Growth rate, survival and color intensity of Clown loach (*Chromobotia macracanthus* (Bleeker,1852)) fry in a recirculation system: differences between wild and cultured varieties

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Abstract. Clown loach (*Chromobotia macracanthus* (Bleeker,1852)), an endemic species to Indonesia, is one of the main freshwater ornamental fish in demand in the international market. The high demand for wild-caught and cultured fries supports supply sustainability. However, the difference in performance between naturally sourced and cultured fries is not fully understood. This study aims to analyze and compare the performance of Clown loach from both sources, including growth rate, survival, and color quality, after 60 days of rearing. In this study, Clown loach fries were raised using a recirculating system. There were two treatments: wild-caught and cultured juveniles, repeated three times each. Juveniles measuring 1.5–2 cm were stocked at three fish/L of water. The results showed that Clown loach from the wild exhibited better growth potential than those from culture. The average growth rate of wild-caught Clown loach reached 3.731±0.087%, significantly higher than that of cultured fish, which only reached 2.020±0.082%. The survival rate between the two groups did not differ significantly, with wild-caught Clown loach recording a survival rate of 98%, while farmed fish reached 91%. The study revealed that wild-caught Clown loach demonstrated superior growth rate, survival, and color quality than farmed fish.
Key Words: Clown loach, fry, performance, recirculating, ornamental fish.

Introduction. Clown loach is a species of freshwater ornamental fish endemic to Kalimantan and Sumatra, Indonesia (Musthofa et al 2018; Liyana et al 2019). The popularity of this fish in the global market is very high, making it one of the most important species for ornamental aquaculture. To meet this demand, using natural resources and cultured juveniles is necessary. Although spawning methods and reproductive management in controlled environments have developed rapidly (Baras et al 2012; Abinawanto et al 2018), the performance differences between juveniles from these sources remain a significant concern.

Natural Clown loach fries tend to show brighter colors than cultured fries, mainly due to access to natural feeds rich in carotenoids. Carotenoids are pigments that cannot be synthesized by fish and must be obtained through their diet (Liyana et al 2019; Nakano & Wiegertjes 2020; Swain et al 2020). Meanwhile, Yustiati et al (2020) informed that supplementation of carotenoids, such as astaxanthin, in aquaculture feed could significantly improve fish color. Previous studies also found that environmental engineering, such as red

LED lights, can enhance fish's color and growth (Virgiawan et al 2020). It indicates that nutrition and ecological manipulation play crucial roles in improving the aesthetic quality of farmed fish.

The application of recirculating aquaculture systems (RAS) has proven effective in maintaining water quality and stabilizing the rearing environment, which is essential for tropical species such as Clown loach. Dasgupta et al (2023) emphasized that this system can improve fish survival, while (Hossain et al 2022) recommended an optimal stocking density of three fish/L of water for best results. However, despite supporting fish growth, the RAS environment often lacks natural sources of nutrients, such as carotenoids, that are necessary for optimal pigmentation in fish.

Clown loach fry from culture generally adapts better to artificial feed and controlled environments, resulting in faster growth (Legendre et al 2012). However, fries from the wild have an advantage in terms of genetic variation, which enhances resistance to disease and environmental stress (Hossain et al 2022). This is consistent with findings that wild goldfish exhibit higher specific growth and survival rates than cultured fries. By utilizing the strengths of each fry source and optimizing aquaculture techniques, such as using enriched feed and advanced recirculation systems, it is hoped that the quality of cultured Clown loach can be significantly improved.

Material and Method

Time and site. The research was conducted over 60 days in the Depok Ornamental Fish Research Institute laboratory using a recirculation system. The water temperature was 26–28°C, and water quality was monitored periodically to maintain pH (6.5–7.5) and dissolved oxygen (DO) levels above 5 mg L^{-1} (Budiardi et al 2022; Heriyati et al 2022; Dasgupta et al 2023; Lindholm-Lehto 2023).

Broodfish. Clown loach fries: Sourced from wild (Sumatra) and aquaculture (Indonesian Ornamental Fish Aquaculture Research Institute). Recirculation System: a container measuring 45 cm long, 30 cm wide, and ±40 cm high, filled with ±20L water. Fries measuring 1.5–2 cm are stocked at a density of 3 specimens/L of water. The fish are reared in a recirculation system equipped with filters (small stones, palm oil, and Dakron) to maintain water quality. Natural feed in the form of frozen bloodworms is provided, with nutritional content including 57.5% protein, 13.5% fat, 2.04% crude fiber, 3.6% ash, and 87.19% moisture. This feed is given daily twice at 8:00 and 16:00 (Rizki et al 2020).

Measuring instruments. TCF (Toca Color Finder) measures changes in color intensity. Water quality measuring devices include a thermometer, pH meter, and DO meter for daily monitoring of water quality (Bande & Nandedkar 2016; Agudelo et al 2018; Yustiati et al 2020; Silva et al 2022; Chuang et al 2023)

Research design. This study used a Completely Randomized Design (CRD) with two treatments: fries from wild and culture, each repeated three times (Legendre et al 2012).

Parameter measurement. The growth and survival rates were measured every 10 days. Growth was assessed based on increasing the total length of the fish, measured from the tip of the mouth to the tail using a measuring device with an accuracy of 0.01 cm. Survival was calculated by counting dead fish. Growth calculations were based on the growth rate and Survival (Kanu et al 2021; Santos et al 2022; Robert et al 2023), as follows:

$$SGR\,(\%)=\frac{\text{In } L_t\text{-In } L_o}{t}\times 100\%$$

$$SR\,(\%)=\frac{N_t}{N_o}\times 100$$

where:
SGR is the specific growth rate (%);
SR is survival rate (%);
L_t = the length of the fish fry at the end of the experiment;
L_o = the length of fish fry at the beginning of the experiment;
t = the number of days;
N_t = the number of fish fry at the end of the experiment;
N_o = the number of fish fry at the beginning of the experiment.

Color quality. It was measured at the end of the study by comparing the color of the fish with the Toca Color Finder (TCF) tool, using three trained panelists (Yustiati et al 2020).

Water quality. To ensure ideal conditions during the study, water quality is measured every 10 days, covering temperature, pH, and DO (Dasgupta et al 2023).

Data analysis. The growth and survival rates were analyzed using ANOVA at a significance level of 95%, followed by the Duncan Test to compare the differences between treatments.

Results

Growth rate. This study shows that fish from nature have a higher growth rate during each observation period than aquaculture fish, as shown in Table 1.

Table 1
The growth rate of Clown loach, in which fries are derived from wild and cultured varieties for 60 days, with 60 specimens of each treatment

Treatment	*The growth rate of day-to-day observations (%)*					
	10	*20*	*30*	*40*	*50*	*60*
Wild Clown loach	6.791	6.885	5.172	4.723	4.353	3.669
Cultivated Clown loach	5.294	4.379	3.079	2.551	2.128	2.016

On the 60th day, at the end of the observation period, fish growth from both treatments declined. Wild varieties of Clown loach recorded a growth rate of 3.669%, while cultured Clown loach reached only 2.016%. This decline may be related to saturation or a decrease in response to feeding over time, as also observed in studies of other tropical species (Yustiati et al 2020).

Overall, wild fish exhibit a higher growth rate than farmed fish. This confirms that the source of the fry significantly affects growth performance. These results provide essential insights for aquaculture practitioners in selecting appropriate fry sources and developing optimal maintenance strategies for both juvenile types.

Table 2
The average growth rate of Clown loach per treatment and replication over 60 days, with 60 specimens of each treatment

Replication	*Treatment*	
	Wild	*Culture*
1	3.810	1.982
2	3.637	1.957
3	3.742	2.109
Average	3.731 ± 0.087^a	2.020 ± 0.082^b

There is a significant difference with different letters at $P<0.05$.

The average growth rate (%) of Clown loach fry from wild and aquaculture over 60 days is shown in Table 2. The analysis showed that fries from the wild fries had a higher average growth rate (3.731±0.087%) than aquaculture fries (2.020±0.082%). This difference was statistically significant (denoted by different superscripts), indicating that fry origin is vital in determining growth performance. The wild Clown loach tends to adapt quickly to new environments, resulting in more optimal growth (Yustiati et al 2020).

Survival. The survival data (%) of Clown loach from wild and cultured sources during the 60-day observation period (Table 3). At the beginning of the period (days 10 to 50), survival in both groups of fish was optimal, at 100%, indicating that both wild and cultured fries adapted well to the rearing environment. However, on day 60, there was a slight decrease in survival in both groups, with each treatment showing a survival rate of 98%, while culture reached 99% on day 50.

Table 3

Survival of wild and cultured Clown loach during the study, with 60 specimens of each treatment

Treatment	*Survival of day-to-day observations (%)*					
	10	*20*	*30*	*40*	*50*	*60*
Wild Clown loach	100	100	100	100	100	98
Cultivated Clown loach	100	100	100	100	99	98

Several factors, such as environmental saturation or a decline in the physiological condition of the fish over time, could cause a decrease in survival rate in the final rearing phase. Yustiati et al (2020) stated that although the recirculation system can maintain optimal water quality, long-term stress accumulation can still affect the condition of the fish. The recirculation system helps manage water quality by filtering waste products, reducing the risk of toxic buildup (Ramli et al 2023). Studies show that different filter media can significantly affect water quality and fish growth rates, demonstrating the need for customized filtration solutions (Lailiyah et al 2023). Proper feed management is essential. Overfeeding can lead to increased waste and decreased water quality. Research shows that optimal feeding levels correlate with better water quality and fish health, emphasizing the need for careful monitoring (Lindholm-Lehto 2023).

Fish color. The study found that Clown loach fries from the wild have more intense color pigments than those from culture after 60 days, especially in the orange and black parts of the body as shown in Figure 1.

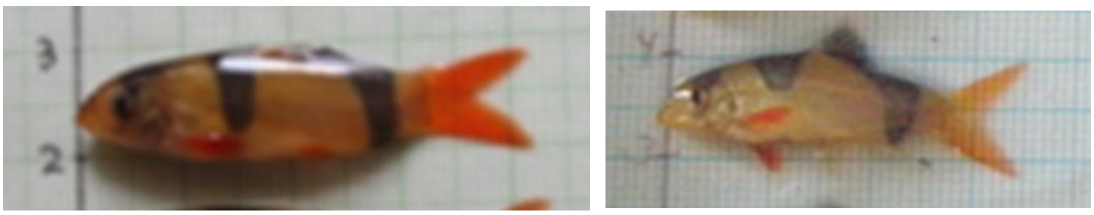

Figure 1. The color of Clown loach after 60 days of rearing: from wild (left) and culture (right). Source: original contribution.

Table 4

The color of the fish after 60 days of rearing, was measured and matched with TCF for both wild and cultured fish, with 60 specimens of each treatment

Color parameters	The color of Clown loach after being kept for 60 days (code TCF)	
	Wild	*Culture*
Yellow color		
Body	606	602
Tail	605	601
Black color		
Body	5226	5228

Water quality. Water quality and environmental conditions play an important role in the growth, survival, and color of Clown loach. Optimal water parameters, such as temperature and pH, are maintained in aquaculture to ensure healthy growth, as presented in Table 5.

Table 5

Water quality over 60 days with a recirculation system for Clown loach fries from wild and culture

Parameter	*Fry source treatment comes from*		
	Wild and culture	*Habitat (Sumatra)*	*References*
Temperature (°C)	28.3-30.6	25-29.3	Husna 2023
pH	7.46-7.64	6.52-7.46	Husna 2023
NH_3 (mg L^{-1})	0.03-0.09	0.021-0.058	Husna 2023
NO_2 (mg L^{-1})	0.18-0.24	0.089-0.128	Husna 2023
Disolved O_2 (mg L^{-1})	4.03-5.30	3.32-7.50	Wike 2020

Discussion

Growth rate. The study findings showed a significant difference in the growth rate of Clown loach from two fry sources, namely wild and cultured, over 60 days. Wild Clown loach fries had a higher average growth rate (3.731±0.087%) than cultured fries (2.020±0.082%). Genetic factors and natural adaptations are essential aspects that support this growth performance. Abinawanto et al (2018) noted that the higher genetic variation in wild-caught fries increases adaptability to environmental changes and more optimal utilization of nutrients.

Fries from nature tend to be superior in utilizing feed, mainly because the feed provided is closer to the type of natural feed found in their habitat. In contrast, cultured fries show limitations, possibly due to low genetic variation resulting from inbreeding (Legendre et al 2012). Also, Yustiati et al (2020) emphasized that feeding enriched with nutrients, such as carotenoids, not only improves the color of fish but also supports better growth. However, long-term adaptation to artificial feed remains a challenge for cultured fries.

Over time, a decrease in growth rate was observed in both fry groups. The wild Clown loach, which initially grew faster, declined to 3.669% within 60 days, while cultured juveniles only reached 2.016%. According to Dasgupta et al (2023), this decline is likely due to feeding saturation or nutritional inadequacies in the final rearing phase. Therefore, proper management of nutrients and the environment is essential to maintaining optimal growth in the long term (Legendre et al 2012).

This study emphasizes the importance of selecting the right fry source in aquaculture to support optimal fish growth. The implementation of the recirculating aquaculture system (RAS) plays a significant role in maintaining water quality stability, which is a key factor in the success of aquaculture. Choosing high-quality fry sources enhances growth and survival rates, as demonstrated in studies on various fish species

(Beltrán et al 2023). The genetic diversity of fry sources can influence resilience to diseases and environmental changes, promoting sustainability in aquaculture (Jin et al 2023). RAS technology minimizes water usage and maintains stable water quality, vital for fish health (Quast et al 2013). Effective water quality management reduces the risk of disease outbreaks caused by opportunistic pathogens, thus supporting fish welfare (Quast et al 2013). Advanced feed formulations, such as those with optimal protein/energy ratios, significantly impact fish growth and water quality (Fan et al 2023). Monitoring nutrient levels in RAS can help mitigate the adverse effects of feed on water quality, ensuring a balanced ecosystem (Fan et al 2023). Conversely, while focusing on fry selection and RAS is critical, reliance on wild fish populations for fry sources can lead to overexploitation, threatening sustainability. Therefore, integrating aquaculture with responsible wild fish management is essential for long-term ecological balance (Rajani et al 2024).

Survival. The survival rate of Clown loach from wild and cultured fries over 60 days showed excellent results, as shown in Table 3. Until day 50, survival in both treatments remained at 100%, although there was a slight decrease to 99% in cultured fries. After day 60, this figure decreased slightly to 98% in both groups. These results indicate that the recirculating system can provide a maintenance environment that supports fish survival.

The recirculating system plays an important role in maintaining the stability of water quality parameters such as temperature, pH, and dissolved oxygen levels, all of which similarly contribute to the good health and physiology of tropical fish. This stability in water quality helps minimize stress on the fish, thus allowing for a high survival rate during the rearing period. Research by Yustiati et al (2020) also confirms that an environment with optimal water quality can reduce the risk of stress and disease in fish in aquaculture systems.

Although the survival remains high, the slight decrease at 60 days can be attributed to long-term stress accumulation or environmental saturation. Other factors, such as population density or less varied diets, can also affect survival rates (Yustiati et al 2020). In addition, the limitations of genetic adaptation in cultured fries may be one of the reasons for this decline, as revealed by Legendre et al (2012), although non-genetic factors, such as the environment, also play a significant role. However, in this study, no factors were observed affecting the occurrence of degradation, such as disease and other physiological stress factors.

The results of this study show that recirculating aquaculture systems effectively support high survival rates in Clown loach from both wild and cultured sources. However, to improve long-term performance, stricter management of water quality, feed diversification, and environmental strategies such as adding shelters are needed (Vielma et al 2021; Ahmed & Turchini 2021). With good monitoring and management, recirculating systems can be a sustainable solution for aquaculture practices, especially in maintaining performance during the final maintenance phase. The study highlights the effectiveness of recirculating aquaculture systems (RAS) in achieving high survival rates for Clown loach, emphasizing the need for improved management practices to enhance long-term performance. Key strategies include stringent water quality management, feed diversification, and environmental enhancements such as adding shelters. RAS requires precise control of water parameters, including temperature, pH, and dissolved oxygen, to ensure optimal fish health (Li et al 2023b). Implementing systems like fuzzy logic controllers can help maintain stable water levels, reducing the risk of fluctuations that could harm fish (Mulyanto et al 2023).

Color. Differences in the color of Clown loach from wild and culture. The study results showed that Clown loach from wild sources had more intense body colors than those from cultured fries after 60 days of maintenance. The main factor influencing this color difference is the composition of pigments, such as carotenoids, which are widely found in natural feed. Fish from wild habitats have access to a natural, nutrient-rich food source, allowing them to produce bright colors on their bodies, particularly in their distinctive orange and black patterns. It demonstrates that feed sources play a significant role in the development of fish color. Fish from cultured fries tend to have more faded body colors due to the limited variety of feed available in the controlled recirculation system. While these systems effectively maintain water quality, they do not fully replicate the natural environment, which supports the availability of nutrients from various sources.

Carotenoid deficiency in cultured feed can affect fish pigmentation. Therefore, pigment supplementation in cultured feed is essential to improve color quality. The pigmentation of fish cultured from fries is significantly influenced by the nutritional composition of their feed, particularly the presence of carotenoids. Research indicates that the limited variety of feed in controlled recirculation systems can lead to carotenoid deficiencies, resulting in faded body colors in fish. To address this issue, pigment supplementation in aquaculture feed is essential for enhancing color quality. Carotenoids, such as astaxanthin, are crucial for fish pigmentation and can be sourced from natural (e.g., microalgae) and synthetic pigments (Zlaugotne et al 2023). Studies show that specific carotenoid formulations can significantly improve the color quality of ornamental fish, demonstrating the effectiveness of targeted supplementation (Destianti et al 2023).

The nutritional profile of fish feed directly affects growth performance and muscle quality. For instance, replacing fishmeal with non-grain proteins can maintain growth but may not address pigmentation needs (Su et al 2023). Supplementing diets with carotenoids has enhanced fish's visual appeal and marketability, which is vital for aquaculture (Zlaugotne et al 2023). While pigment supplementation is beneficial, it is essential to consider the potential environmental impacts of sourcing these pigments, particularly from synthetic origins, which may have lower ecological footprints than natural sources (Zlaugotne et al 2023). Balancing nutritional needs with sustainable practices remains a challenge in aquaculture.

Stress is another important factor that affects the quality of fish color. Fish raised in artificial systems tend to experience higher stress levels than those in their natural habitat, which can be caused by population density, limited space for movement, and suboptimal water quality. According to Sudirman et al (2020), prolonged stress can interfere with metabolism and pigment production, causing the body's color to fade. It also impairs the fish’s ability to absorb and store pigments from their feed.

The difference in color quality between fish whose juveniles come from the wild and those from aquaculture highlights the need for improvements in environmental management and feed in aquaculture systems. Carotenoid supplementation in farmed fish feed is crucial to mimic natural nutrients. In addition, reducing stress levels through population density management and improving water quality are necessary to produce more intense and attractive body colors. The stress level of the wild fish could be related to the higher adaptability than that of culture fish. This study emphasizes integrating nutrition and environmental management to improve farmed fish's aesthetic quality and support the aquaculture industry's sustainability.

Water quality. Using a 60-day recirculation system, Clown loach, whose fries are derived from nature and cultured, were analyzed. The results of the water quality analysis include the following parameters: temperature, pH, ammonia, nitrites, and oxygen.

Temperature. Water temperature affects fish metabolism. In their natural habitat, water temperature ranges from 25–29.3°C, while in the rearing environment, it is higher, ranging from 28.3–30.6°C. An increase in temperature can improve fish metabolism but also carries the risk of increasing stress. Fish from aquaculture ponds tend to be more resistant to higher temperatures than fish from natural habitats. It is due to changes in the controlled environment of the culture pond. These findings are consistent with the information gathered, which shows that farmed fish can tolerate higher temperatures. Standard metabolic rate (SMR) increases with temperature, while maximum metabolic rate (MMR) peaks before declining at extreme temperatures (Jonsson 2023).

Fish species like *Sinilabeo rendahli* show a positive correlation between routine metabolic rate and critical oxygen tension at varying temperatures, indicating adaptive responses to thermal stress (Li et al 2023c). Optimal growth temperatures for species such as *Percocypris pingi* are identified between 18-22°C, with significant growth reductions at lower and higher extremes (Wu et al 2022). Higher temperatures during embryonic development can lead to larger egg sizes, enhancing reproductive success (Jonsson 2023). Aquaculture fish demonstrate increased resistance to thermal stress due to acclimatization in controlled environments, contrasting with wild fish that may experience higher stress levels at elevated temperatures (Jonsson 2023; Shima et al 2023). Conversely, while farmed fish may adapt better to higher temperatures, the potential for metabolic breakdown and increased mortality at extreme temperatures remains a concern, highlighting the need for careful management in aquaculture practices.

The pH. The water pH in fish from the habitat ranges from 6.52 to 7.46, while fish from aquaculture have a higher pH, ranging from 7.46 to 7.64. The optimal pH for a recirculation system in tropical fish ranges from 7.0 to 8.0 to maintain an ionic balance that supports fish health. These results show that the pH in the maintenance of farmed Clown loach is close to the optimal value, which may help maintain fish health in a controlled environment. It suggests that controlled environments can effectively support fish health.

Optimal Range: The ideal pH for tropical fish is between 7.0 and 8.0, which promotes ionic balance and overall health. Monitoring Systems: Advanced water quality monitoring systems can help maintain these pH levels, reducing fish mortality (Wei et al 2023). Natural vs. Aquaculture: Wild fish exhibit a pH range of 6.52 to 7.46, which is lower than that found in aquaculture, indicating a potential advantage for farmed fish regarding health and growth (Green et al 2023). Environmental Factors: temperature and salinity can influence pH levels, which are critical for aquatic ecosystems (Rugebregt et al 2023). While the pH levels in aquaculture appear beneficial for fish health, it is essential to consider the potential stressors from environmental changes and anthropogenic activities that could affect water quality in natural habitats (Green et al 2023).

The NH_3. The concentration of ammonia (NH_3) in fish from natural habitats ranges from 0.021 to 0.058 mg L^{-1}, while in farmed fish it ranges from 0.03 to 0.09 mg L^{-1}. High levels of NH_3 can potentially cause fish poisoning, especially in closed systems such as recirculating systems. The study showed that the safe level of NH_3 is below 0.05 mg L^{-1}.

In farmed fish, some values are close to this limit, so ammonia management needs to be considered in the aquaculture system to prevent stress and disease in the fish. Managing ammonia (NH_3) levels in aquaculture is critical for fish health, particularly in farmed species where concentrations can approach toxic thresholds. Research indicates that while natural habitats show lower NH_3 levels, farmed fish often experience higher concentrations, necessitating effective ammonia management strategies to mitigate stress and disease risks (Subaramaniyam et al 2023; Ciji et al 2023; Ramírez et al 2023). High NH_3 levels can lead to poisoning, especially in closed systems like recirculating aquaculture systems (RAS) (Subaramaniyam et al 2023). The safe threshold for NH_3 is below 0.05 mg L^{-1}, with farmed fish sometimes nearing this limit (Ciji et al 2023). Implementing advanced control systems, such as dual-input fuzzy logic control, can optimize water quality by rapidly reducing NH_3 levels (Li et al 2023a). Dietary interventions, like β-glucan supplementation, have shown potential in enhancing fish resilience to ammonia stress (Ciji et al 2023). Climate change exacerbates ammonia toxicity, impacting fish growth and health, which could lead to economic losses in aquaculture (Ramírez et al 2023).

The NO_2. Nitrite (NO_2) levels in fish from natural habitats range from 0.089 to 0.128 mg L^{-1}, while in farmed fish, the values are higher, ranging from 0.18 to 0.24 mg L^{-1}. According to (Hernández-Casas et al 2023), nitrite is a by-product in recirculation systems that must be managed appropriately due to its toxicity. The elevated NO_2 levels in farmed fish in this study indicate potential risks and highlight the need for optimal biofilter management to reduce nitrite concentrations in the water.

The O₂. The concentration of dissolved oxygen in fish from natural habitats ranges from 3.32 to 7.5 mg L^{-1}, while farmed fish have a more stable oxygen level, ranging from 4.03 to 5.3 mg L^{-1}. Oxygen is essential for fish respiration; higher levels generally support better health. The dissolved oxygen concentration (DO) is crucial for fish health, with natural habitats showing a range of 3.32 to 7.5 mg L^{-1}, while farmed fish maintain levels between 4.03 to 5.3 mg L^{-1}. Research indicates that these levels are generally sufficient for optimal health, particularly for tropical fish like Clown loach, which thrives above 4 mg L^{-1} (Mahamuni & Goud 2023; Song et al 2023).

Natural habitats exhibit DO levels from 3.32 to 7.5 mg L^{-1}. Fluctuations in these levels can impact fish health, particularly in dynamic ecosystems (Kroeker et al 2023). Farmed fish maintain a more stable DO range of 4.03 to 5.3 mg L^{-1}. Studies show stable DO levels enhance fish culture performance and stress resistance (Heriyati et al 2022). Optimal DO levels are essential for preventing hypoxic stress, which can lead to health issues in fish (Song et al 2023). Technologies like microbubble aeration can effectively stabilize DO levels in aquaculture systems, promoting better health outcomes (Heriyati et al 2022). Conversely, while stable DO levels in aquaculture are beneficial, extreme fluctuations in natural habitats can lead to significant stress and health challenges for fish, highlighting the need for effective monitoring and management strategies in both environments.

Conclusion. This study shows that Clown loach whose fries come from the wild have better performance than cultured fries in terms of growth rate, survival, and color quality after being kept for 60 days. Clown loach whose fries come from nature consistently show a higher growth rate, with a significantly larger average growth rate than Clown loach whose fries come from culture. These results indicate that natural conditions are more supportive in facilitating optimal growth, both in terms of natural nutrients and lower stress, which contributes to the improvement of fish color quality. Therefore, to improve the quality of farmed fish, environmental and feed optimization is required, including the supplementation of important nutrients such as carotenoids.

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