ha) during the summer rearing season. The research results demonstrate that maximum weight gain occurs under environmental conditions where ammonia levels range from 0.05 to 0.07 mg/L, dissolved oxygen is at least 4.5–5.5 mg/L, water temperature stays between 20.7 and 25.3 °C, and water hardness is maintained at 3.0 mEq/L. Furthermore, the findings indicate that increasing water temperatures combined with decreasing water hardness exacerbate the toxic effects of free ammonia. These results highlight the importance of monitoring the hydrochemistry of intensive aquaculture systems in order to optimise fish growth and health.

Keywords: Common carp (Cyprinus carpio); pond water; hydrochemical parameters; ammonia; dissolved oxygen; body weight; stocking density; water hardness; toxicity; water temperature.

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Introduction

Aquaculture is one of the fastest-growing sectors of global food production and plays a vital role in providing high-quality animal protein to an ever-growing world population. In Uzbekistan, the common carp (Cyprinus carpio) remains the most important species in freshwater aquaculture thanks to its adaptability, fast growth and high market value [1]. However, achieving stable, high productivity in intensive pond systems is becoming increasingly challenging as fish growth is heavily influenced by seasonal changes in water quality and hydrochemical conditions [2].

In intensive farming, farmers often increase stocking density to raise production per hectare. While this strategy can increase output, it also puts greater pressure on the aquatic environment. Higher densities lead to faster accumulation of organic matter, reduced dissolved oxygen, increased levels of toxic free ammonia (NH_3) and significant fluctuations in water temperature and pH. Previous studies have demonstrated that elevated ammonia concentrations and low oxygen levels strongly suppress metabolic activity and growth in carp and other cyprinid species [3].Seasonal variations typical of Uzbekistan's continental climate make the situation even more complex. During hot summer months, rising water temperatures reduce oxygen solubility while increasing the proportion of toxic unionized ammonia, especially in ponds with high stocking density. Water hardness has been identified as an important natural buffer that can reduce ammonia toxicity, particularly when temperatures are high. Despite the economic importance of carp farming in the country, there is still insufficient detailed local research examining how different stocking densities interact with seasonal hydrochemical parameters to affect fish growth performance [4].

This study was conducted from 2023 to 2024 in the experimental ponds and laboratory facilities of the Samarkand State University of Veterinary Medicine, Animal Husbandry and Biotechnologies [5]. The main objective was to investigate body weight gain dynamics in yearling common carp reared at two stocking densities (5,000 and 10,000 fish per hectare) and to determine the optimal ranges of key hydrochemical indicators — temperature, dissolved oxygen, free ammonia and water hardness — that support maximum growth.The research also aimed to provide practical, science-based recommendations for improving water quality management in intensive carp aquaculture systems under local climatic conditions [6].

Research Objective: The objective of this study is to examine the dynamics of body weight gain in common carp (*Cyprinus carpio*) within ponds of varying stocking densities and to determine the optimal hydrochemical parameters required for maximizing fish growth.

Research Tasks: To achieve the research objective, the following tasks were identified:

Monitoring Hydrochemical Fluctuations: In order to record seasonal changes in water quality parameters, including temperature, dissolved oxygen (O2), ammonia (NH3), pH, and water hardness, ponds with stocking densities of 5,000 and 10,000 fish/ha are used.

Comparative Growth Analysis: This study aims at a comparative analysis of growth performance of fish in the high density (10,000 fish/ha) and the control (5,000 fish/ha) ponds.

Laboratory Observation of Toxicity: The present study will explore the toxic effect of the ammonia (NH_3) concentration levels over the gill apparatus of fish in aquarium conditions. To realize this aim, the current research will embrace an extensive examination of the relationship between ammonia toxicity, water hardness and temperature. The policy of practical recommendations is a key part of the research process.

This research aims at making evidence based recommendations about intensive aquaculture farms. These suggestions will be informed by the research findings and the objective will be to optimise fish production.

Methods and Materials

The studies were carried out in 2023-2024 at the "Fishery" Educational and Scientific Laboratory of the Samarkand State University of Veterinary Medicine, Animal Husbandry and Biotechnologies (in the aquarium experiments), and on intensive aquaculture farms of the region (in the pond experiments).

Research Object: The primary subjects of this research were yearling common carp (*Cyprinus carpio*) reared under intensive aquaculture conditions in the Samarkand region. The experiments were conducted in two ponds, each with a total area of 1 hectare, using different stocking densities:

- Group 1 (Control): 5,000 fish/ha;
- Group 2 (Experimental): 10,000 fish/ha.

Research Methods. The following scientific research methods were employed during the study:

1. Hydrochemical Analysis Methods. Thermometry, Oxymetry: The temperature and the dissolved oxygen (DO) concentration of the water were determined through an OxyGuard digital oxy-thermometer (precision: 0.1 mg/L). Ammonium Ion Determination: The amount of free ammonia (NH3) concentration was established in the Nessler method which we used in a V.I. Lukin methodology with KFK-3-01 photocolorimeter at 400-425nm. Water Hardness Total Hardness: The total hardness was determined using the complexometric method, which consisted of titrating the sample with a Trilon-B solution and adding Eriochrome Black T into it as an indicator. Hydrogen Ion Concentration (pH): The pH levels were measured using a portable pH-150 electronic pH meter.

2. Ichthyological and Biometric Methods. Weight Gain Dynamics: The mass of the fish was monitored every 30 days through control fishing. From each pond, 50–70 fish were randomly sampled and weighed using an electronic balance (accuracy: 0.1 g). The percentage of weight gain (*S*) was calculated using the following formula:

$S = W0/Wt - W0 \times 100\%$

Where:

- *Wt* - final weight;
- *W*0 - initial weight.

3. Laboratory Toxicological Methods. To determine the effect of ammonia on fish physiology, aquarium experiments were conducted under laboratory conditions. The "acute toxicity test" method was applied to observe the fishes' branchial (gill) apparatus and behavioral changes, including locomotion and respiration rate (opercular movement frequency).

4. Statistical Analysis. All quantitative data were statistically processed using Microsoft Excel. Key parameters, including the arithmetic mean (*M*), standard error (*m*), and statistical significance (confidence level, *P*), were determined.

Results and Discussion

The conducted experiments revealed a distinct correlation between the hydrochemical environment and the growth rates of common carp (Cyprinus carpio) across different stocking densities. The primary findings are summarised in Table 1.

The findings of the present study indicate a progressive decline in the rate of body mass accumulation during the summer period. This phenomenon has been attributed to a combination of the carp's biological characteristics and the environmental conditions present in their cultivation [7]. In order to achieve substantial weight gain in year-old carp during the summer months, it is imperative to concentrate not only on the establishment of optimal feeding regimes but also on the maintenance of ideal hydrochemical parameters. The maximum weight gain observed in carp was directly associated with optimal water quality indices [8].

Relationship between fish stocking density, seasonal growth dynamics, and hydrochemical parameters.

Table 1.

Stocking Density (pcs/ha)	Month	Weight Gain (%)	NH_3 (mg/L)	Temperature (°C)	O_2 (mg/L)	Hardness (mg-eq/L)
5,000	May	60.7	0.06	20.7	5.5	3.0
	June	47.7	0.05	24.2	5.4	3.1
	July	44.5	0.05	24.5	5.2	3.2
	August	33.0	0.04	25.1	5.3	3.5

	September	13.0	0.02	19.9	4.9	3.1
	May	53.5	0.07	20.8	5.2	3.3
	June	38.6	0.06	24.4	4.8	2.9
10,000	July	33.5	0.05	25.3	5.0	3.1
	August	21.2	0.05	24.9	4.7	3.0
	September	11.0	0.04			

Discussion

Based on the synthesis of the results obtained from ponds with varying stocking densities, the following conclusions can be drawn. Our experiments indicate that the maximum weight gain in common carp occurs when ammonia levels remain within the range of 0.05–0.07 mg/L, dissolved oxygen is at least 4.5–5.5 mg/L, water temperature is between 20.7–25.3°C, and water hardness is 3.0 mg-eq/L or higher [9].

The presence of ammonia throughout the fish farming season is a factor of critical importance. Its concentration was found to be functionally dependent on pH, water temperature, dissolved oxygen levels, and water hardness [10]. Based on the accumulation of ammonia, the fish cultivation season can be categorized into three distinct periods:

Spring and Early Summer: Characterized by ammonia concentrations reaching 0.05–0.06 mg/L, with high dissolved oxygen levels (4.8–5.5 mg/L) and a pH range of 6.9–7.5. The water temperatures at this time were comparatively low (up to 20.7°C) and the hardness levels were low (the lowest 2.93.3 mg-eq/L) [11].

Summer: Ammonia could reach 0.20 mg/L or lower occasionally, and oxygen could be 2.0-3.0 mg/L or even lower. The PH was lowered to 6.7-7.0 and the temperatures were increased to 24.2-25.1 C and the hardness level was 2.9-3.5 mg-eq/L.

Autumn: Both the temperature and pH decreased and ammonia concentration was low and there was no damage of the branchial apparatus (gill).

In order to achieve maximum weight gain in intensive ponds, it is imperative to undertake consistent monitoring of water quality. The findings of the present study demonstrate that the following parameters are optimal for the entire production cycle: ammonia content below 0.07 mg/L, oxygen saturation not less than 5.5 mg/L, pH between 7.2–8.0, temperature between 20.0–23.0°C, and hardness between 3.0–3.5 mg-eq/L [12].

While fish can tolerate ammonia concentrations of 0.10 mg/L or higher for a few days, this requires specific conditions: the water temperature should not exceed 20.0°C if the oxygen level is 5.0 mg/L, and the water hardness must be at least 2.0 mg-eq/L.Critical Note: Stocking is strictly discouraged in water bodies where ammonia consistently exceeds 0.10 mg/L, especially when temperatures surpass 20.0°C and hardness is below 1.5 mg-eq/L.

Our aquarium-based toxicological tests demonstrated that when water temperature exceeds 20.0°C in soft water, the proportion of free ammonia increases, significantly enhancing its toxic effect. Therefore, maintaining ammonia levels within safe thresholds is of paramount practical importance for sustainable aquaculture [13].

Hydrochemical Parameters of Water in Natural and Artificial Reservoirs

Water (chemical formula: H_2O) is a transparent, odorless, and uniquely colored liquid substance that covers approximately 71% of the Earth's surface (though the total hydrosphere constitutes a vast volume of about 1.5 billion *km*3). As the primary habitat for fish, water exerts various influences on their morphology and physiology through its physical properties. Water has a higher density than air and a specific gravity that is close to that of fish. This property enables aquatic organisms to remain buoyant and suspended [14].

It is imperative to acknowledge the paramount significance of the thermal capacity of water and its anomalous expansion during the process of freezing for aquatic life.

During the winter months, the surface layer of the Earth's crust undergoes a process of freezing, forming a barrier that acts to insulate the underlying layers and thereby retain heat.

Consequently, natural water bodies generally do not freeze to the bottom, thereby preserving a viable environment for fish. The level of dissolved oxygen (DO) in these environments is contingent upon the temperature of the water and the pH levels thereof.

The oxygen levels present in water are approximately 20 times lower than those found in the atmosphere. It has been determined that chemically pure water may contain up to 10 cm^3/L of oxygen, whereas the oxygen content of mountain streams typically ranges from 7–8 cm^3/L. In seawater characterised by a temperature of 30°C and a salinity of 3.5%, the oxygen content exhibits a decline to 4–5 cm^3/L. It is evident that fish have evolved in response to the presence of relatively low oxygen levels in their natural habitats. Nevertheless, there may be mass mortality events (asphyxiation or zamor) during winter when there is no aeration available in the atmosphere through ice cover or during summer caused by decomposition of organic material (which is typically worsened by bad zoo-hygienic conditions). The oxidation of decomposing organic elements takes up available oxygen during such periods and results in hypoxia and consequent fish kills [15].

There is a dire need to recognize the importance of other gases, and one quality example is carbon dioxide (CO_2). In carp species the skin release of metabolic CO_2 has been observed to be more than 90 percent. Carbon dioxide (CO_2) plays a vital role in the photosynthesis of aquatic plants which in their turn are the major source of oxygen and shelter. Nonetheless, the high concentrations of toxic gases might be fatal. An example is hydrogen sulphide (H_2S), which is very toxic; at a concentration of 15 cm3/L; it was found to result in the premature demise of cyprinids.Laboratory experiments demonstrated that trout perished within 10 minutes at H_2S levels as low as 0.001 cm^3/L. In contrast, common carp exposed to 0.1 cm^3/L of H_2S exhibited decreased activity within 3 hours and total mortality within 8–10 days.

Conclusions

The present study clearly demonstrates that seasonal fluctuations in hydrochemical parameters significantly affect the body weight gain of yearling common carp (*Cyprinus carpio*) under different stocking densities in intensive pond aquaculture. The outcome indicated a strong seasonal trend, where May had the highest growth rate (53.5 -60.7) and it became negative in September (11.0-13.0). The detected slowing down was mostly caused by a rise in water temperature, drop in dissolved oxygen, and rise in the amounts of free ammonia (NH_3) especially in ponds with high stocking density (10,000 fish/ha).

The growth in stocking density led to systematic decline in water quality, causing an average weight gain difference 712% lesser than it was in the control group (5,000 fish/ha). The experiment had scientifically based optimum thresholds of hydrochemical environment to enhance maximum growth of carps. These were discovered to be levels of free ammonia (NH 3) of 0.05-0.07 mg/L, dissolved oxygen of not less than 4.5-5.5 mg/L, water temperatures of 20.7 -25.3 C and the total hardness of at least 3.0 mg-eq/L. As can be seen, the buffering of water hardness was critical and therefore lessening the toxicity of ammonia especially at high temperatures.

The results highlight the importance of continuous monitoring and active management of key water quality indices in intensive carp feedlot systems. Clearly, the preservation of the discovered optimal hydrochemical regime may lead to a significant increase in a growth activity, a decrease in stress and risk of mortality, and increase in the overall efficiency of the economic activity of aquaculture production in a continental climate.

The results contribute valuable practical recommendations for fish farmers and researchers in Uzbekistan and similar regions. Future studies should focus on integrating bioremediation techniques and advanced aeration systems to sustain optimal water quality at even higher stocking densities, thereby supporting the sustainable intensification of common carp aquaculture.

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