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Effect of Oxygen Concentration on the Survival of the Goldfish Fry Ryukin (*Carassius auratus*) by Transportation System

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ABSTRACT

The transportation of live fish fry involves transferring the fry using specific treatments to ensure their survival during transit. This practice is important for maintaining the health and viability of the fry until they reach their intended destination. In general, fish fry are transported from one location to another to support distribution efforts while ensuring that the fry remain in stable and healthy condition throughout the journey. This study aimed to determine the effect of different oxygen concentrations on the survival of the goldfish fry (*Carassius auratus*), and to identify the oxygen concentration that yields the best survival outcome. A closed transportation system was used, with a transport duration of six hours. The fry used were the Ryukin goldfish fry, each with a total length of approximately 3cm and an average age of 60 days. The transportation containers consisted of plastic bags with a total volume of two liters, filled with one liter of water and different oxygen concentrations. Each bag contained three goldfish fry, and a total of 36 fry were used across four treatments, each replicated three times. The study included four treatment groups: Treatment A used an oxygen concentration of $3mg \cdot L^{-1}$, Treatment B used $4mg \cdot L^{-1}$, Treatment C used $mg \cdot L^{-1}$, and Treatment D (the control) had an oxygen concentration of $0mg \cdot L^{-1}$. All treatments were conducted over a six-hour period. The results indicated that oxygen concentration did not have a significant effect on the survival of goldfish fry. However, the oxygen concentrations of $3mg \cdot L^{-1}$, $4mg \cdot L^{-1}$, and $5mg \cdot L^{-1}$ all resulted in a 100% survival rate, suggesting that these concentrations are sufficient to maintain fry viability during short-term transportation.

INTRODUCTION

Ornamental fish cultivation and marketing hold excellent potential, both economically and culturally. One of the most promising ornamental fish species is the goldfish (*Carassius auratus* Linnaeus, 1758). Goldfish are widely appreciated for their visual appeal and are commonly cultivated in aquariums and ponds. The production of chef goldfish has shown notable growth, with an average increase of 31.1% in 2018, reaching 81,284.1 thousand individuals. Based on current trends in ornamental fish cultivation, goldfish production is projected to reach 129,734 thousand individuals by 2024 **(Risdawati & Widiastuti, 2021)**.

Goldfish are highly favored in the ornamental fish market due to their aesthetic qualities and distinctive features. They are available in a wide range of colors, shapes, and varieties, making them particularly attractive to hobbyists. Proper care is essential for maintaining their health and ensuring a long lifespan. The beauty of chef goldfish lies not only in their physical traits but also in their elegant swimming patterns, which are calming and therapeutic. In Chinese culture, the goldfish are also considered symbols of good fortune, and they are often given as gifts to convey positive wishes **(Danang, 2024)**. The goldfish market is characterized by high demand and relatively affordable prices, ranging from Rp. 5,000 to Rp. 50,000 depending on type and size **(Novanto, 2013)**.

Live fish fry transportation is a critical aspect of ornamental fish cultivation, as it involves moving fish fry using specific methods to preserve their health and viability. According to **Utomo (2002)**, the purpose of this process is to ensure that the fry remain in good condition until they arrive at their destination. Fish fry are typically transported to support distribution from hatcheries to rearing facilities or farms. Transportation is categorized into short-distance and long-distance methods, with the closed system method being the most suitable for longer distances due to its ability to sustain oxygen levels over time **(Septia, 2012)**.

A major challenge in fry transportation is the distance from fry sources, which increases the need for reliable transport methods. Ensuring that fish farmers and entrepreneurs receive healthy, viable fry is critical for meeting production targets **(Okoh *et al.*, 2008)**. One of the main issues encountered during transport is stress, which significantly contributes to fry mortality. Stress can arise from changes in water quality, especially due to the accumulation of feces and ammonia. Managing these factors is vital to improving fry survival during transport. One potential solution is the use of controlled oxygen concentrations during transportation **(Supriaddin *et al.*, 2013)**.

Oxygen plays a vital role in water quality and is essential for the survival and reproduction of goldfish, particularly during their fry stage. Dissolved oxygen levels in the aquatic environment directly impact the health and viability of the fry. Therefore, maintaining appropriate oxygen concentrations is necessary to minimize competition among fish for oxygen. Intense competition may lead to stress responses, the development of dominant or defensive behaviors, and ultimately a reduction in survival rates **(Sari *et al.*, 2023)**.

This study aimed to evaluate the effect of varying oxygen concentrations on the survival of chef goldfish fry. Specifically, it seeked to determine which oxygen concentration yields the highest survival rate, contributing to improved practices in the transportation of ornamental fish fry.

MATERIALS AND METHODS

1. Study area

The implementation of the research began by transporting live goldfish fry in a closed system from the Bastiong Ternate Ferry Pier port to the Sofifi Ferry Port, Tidore Islands City for 6 (six) hours of travel. This research was conducted in October 2024.

2. Research procedure

This study employed a closed transportation system over a duration of six hours. The fry used were Ryukin chef carp (*Carassius auratus*) with an average total length of 3cm and an approximate age of 60 days. The transportation containers were plastic bags with a total volume of 2 liters, each filled with 1 liter of water and different concentrations of dissolved oxygen.

Each plastic bag contained three chef carp fry, resulting in a total of 36 fry used in the study. The experiment consisted of four treatment groups, each replicated three times. After placing the fry into the bags, oxygen was added according to the designated concentrations for each treatment. The mouths of the bags were then sealed using rubber ties. In the control group, which did not receive oxygen supplementation, the plastic bag was left open and unsealed.

All prepared bags were placed in a cool box and transported by ferry from Bastiong Ferry Port in Ternate to Sofifi Ferry Port. During transportation, the behavior and survival rate of the fish fry were observed. Additionally, water quality parameters such as temperature and pH were measured at the beginning and end of the study using a thermometer and a pH meter. The data obtained from these observations were recorded for further analysis. This study consisted of 4 treatments with 3 replicates, namely:

A : Oxygen concentration 3 mg.L^{-1} for 6 hours
B : Oxygen concentration 4 mg.L^{-1} for 6 hours
C : Oxygen concentration of 5 mg.L^{-1} for 6 hours
D : Oxygen concentration 0 mg.L^{-1} for 6 hours (as a control)

The oxygen concentrations used in this study were determined based on the oxygen requirements of chef carp fry, which range from 3 to 5 mg·L^{-1} **(Syaifudin, 2004)**.

3. Data analysis

Data collection included information on survival rate and water quality parameters, specifically temperature and pH. Survival rate was calculated by recording the number of fish alive at the beginning and end of the transportation period, then expressed as a percentage using the formula provided by **Efendie (1997)**.

$SR = Nt/N0 \times 100$

Information:

SR = Survival Rate (%)

Nt = Number of fish at the end of the study (tail)

N0 = Number of fish at the beginning of the study (tail)

The data were analyzed using a Completely Randomized Design (CRD), applying analysis of variance (ANOVA), as described by **Steel and Torrie (1993)**. If the results indicated a significant effect, further analysis was conducted using the Least Significant Difference (LSD) test.

RESULTS

1. Survival rate and fish conditions during transportation

Survival refers to the number of cultured organisms that remain alive over a specified period during the maintenance or transportation process. The results of the survival rate analysis of the goldfish fry during transportation are presented in Table (1).

Table 1. Survival (%) of goldfish fry during 6 hour transport

Replicate	Treatment				Number
	A	B	C	D (control)	
1	100	100	100	66.6	366.6
2	100	100	100	66.6	366.6
3	100	100	100	100	400
Total	300	300	300	233.2	1,133.2
Average	100	100	100	77.73	

Table (1) shows that the highest average survival rates were observed in Treatments A, B, and C, each with a survival rate of 100%. In contrast, the lowest survival rate was recorded in Treatment D (control), with an average of 77.73%. To determine whether the differences among treatments were statistically significant, an analysis of variance (ANOVA) was conducted. The results of this analysis, assessing the effect of oxygen concentration on the survival rate of chef carp fry, are presented in Table (2).

Table 2. Analysis of diversity of treatment effects on the survival of goldfish fry

Diversity Resources	Free	Sum Squared	Middle Squared	F_{count}	F_{table}	
					5%	1%
Treatment	3	1,115.560	371.853	4.000 ^{tn}	4.07	7.59
Error	8	743.707	92.963			
Total	11					

Information : tn = no real difference.

Table (2) shows that the calculated F-value (4.000) is less than the F-table value at both the 5% and 1% significance levels. This indicates that the treatments did not have a statistically significant effect on the survival rate of the goldfish fry. In other words, the use of different oxygen concentrations did not result in a significant difference in the survival of goldfish fry.

During the transportation of fish from Bastiong Ferry Port to Sofifi Ferry Port, observations were made on the condition of the goldfish fry in each treatment group. The results showed that in Treatments A (3mg·L^{-1}), B (4mg·L^{-1}), and C (5mg·L^{-1}), all goldfish fry exhibited active and responsive behavior throughout the transportation process—from departure to return to Ternate. These observations suggest that oxygen concentration influences the physiological condition and activity of goldfish fry during transport.

Although the statistical analysis indicated no significant difference, the observational data demonstrated that fry in the oxygen-supplemented treatments (A, B, and C) maintained high vitality and experienced no mortality. In contrast, Treatment D (control), which received no oxygen (0mg·L^{-1}), resulted in approximately two mortalities. This supports the idea that while oxygen concentration may not significantly alter survival statistically, it does influence the overall health and stress levels of goldfish fry during transportation.

2. Water quality

The results of water quality measurements during the study, including temperature and pH, are presented in Table (3).

Table 3. Water quality measurement results (temperature and pH)

Parameter	Range
Temperature (^{o}C)	26.2 - 29.5
pH	6.3 - 6.7

The water temperature recorded during the study ranged from 26.2 to 29.5°C. These results indicate that the temperature conditions during transportation remained within a suitable range to support the viability and survival of goldfish fry. Similarly, the pH values measured during the study ranged from 6.3 to 6.7. These values also fall within the optimal range for the health and longevity of goldfish fry, indicating that the water quality during transportation was conducive to maintaining fry survival.

DISCUSSION

The degree of fish survival refers to the comparison between the number of fish stocked at the beginning of the study and the number of fish still alive at the end, expressed as a percentage **(Sulaeman, 2017 in Ilham, 2021)**. In this study, the average survival rate of the goldfish fry during the 6-hour transportation period was relatively high across all treatments. The high survival rate is likely due to the fry's ability to adapt to water conditions during transportation and the fact that the oxygen concentrations used were within the acceptable range for goldfish fry. According to **Syaifuddin (2004)**, the correct concentration of dissolved oxygen enhances the immune system of goldfish fry, contributing to better survival. He further noted that the ideal range for goldfish fry is between 3 $mg \cdot L^{-1}$ and 5 $mg \cdot L^{-1}$. Concentrations outside of this range may lead to increased stress and even mortality.

Oxygen plays a vital role in supporting the life processes of fish fry, including immunity, energy production, cellular function, and recovery from stress **(Danang, 2024)**. The primary principles of fish transportation center on ensuring survival and maintaining healthy physiological conditions during and after transport. **Nurhayati *et al.* (2021)** emphasized that several factors influence the health and survival of fish during transport, including fish quality, oxygen levels, pH, carbon dioxide (CO_2), ammonia, temperature, stocking density, and handling procedures. These variables collectively affect the fish's physiological response and stress tolerance.

In this study, mortality was only observed in Treatment D (control), which had no added oxygen (0 $mg \cdot L^{-1}$). The deaths in this treatment were likely caused by stress due to inadequate oxygen levels during transport, which negatively affected the physical condition of the fry. Changes in environmental parameters during transportation, especially oxygen depletion, can induce stress—a biological response that disrupts homeostasis and leads to physiological damage or even mortality **(Ismi, 2017 in Ilham, 2021)**.

In contrast, fry in Treatments A, B, and C—where oxygen concentrations were 3 $mg \cdot L^{-1}$, 4 $mg \cdot L^{-1}$, and 5 $mg \cdot L^{-1}$, respectively—remained active and exhibited no signs of stress or mortality. However, in Treatment D, the fry showed signs of stress, such as reduced movement and tendency to stay at the water surface, eventually resulting in the death of approximately two fry. This supports **Syaifuddin**'s **(2004)** assertion elucidating that oxygen levels within the 3–5 $mg \cdot L^{-1}$ range are optimal for the survival of the goldfish fry during transport.

Although oxygen is a critical factor in fish fry transportation, it is not the sole determinant of successful transport. The fish's ability to utilize oxygen effectively can be influenced by water temperature, pH, CO_2 and ammonia accumulation, overactivity, bacterial infections, physical damage from handling, and other stress factors **(Budidayati *et al.*, 2007 in Ilham, 2021)**.

Temperature is one of the most important environmental parameters affecting fish growth and metabolism. It influences oxygen solubility, photosynthesis, metabolism, reproductive cycles, and appetite **(Asmawi, 1986)**. Furthermore, **Guighley and Hinch (2006)** noted that temperature affects the physical, chemical, and biological characteristics of water, including fish sensitivity to toxins. Goldfish, including various color variants, can tolerate a wide temperature range from approximately 4 to 35°C **(Danang, 2024)**.

pH, or the acidity level of water, reflects the concentration of hydrogen ions and plays a key role in aquatic life health. A neutral to slightly alkaline pH is considered ideal for freshwater fish. Low pH levels can suppress growth and increase vulnerability to disease and mortality **(Asmawi, 1986)**. As a critical indicator of water quality, pH is frequently used to assess the suitability of aquatic environments **(Nugroho, 2006)**. **Novianto and Manan (2013)** identified the optimal pH range for goldfish survival as 6.2 to 6.9, which aligns with the findings of this study, where pH remained within 6.3 to 6.7.

CONCLUSION

Based on the results of the research that was carried out, oxygen concentration has no significant effect on the survival of goldfish fry. Oxygen concentrations of 3mg.L^{-1}, 4mg.L^{-1}, and 5mg.L^{-1}, gave the best results on the survival of goldfish fry by 100%.

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