Features of maturation of two-year-old common carp (*Cyprinus Carpio*) in cages in Uzbekistan

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Abstract. In contrast to pond polyculture, where fish are raised in natural bodies of water and typically fed lower protein feeds, common carp raised in cages are fed high-protein feeds, leading to significantly faster growth rates. This study analyzed the sexual maturation characteristics of common carp raised in intensive culture in floating cages in the Tuyabuguz reservoir of Uzbekistan. One-year-old common carp fingerlings, weighing between 20 and 30 grams, were stocked in the cages in the spring. The fish were fed a diet containing 35% protein ("Aller Aqua" for common carp). By winter, the common carp had grown significantly, reaching weights between 992 and 1691 grams. Remarkably, by December of the same year, at just one year of age, all female and male common carp had gonads at stages III - IV, indicating their first sexual maturation. This rapid rate of maturation is noteworthy, as it occurs 1-2 years faster than in common carp raised in ponds in the temperate climate of Uzbekistan.

1. Introduction

Common carp (*Cyprinus carpio*) plays a crucial role in global aquaculture, particularly in Uzbekistan, where it is extensively cultivated in semi-intensive pond systems as part of polyculture practices. These fish are known for their adaptability to various environmental conditions and their rapid growth rate, making them a valuable asset in aquaculture systems [1].

In Uzbekistan, the reproduction of common carp is carefully managed through gonadotropic stimulation in fish hatcheries [2]. This process ensures a controlled and consistent breeding cycle, allowing for the production of high-quality fingerlings for stocking in ponds. Common carp's ability to thrive in diverse environments and its efficient growth make it an ideal species for aquaculture, contributing significantly to the country's aquaculture production [3]. The inclusion of common carp in polyculture systems further enhances its value. By combining common carp with other fish species, farmers can optimize pond resources and maximize productivity. This approach not only increases overall fish yield but also provides a balanced and sustainable source of protein for local communities [4].

Common carp plays a vital role in Uzbekistan's aquaculture sector, offering a reliable and efficient means of fish production that contributes to food security and economic development. In the Tuyabuguz reservoir, one-year-old common carp fingerlings (20–30 g) were stocked in cages in the spring and fed a high-protein diet ("Aller Aqua" for common carp) with a protein level of 35% [5]. By winter, the common carp grew to 992 - 1691 g. Surprisingly, in December, at the age of just one year, all females and males had gonads at stage III - IV, indicating their first sexual maturation. This rate of maturation is notably faster than that observed in ponds in the temperate climate of Uzbekistan, where common carp typically reach sexual maturity at 3 years of age, with breeders used for mass reproduction at 4 years of age [6]. Unlike in pond polyculture, where common carp feed on organisms from the natural food base and additional feed based on cereals with a protein content of 14–20%, in floating aquaculture cages, common carp are fed high-protein balanced feed (protein 33 - 35% and higher) [7].

To analyze the reproductive function of common carp in the second year of life when grown as table fish in cages, the research likely focused on several key aspects [8]. Firstly, it would have involved monitoring the growth and development of the carp, assessing their overall health and condition. Secondly, the study would have examined the onset of sexual maturity in the carp, looking at the development of their gonads and the presence of mature gametes.

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The researchers would have also investigated the reproductive behavior of the carp, observing any spawning activities or courtship behaviors [9, 10]. Additionally, the study might have looked at hormonal changes associated with sexual maturation, as well as the impact of the high-protein diet on the reproductive physiology of the carp.
Overall, the goal of the research would have been to understand how the intensive culture conditions in floating cages, including the high-protein feed, affect the reproductive function of common carp in the second year of life.

2. Material and Methods

The work was carried out from the beginning of April to December 2023. Four floating fish cages (5 x 5 x 4 m each) of the 'Fishberg' fish farm at the Tuyabuguz reservoir (Tashkent reagion, Uzbekistan) were used (Fig. 1). In April, yearlings of common carp (20–30 g) were stocked in cages and raised with ‘Aller Aqua’ carp feed (33% protein) throughout the vegetation season. To adjust the feed dose, water temperature and fish size were measured weekly. From the beginning of summer, the ratio was 3% of fish biomass per day.

Fig. 1. Tuyabuguz reservoir in Tashkent region, Uzbekistan

The researchers likely conducted regular monitoring of the water parameters in the cages, including water temperature, dissolved oxygen levels, and pH, to ensure optimal conditions for the fish. These parameters are crucial for the health and well-being of the fish, as they can affect growth, metabolism, and overall physiological functions.
In December, a sample of 40 random fish was selected from the cages for detailed analysis. The researchers measured the total and standard body lengths of the fish with an accuracy of 1 mm, as well as the total body weight with an accuracy of 1 g. This data provides important information about the growth and development of the fish over time.
During the autopsy, the researchers determined the sex of the fish and assessed the stage of maturation using a 6-graded scale. This scale likely indicates the degree of development of the gonads, which is an indicator of sexual maturity. The weight of the gonads was also measured with an accuracy of 0.1 g, providing information about the reproductive health and potential of the fish.
These measurements and observations help to understand how the fish are responding to the intensive culture conditions in the cages and the high-protein diet. They provide valuable insights into the reproductive biology of common carp and how it is influenced by aquaculture practices.

3. Results

Raising common carp as table fish in floating cages during its second year of life is a common practice in aquaculture. This approach allows for the efficient production of high-quality fish for consumption. The use of floating cages provides a controlled environment where factors such as feeding, water quality, and growth can be closely monitored and managed.
During this stage of development, common carp undergo significant growth and maturation. They are fed a high-protein diet to promote growth and are closely monitored for signs of sexual maturation. By the end of the second year, common carp raised in floating cages typically reach a size and weight suitable for consumption as table fish.
Raising common carp in floating cages offers several advantages, including efficient use of space, reduced environmental impact compared to traditional pond culture, and the ability to produce high-quality fish for the market. Overall, it is a sustainable and effective method for producing table fish for consumption (Fig. 2).
The dynamics of water temperature in the cages during the vegetation season, as depicted in Figure 3, indicate a notable warming trend as summer progresses. From June 1st to the start of September, the average daily water temperature consistently remained above 25°C. Particularly, from the final ten days of June through early August, temperatures exceeded 27°C. However, they did not rise above 29°C during this period.

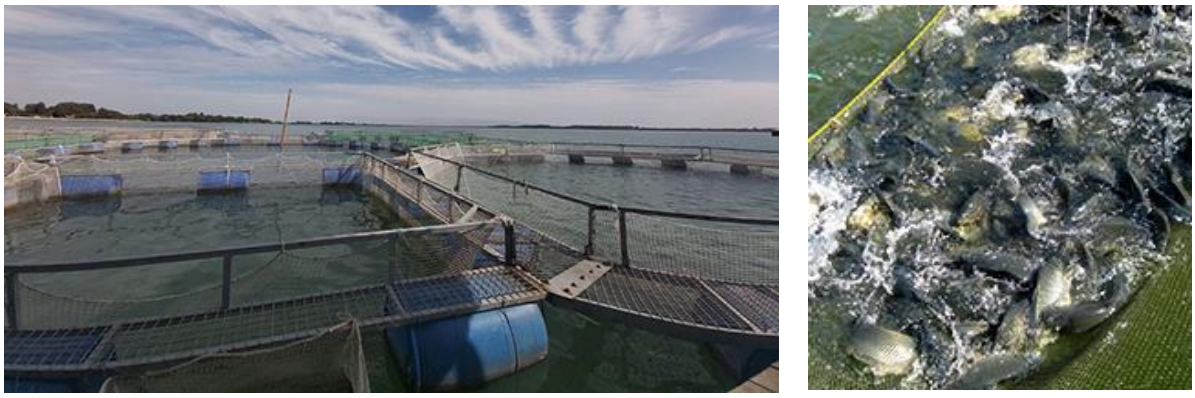

Fig. 2. Innovative floating cages in Tuyabuguz reservoir (left - common view of cages, right - table common carp)

This temperature profile is significant for the growth and development of common carp, as it falls within the optimal range for their physiological processes. Maintaining water temperatures within this range is crucial for maximizing growth rates and ensuring overall health and well-being of the fish population.
The data presented in Figure 3 underscores the importance of monitoring water temperature in aquaculture systems to provide an optimal environment for fish growth and development.

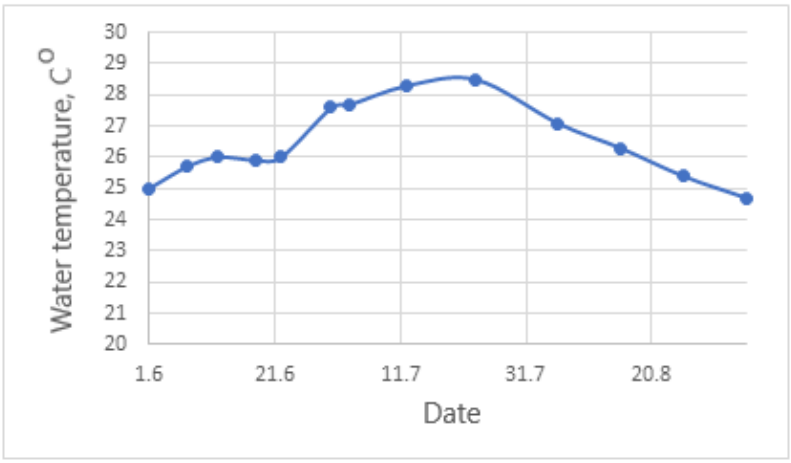

Fig. 3. Average daily water temperature in cages, 2023, Tuyabuguz reservoir

Throughout the vegetation season, the dissolved oxygen level in the water within the cages remained within the optimal range for common carp, varying from 5.9 to 6.76 mg/l. This consistent level without rapid fluctuations indicates a stable and suitable environment for the fish. Similarly, the pH of the water, ranging from 7.3 to 8.8, remained within acceptable limits for common carp, ensuring that the water was neither too acidic nor too alkaline for their well-being. Another critical parameter, the total ammonia nitrogen dissolved in the water, varied between 0.00 and 0.01 mg/l, indicating minimal ammonia levels, which is essential for fish health. These findings suggest that the water quality in the cages was well-maintained and suitable for supporting the growth and development of common carp.
The total fish catch in December provided insights into the overall productivity of common carp in the cages, indicating a total fish productivity of 36 kg/m^3. This productivity level is a testament to the effectiveness of the aquaculture practices employed, including feeding strategies, water quality management, and overall care provided to the fish population. The results underscore the success of raising common carp as table fish in floating cages during their second year of life, highlighting the potential of this approach for aquaculture development in the region (Fig. 4).
In our sample, we found that the common carp exhibited a range of sizes and weights, indicating healthy growth and development. The individuals in the sample had a total length ranging from 41 to 46 cm, with an average of 44.1 cm. The standard length fell between 35 and 40 cm, with an average of 37.9 cm. The total body weight ranged from 992 to 1691 g, with an average weight of 1323.9 g. Interestingly, there were no significant differences observed between the sexes in terms of body weight, with females averaging 1328.5 g and males averaging 1316.3 g. This uniformity in weight distribution suggests balanced growth and development among the common carp population in the cages.

In the sample of male common carp, the majority exhibited gonads at stage IV of maturity, indicating a more advanced stage of sexual development compared to the single male with gonads at stages II–III. These mature males had gonad weights ranging from 16 to 103 grams, with an average of 65.5 grams. The maturity coefficient for these males by the end of December ranged from 2.2% to 7.8%, with an average of 5.7%. This suggests that the males in the sample were actively progressing towards sexual maturation, with a notable increase in gonad development compared to earlier stages. This trend in gonad development is indicative of the species' natural reproductive cycle, as common carp typically reach sexual maturity at around three to four years of age. The observed ratio of females to males in the sample was 1.6:1, indicating a slightly higher representation of females. Additionally, the females in the sample displayed secondary characteristics of maturity, such as a noticeable abdomen, further confirming the advanced stage of sexual development in the common carp population under study.

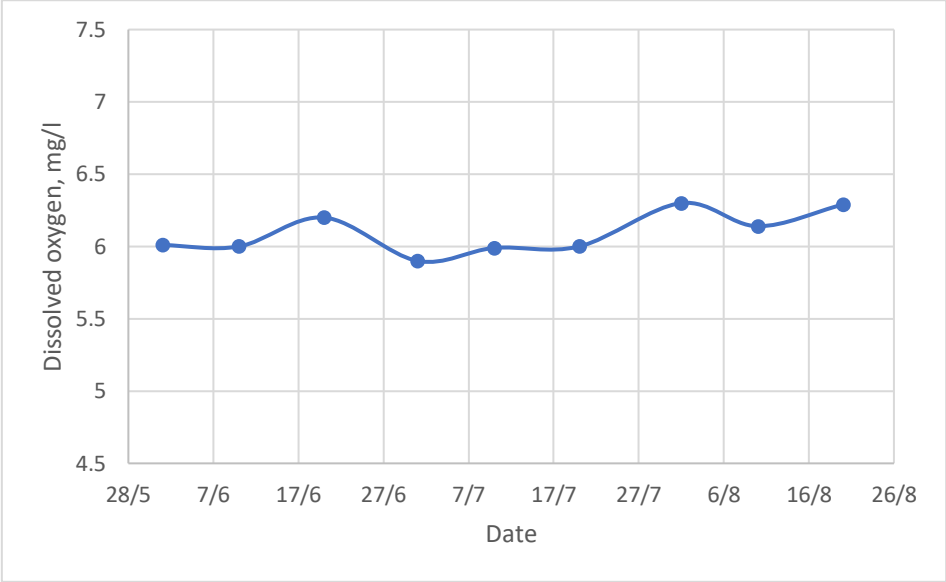

Fig. 4. Average daily dissolved oxygen level in water in cages, 2023, Tuyabuguz reservoir

In the sample of female common carp, all individuals exhibited gonads at stage IV of maturation, indicating a high degree of sexual development. The weight of their gonads ranged from 65 to 200 grams, with an average weight of 116.1 grams. The maturation coefficient of the females varied from 4.7% to 14.8%, with an average of 8.7% in January. These findings suggest that the female common carp in the sample were undergoing active sexual maturation, with a significant proportion of individuals nearing full maturity. The observed maturation coefficients indicate that the majority of females were progressing towards spawning readiness, which is crucial for the reproductive success of the species.

4. Discussion

The Tuyabuguz reservoir was built in the middle stream of the Angren River. The reservoir has area about 20 km², when it is fully filled with water (in May). The total volume of water is 250 million m³, the useful volume is 224 million m³. The average depth of the reservoir when filled is 12.5 m. The cages are installed in the dam part of the reservoir.

In the conditions of pond polyculture in Uzbekistan (in Central Asia), the technology of artificial reproduction of common carp has been carried out since the 1960s [2]. Common carp also lives in lakes and reservoirs of Uzbekistan. Both in ponds and in the wild conditions of natural water bodies of Uzbekistan, the onset of first sexual maturity in female common carp was noted when they reached a standard length of more than 28 cm. In the plain Aydar-Arnasay system of lakes and in the Talimarjan reservoir, the first sexual maturiation was noted at 3 years of age, in the cold-water Charvak reservoir - at 4-5 years of age. In the conditions of fish hatcheries in the Tashkent region, the achievement of sexual maturity was noted at 3 years of age [3, 4]. In fish farms, 4-5 year old fish are used for reproduction, i.e. re-ripening. The above corresponds to the standards for semi-intensive pond fish farming [5].

In our study, raising of common carp in cages and feeding them high-protein diets resulted in the entire generation (even at much higher stocking densities compared to ponds) having a significantly higher growth rate in the second year of life. This also led to a higher rate of development of the reproductive function. All fish of the generation in the cages reached their first sexual maturity at the age of 2 years. This is 1-2 years faster than previously noted for

reservoirs in Uzbekistan. According to aquaculture standards, such fish can be used for breeding at 3 years of age, which is also much faster than in pond fish farming in the country.

Let's pay attention to one more important aspect. In pond fish farming, in the second year of common carp life, the stocking density is 1000 - 1400 pieces/ha, in the third year of life - 400-500 pieces/ha during the formation of the broodstock. In our study, we kept 35 pieces/m^3 in cages; stocking rate is many thousand times higher in volume of water than in pond fish hatcheries. In addition, ponds are target water users; water is taken into the ponds from surface runoff for the entire growing season. Cages are neither water consumers nor target water users; they are an additional function on the reservoir and do not interfere with the surface regime of the irrigation structure in use.

5. Conclusions

Our research opens up great prospects for the creation of cage fish hatcheries for common carp entirely on the principles of an additional function on existing irrigation reservoirs. Pond fish hatcheries raise broodstock of common carp with a fish productivity of 0.1 - 0.2 t/ha and occupy areas of tens and hundreds of hectares of ponds with water intake from surface runoff. Broodstock of common carp can be raised in cages. The cages do not require land resources and do not require dedicated water resources; they will work as an additional function on reservoirs and lakes. At the same time, the productivity of cages can be (according to our data) up to 30-40 kg/m^3 (i.e., thousands of times smaller in water area in compare with ponds, more intensive). Carp will mature faster than in ponds if fed with balanced high-protein feed (protein up to 35%). To understand, in a cage with an area of 40 m^2 (6 * 6 m) and a depth of only 3 m, farmer can raise 600 breeder fish, while the same stock will require a pond of 20 hectares!!!

Acknowledgments

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