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Original Article

Comparison of the traditional outdoor and recirculation indoor rearing systems on survival rate and growth performance of common carp (*Cyprinus carpio*) larvae during early development

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Abstract: The larvae of common carp (*Cyprinus carpio* L.) were studied for 6 weeks in an indoor recirculatory system (RAS) and an outdoor earthen pond to compare their effects on growth performance and survival rate. Larvae reared in outdoor earthen ponds achieved significantly higher total length, weight, weight gain, and length increments than indoor groups ($P \leq 0.05$). However, the indoor recirculatory system had the highest survival rate (83±1.9%) than outdoor earthen ponds (42±3.6%) ($P \leq 0.05$). The results of the present study revealed that the raising system has a significant impact on the survival and growth performance of the larvae in common carp, and the best growth performance was in the outdoor earthen ponds, while the better survival rate was recorded in the indoor recirculatory system. Therefore, to minimize mortality and maximize survival rate, it is suggested that the larvae were released after hatching into closed and controlled rearing systems before being reared into earthen ponds after starting the exogenous feeding.

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Introduction

Larval rearing is vital to a successful aquaculture program (Islam et al., 2004). Larviculture in the common carp (*Cyprinus carpio*) follows the usual practices in Iraq, i.e., applying a semi-intensive system in the earthen ponds. In this system, larvae feeding during the exogenous stage is based on ingesting natural food items produced by fertilizing the ponds (Portella et al., 2014). This approach causes losses during the initial phase i.e. up to grown to fry with a weight of 1 g (Jelkić et al., 2012). These losses can be due to variations in the water quality of the earthen ponds.

In nature, larval survival is determined by predator avoidance and feeding conditions (Feldlite and Milistein, 1999). Large-scale mortality is a concern during the early developmental stages of some freshwater fish in the wild and even in some nursery ponds (Jana and Jana, 2003). Dietary deficiencies have been reported to be the main reason for high larval mortality in hatcheries (Ayyappan and Jena, 2003; Ghosh et al., 2004), along with low water quality (Rice et al., 1987), predation and disease (Smith and Kernehan, 1981; Ludwig, 1999; Frimpong and Lochmann, 2005).

The greatest losses of fish larvae occur during the larvae to fry transition period, ranging from 50 to 90 % in earthen ponds (Matic and Jurakic, 2006; Kumar et al., 2012; Jelkić et al., 2012; Gjurcevic et al., 2012). This could result in a severe shortage of common carp fingerlings in the developing aquaculture industry. Modifications in larval rearing technology, like controlled production, can increase the survival rate of larvae from up to 80-90% (Barr et al., 2007). In semi-intensive production systems, larviculture is typically done in earthen ponds; however, rearing the larvae in an intensive system for a short period is more efficient than direct release into earthen ponds (Jomori et al., 2003).

Indoor systems for larvae production are an alternative for improving survival rates (Jomori et al., 2005; Motta et al., 2019), especially during months in which climatic conditions are improper. Nutrition is the main issue with raising common carp larvae in hatcheries under controlled conditions. However, outdoor earthen-pond-produced zooplankton is frequently irregular in quantity and quality, and there is a high risk of parasites in such hatcheries. Artificial diets can be used in indoor hatcheries (Charlon and Bergot, 1986), but the development of common carp larvae using formulated diets are frequently reduced (Kamler, 1992). In addition, feeding live food first can compensate for this deficiency and reduce the high mortality rates in common carp larvae fed formulated diets from the start of exogenous feeding. Recent works on rearing common carp larvae using artificial feed instead of live-food have shown good results (Regenda et al., 2003). Although the survival rate of fish larvae is higher under controlled conditions due to food supply and the absence of predators, but mortality is high and varies depending on the species. Hence, this study aimed to compare the growth performance and survival rate of common carp larvae during early development in an indoor recirculatory system fed artificial feed to those of traditional systems i.e. outdoor earthen pond system.

Materials and Methods

This experiment was conducted in the wet laboratory of the Marine vertebrates Department, Marine Science Centre, the University of Basrah in March-April of 2021. The experiment was conducted in an indoor recirculatory aquatic system including 12 plastic tanks of 30× 30× 40 cm, fitted with an underwater biofilter, solids settling tank, and oxygen pumps. The outdoor earthen ponds include three earthen ponds of 10×15×0.75 m. The recirculatory system was cleaned and filled with water before beginning the experiment. Before the experiment, the earthen ponds were dewatered and sun-dried for about two weeks. The earthen ponds will be filled with water in February 2021. Furthermore, extra water was added to each earthen pond 10 days before the experiment began to keep the water level stable.

The healthy larvae with an average length of 0.45±0.001 cm and an average weight of 0.0029±0.0001 g were obtained from the Marine Science Centre Hatchery of the University of Basrah. Fish larvae were introduced into tanks of the recirculatory system and earthen ponds at random and reared for six weeks. The density of the tanks and earthen pond culture system were considered as five larvae per liter. The larvae were fed *ad libitum* four times per day during the rearing period. Initially, the larvae were fed boiled egg yolk four times a day at four-hour intervals for the first three days. Then, they were fed algae and mixed zooplankton for the next eleven days. The larvae were then fed commercially available feed pellets containing 25% crude protein, 2.5% crude fat, 7% fiber, and 10% moisture for the remaining study period. The feed pellets were crushed before feeding the larvae.

Some physio-chemical water quality parameters, including water temperature, pH, salinity, and dissolved oxygen, were measured daily during the rearing period (Baird et al., 2012). The length, weight, and the total number of larvae were recorded at the end of the experiment (6 weeks). The following formula was used to calculate growth parameters, weight gain, average length increment, and survival rate.

Weight gain (g) = final fish weight (g) - initial fish weight (g)

Length increment (cm) = Final fish length (cm)-Initial fish length (cm)

Survival rate (%) = harvested larvae / stocked larvae x 100

The statistical analysis was performed in SPSS (version 26) using the one-way analysis of variance (ANOVA), followed by the LSD test. The differences were considered statistically significant at the level of $P \leq 0.05$. The results were all described as mean±SD.

Results

All physical and chemical water quality parameters were within acceptable limits for larval rearing (Table 1). Based on the results, the larvae reared in outdoor earthen ponds achieved a higher average total length (6.54±0.13 cm) and weight (5.324±1.276 g) (Fig. 2). Those of the indoor recirculatory system had a lower average length (2.60±0.06 cm) and weight

Table 1. Water physical and chemical properties in common carp larvae rearing systems.

Parameters	Indoor recirculatory aquatic system Range (mean)	Outdoor earthen ponds Range (mean)
Temperature (ºC)	26.5-27.7 (27.1)	22.3-28.1 (25.2)
pH	8.1-8.6 (8.3)	8.1-8.9 (8.5)
DO (mg/l)	7.2-8.9 (8.05)	5.4-7.8 (6.6)
Salinity (g/l)	1.23-2.52 (1.87)	2.45-3.27 (2.68)

Table 2. Common carp larvae growth parameters in outdoor earthen ponds and indoor recirculatory aquatic systems.

Parameters	Indoor recirculatory system	Outdoor earthen ponds
Initial weight (g)	0.0029±.0001[a]	0029±.0001[a]
Final weight (g)	0.267±0.088[b]	5.324±1.276[a]
Weight gain (g)	0.257±0.088[b]	5.314±1.276[a]
Initial length (cm)	0.45±0.02[a]	0.45±0.02a
Final length (cm	2.60±0.06[b]	6.54±0.13[a]
Length increments (cm)	2.15±0.08[b]	6.09±0.17[a]
Survival rate (%)	831.9%[a]	42±3.6%[b]

The data is presented as mean ± SD. The difference in means is represented by different letters in the rows (P≤0.05).

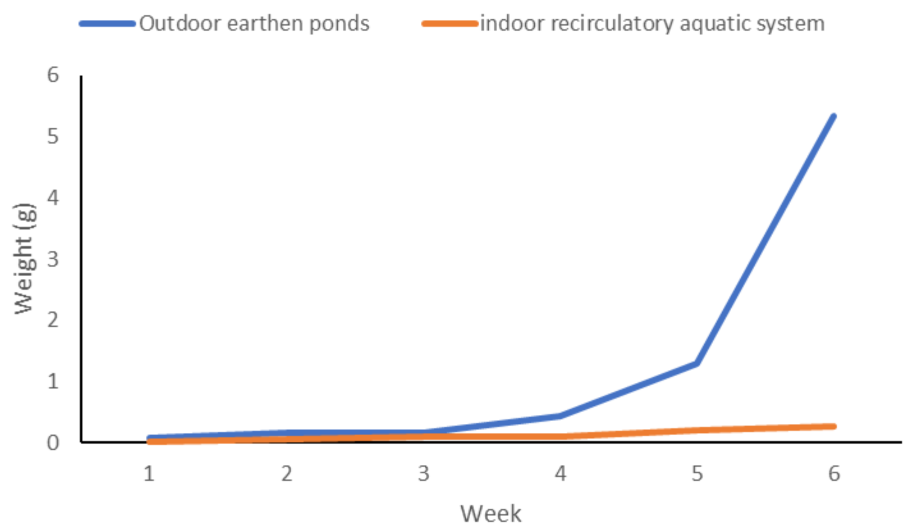

Figure 1. Weekly increase in the weight of the common carp larvae.

(0.267±0.088 g) (P≤0.05) (Fig. 1). The larvae reared in outdoor earthen ponds had higher weight gain, and length increments, than those of reared indoor (P≤0.05) (Table 2). The survival rates of larvae in two rearing systems are shown in Table 2. The indoor recirculatory system had a higher survival rate (83±1.9%) than outdoor earthen ponds (42±3.6%) (P≤0.05).

Discussions

The water quality parameters during the experiment were within the acceptable range for carp larvae cultivation (Motta et al., 2019). The indoor tanks effectively maintained acceptable water quality parameters during the experiment. In addition, the used feeding protocol in this study, which was based on Motta et al. (2019), showed proper results for the rearing of an indoor system. The adopted feeding frequency (4 times per day) was also effective for rearing larvae. Fish larvae are transitional animals that require constant feeding (Portella et al., 2014).

In the current study, larvae reared in the outdoor earthen ponds gained higher total length and weight. Under any management regime, larvae gained more weight in earthen ponds than indoor tanks (Ayyappan and Jena, 2003). Similar findings have been reported

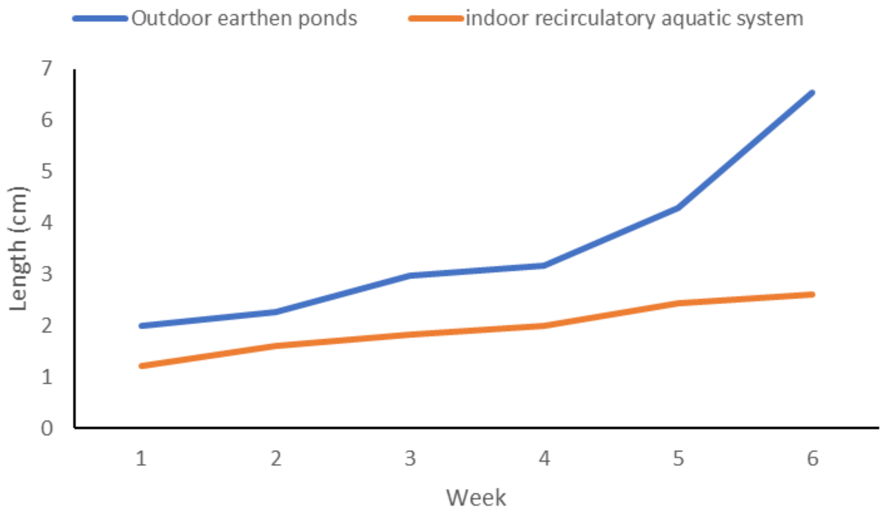

Figure 2. increase in the length of the common carp larvae.

in studies with other fish species (Summerfelt et al., 1996; Jomori et al., 2003, Malison, 2003). The increases in total length and weight of larvae in earthen ponds were significant, which attributed to the live food availability in earthen ponds as a result of fertilization and additional food (Ayyappan and Jena, 2003). Whereas indoor tanks have small spaces limiting natural food production (Fotedar, 2016).

Competition for space and food is the primary factor influencing larvae growth in indoor tanks (Fotedar, 2016). Even food for the larvae is sufficient; this did not guarantee that every larva would consume the estimated amount of food. Differences in food availability were more directly related to growth, weight gain, and length increments. In contrast to our findings, Ako et al. (2005) found that common carp were non-competitive feeders. Despite laboratory success, tank culture of yellow perch (*Perca flavescens*) fingerlings is not widely used, and commercial production is done in ponds with live food (Malison, 2003). Ponds are commonly used for walleye, *Stizostedion vitreum*, and younger fry (up to 6.5 cm) because they grow faster (Summerfelt et al., 1996).

The high survival rate in the indoor recirculatory system was most likely due to the improved conditions promoted by larvae production, such as high-quality food supply and water quality control. The larval stage immediately the following hatching is the most critical developmental stage in fish life history, requiring a significant pause to maintain growth and survival until later life stages (Jelkić et al., 2012). Controlling environmental factors such as water quality, predators, diseases, and nutrition are crucial. Common carp larvae were transferred to laboratory tanks while environmental factors were kept within acceptable limits, allowing for appropriate growth and survival rates, which is consistent with the findings of Smagula and Adelman (1982), and Elliot (1982).

The results of the present study showed that the raising system has an important effect on the survival rate and growth performance of common carp larvae. The best weight gain and length increments were found in the outdoor earthen ponds, while the better survival rate was recorded in indoor tanks. Therefore, it is suggested that the larvae are released after hatching in a closed and controlled rearing system, and then released into earthen ponds to avoid mortality and achieve the highest growth performance.

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