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RESEARCH ARTICLE

The Effect of Water Renewal Rate and Frequency on the Growth Performance of *Ancistrus multispinis* (Regan, 1912, Pisces, Teleostei) Fry

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ABSTRACT

In this study, the effects of different water renewal rates on the development of *Ancistrus multispinis* fry, a popular aquarium fish species, were examined during the growth phase. For this purpose, five different water renewal programs were applied to *A. multispinis* fry stocked in glass aquariums during the trial period. The water renewal rates in the groups were planned to be 10%, 20%, and 30% daily (d1, d2, and d3) and 30% and 50% weekly (dh3, dh5). The fry, whose total lengths and weights were measured around the 30-35th day after hatching, were placed in trial tanks. At the beginning of the trial, the average total length of the fry was measured at 13.97±0.47 cm, and their average live weight was 0.027±0.05 g. The trial lasted for 90 days. At the end of the trial, it was observed that the fry in the d3 group, which received a 30% daily water renewal, grew better than those in the other groups. In this group, an average total length of 2.75±0.24 cm and an average weight of 0.23±0.05 g were obtained at the end of the trial. In contrast, the growth performance of the other groups was lower compared to the d3 group. Statistical analyses indicated significant differences among the groups. According to the results of the study, it can be stated that regular monitoring of water quality and consideration of periodic water renewal amounts in the rearing process are important in the farming of this fish species. In this regard, this research emphasizes the need to improve existing traditional methods in *A. multispinis* fry rearing and suggests that optimizing water renewal practices can enhance the growth performance of *A. multispinis* fry.

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1. Introduction

Water quality has a critical impact on the growth performance and overall health of fish in aquaculture. The physical and chemical properties of water directly affect the metabolism, growth, and immune system of fish that live in aquatic environments (Obirikorang et al., 2022). Deterioration of water quality in which fish are raised can lead to direct mortality and can also stress the fish, making them more susceptible to infectious diseases. In particular, parameters such as water temperature, dissolved oxygen, pH, ammonia, and nitrate are among the most important factors determining the development and health of fish (Martins et al., 2009; Timmons et al., 2002). Therefore, monitoring and managing water quality is vital for the success of aquaculture systems. Problems arising from water quality in aquaculture are often due to the unsuitability of the water chemistry used and the negative effects of feed and waste on water quality (Kisia & Hughes, 1993). The frequency of water renewals is important in closed-

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loop systems. Over time, the deterioration of water quality can negatively affect the growth performance of fish, reducing survival rates (Obirikorang et al., 2022). Similarly, problems can arise in the development of fish raised in tanks with high stocking densities (Jha & Barat, 2005; Sahoo et al., 2004). Therefore, improving water quality is an important requirement for the healthy development of fish. The more frequently the water in the tank is changed, the more beneficial it is considered to be. However, it is known that there is a limit to the frequency of water renewals. Thus, determining specific water renewal rates for the fish species being cultivated is important. Adequate water renewals help reduce harmful waste accumulation in the tank while also contributing to the maintenance of the water's chemical balance (Kpundeh et al., 2013). Adjusting water renewal rates in closed-loop systems can positively affect the growth rates and health conditions of fish (Zhang et al., 2025). For example, a study on the effects of water renewal rates on growth reported that increasing water renewal rates improved the growth performance of fish and increased resistance to diseases (Kpundeh et al., 2013). This situation demonstrates the importance of regularly implementing water renewal practices in fish farming. *A. multispinis* is a species sensitive to water quality conditions. The fry of this species can grow faster and undergo a healthier development process with increased water renewal rates. In some fish species raised in closed-loop systems, increasing water renewal rates has been reported to enhance the growth performance of fry and increase resistance to diseases (Kpundeh et al., 2013). In this context, the effects of water renewal rates on the growth process of *A. multispinis* fry represent an important research area for the commercial cultivation of this species. Water renewal is a practice that directly maintains the chemical balance of water. Therefore, it positively contributes to better nutrition and increased digestive efficiency in fish (Zhang et al., 2025).

Based on this information, this study observed the effects of water renewal practices, which can have sudden and direct impacts on improving water quality, during the fry rearing phase of the *A. multispinis* species.

2. Materials and Methods

The study protocol was approved by local ethics committee of animal trials of the Çanakkale Onsekiz Mart University in the meeting dated 23.12.2022 with the decision number 2022/12-01.

2.1. The Fish

In this study, newly hatched *A. multispinis* fry that had exhausted their yolk sacs were used. In summary, the effects of different water renewal rates on the development of *A. multispinis* fry were observed. The broodstocks of *A. multispinis* available in our laboratory were used to obtain the fry. Initially, a sufficient number of fry were produced for the experiment. The newly hatched fry of the same age were kept in larval rearing tanks until their yolk sacs were depleted and they began to consume artificial micro-particle feed. Approximately 30-35 days after hatching, the fry, whose total lengths and weights were measured, were placed in trial tanks. To determine the initial length and weight data, 27 samples were measured. According to these measurements, it was found that at the beginning of the trial, the average total length of the fry was 13.97±0.47 cm, and their average live weight was 0.027±0.05 g.

2.2. Experimental Design

The trial lasted for 90 days. The fry used in the experiment were produced from broodstock raised in the same laboratory. After obtaining a sufficient number of fry for the experiment, the trial setups were established. At the beginning of the trial, the live weight and total length measurements of the fry were taken. No anesthetic was applied during the measurements. A total of 5 groups were created (Table 1). The first three groups were designed with daily water renewal rates of 10%, 20%, and 30% (designated as d1, d2, and d3, respectively), while the last two groups were planned with weekly water renewal rates of 30% and 50% (designated as dh3 and dh5, respectively). Each experimental group was replicated three times. At the end of the 90-day trial, live weight and total length measurements were taken. The survival and growth rates between the groups were compared at the end of the trial. All groups were fed with the same brand of commercial fish feed (0.5-0.8 microns, ALLTECH) in the same amounts and meal frequencies. Fish were given 0.01 g of feed per fish per liter, which means 0.05 g of feed per meal for 5 fish in 5 liters and 0.1 g of feed per meal for 10 fish in 5 liters. Water quality parameters were maintained under similar conditions for all groups. In this trial, 20 fry were stocked in aquariums, each with a capacity of 4 L. A total of 300 fry were used in the experiment.

Table 1. Experimental design of the study.

Group	Water renewal Rates	Stock Density	Repetition	Total Number of Fry in the Group (= 3 repetitions)
d1	Daily % 10	20 fry / 4 L	3	60
d2	Daily % 20	20 fry / 4 L	3	60
d3	Daily % 30	20 fry / 4 L	3	60
dh3	Weekly % 30	20 fry / 4 L	3	60
dh5	Weekly % 50	20 fry / 4 L	3	60

2.3. Statistical Analyses

For statistical analyses, ANOVA was used to test the hypothesis regarding the differences among group means. Before this analysis, the assumptions of normality and homogeneity of variances were tested. ANOVA analyses were applied if the assumptions were met. To investigate whether there are differences among the groups, the Kruskal-Wallis test was conducted. The Dunn test was performed to determine which groups had differences.

3. Results

In this study, the development of *A. multispinis* fry was tested under different water renewal frequencies. At the beginning of the experiment, the average length of the fry was 13.97±0.47 cm, and their live weight was 0.027±0.05 g. Based on the data set, five trials were established according to the water renewal. Descriptive statistics and graphs for total length (cm) were obtained from the collected data (Table 2, Figure 1).

Table 2. Descriptive statistics of end-of-trial data for total length (cm) in groups where the effect of water renewal on the growth of *A. multispinis* was measured.

	Experiment	**n**	**min**	**max**	**median**	**iqr**	**mean**	**sd**	**se**	**ci**
1	d1	45	2	3.7	2.7	0.5	2.68	0.373	0.056	0.112
2	d2	45	2	3.6	2.6	0.5	2.709	0.385	0.057	0.116
3	d3	54	1,9	3.7	2.7	0.6	2.752	0.458	0.062	0.125
4	dh3	44	2	3	2.5	0.3	2.527	0.242	0.037	0.074
5	dh5	40	2	3.2	2.6	0.7	2.61	0.359	0.057	0.115

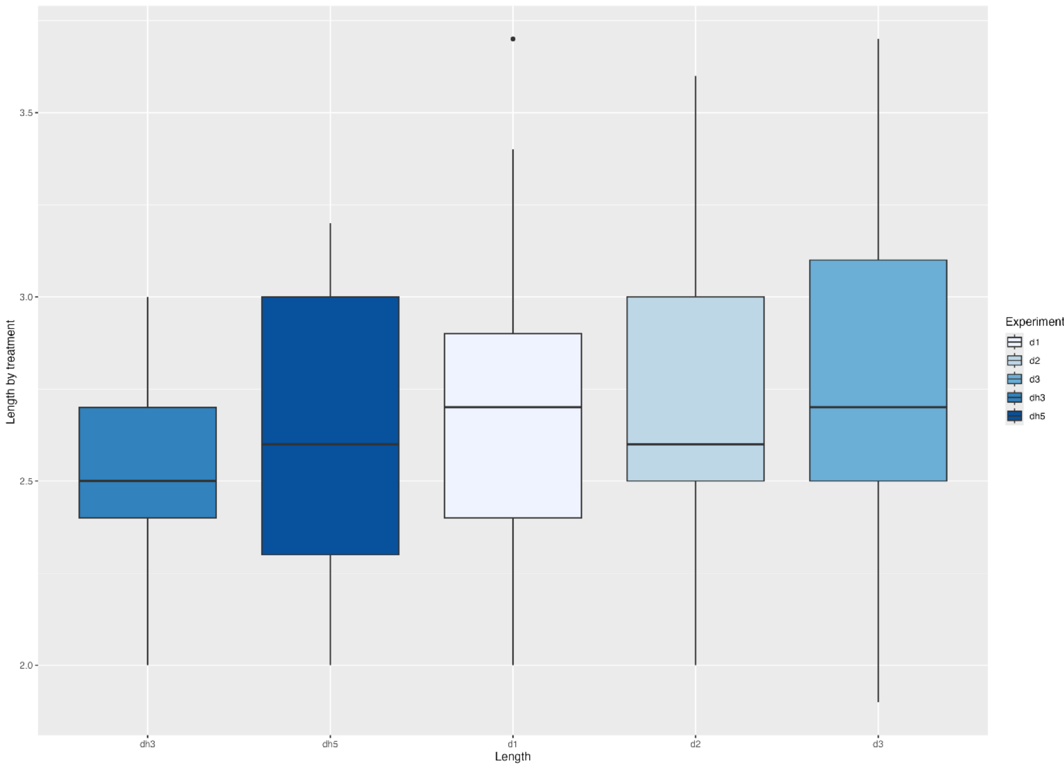

Figure 1. Graph showing the differences in total length (cm) among groups at the end of the water renewal trials. Groups: :Daily water renewal rates of 10%, 20%, and 30% (designated as d1, d2 and d3, respectively), weekly water renewal rates of 30% and 50% (designated as dh3 and dh5, respectively).

To investigate whether there are differences in length among the trials, after determining the suitability of assumption checks, the Kruskal-Wallis test was conducted due to the failure of the assumptions. According to the test results, the null hypothesis stating "there is no difference among the trials" was rejected, and the difference among the trials was found to be statistically significant ($p<0.05$). To identify which trials had differences, the Dunn test was performed. According to the results obtained from the Dunn test, the difference among the trials is statistically significant. Figure 1 is presented to evaluate the differences in total length among the groups.

In this test, statistical comparisons were made between two or more groups. Accordingly, comparisons of some pairs were evaluated using Z, P.unadj (unadjusted p-value), and P.adj (adjusted p-value).

According to this analysis, the differences among the groups are summarized in Table 3.

Table 3. Statistical comparison of total length (cm) among groups at the end of the trial.

	d2	d3	dh3	dh5
d1	O	O	X	O
d2		O	*	O
d3			*	O
dh3				O

O: No significant difference ($p>0.05$); *: Significant difference ($p<0.05$); X: Slight but not significant difference ($p>0.05$).

When evaluating these analysis results overall, only the comparisons between d2-dh3 and d3-dh3 show statistically significant differences. All other comparisons have p-values above 0.05, leading to the conclusion that there is no significant difference.

According to the data obtained at the end of the trial, the descriptive statistics of the groups in terms of live weight (g) are presented in Table 4. Additionally, the differences in live weight among the groups at the end of the trial are shown in Figure 2.

According to the results of the Kruskal-Wallis test, the null hypothesis stating "there is no difference among the trials" was rejected, and the difference among the trials was found to be statistically significant ($p<0.05$). The Dunn test was performed to identify which trials had differences.

Table 4. Descriptive statistics of end-of-trial data for live weight (g) in groups in the water renewal trials.

	Experiment	n	min	max	median	iqr	mean	sd	se	ci
1	d1	45	0.07	0.43	0.18	0.14	0.193	0.081	0.012	0.024
2	d2	45	0.05	0.48	0.19	0.12	0.208	0.097	0.014	0.029
3	d3	54	0.05	0.51	0.215	0.15	0.227	0.104	0.014	0.028
4	dh3	44	0.07	0.32	0.16	0.062	0.165	0.055	0.008	0.017
5	dh5	40	0.06	0.32	0.17	0.13	0.174	0.073	0.011	0.023

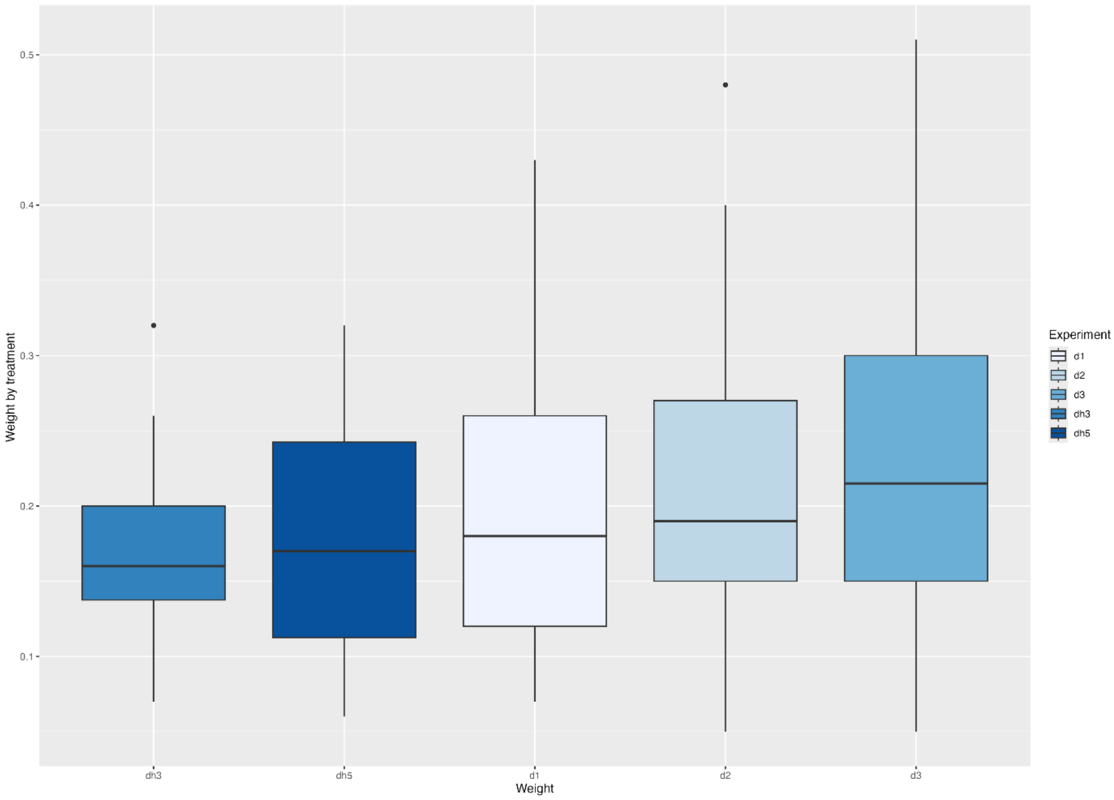

Figure 2. Graph showing the differences in live weight (g) among groups at the end of the water renewal trials. d1: daily 10% water renewal, d2: daily 20% water renewal, d3: daily 30% water renewal, dh3: weekly 30% water renewal, dh5: weekly 50% water renewal.

The evaluation of the data containing statistical comparisons among different groups is as follows (Table 5):

Table 5. Statistical comparison of weight (gr) among groups at the end of the trial.

	d2	d3	dh3	dh5
d1	O	X	X	O
d2		O	*	X
d3			*	O
dh3				O

O: No significant difference (p>0.05); *: Significant difference (p<0.05); X: Slight but not significant difference (p>0.05).

When we make a general assessment based on this data, the comparisons of d2-dh3, d3-dh3, and d3-dh5 show statistically significant differences. In all other comparisons, since the p-values are above 0.05, it can be concluded that there is no significant difference.

The scatter plots (Figure 3) illustrating the relationship between weight and length in *A. multispinis* fry affected by water renewal rates serve as an important observational tool for understanding the results of the trials.

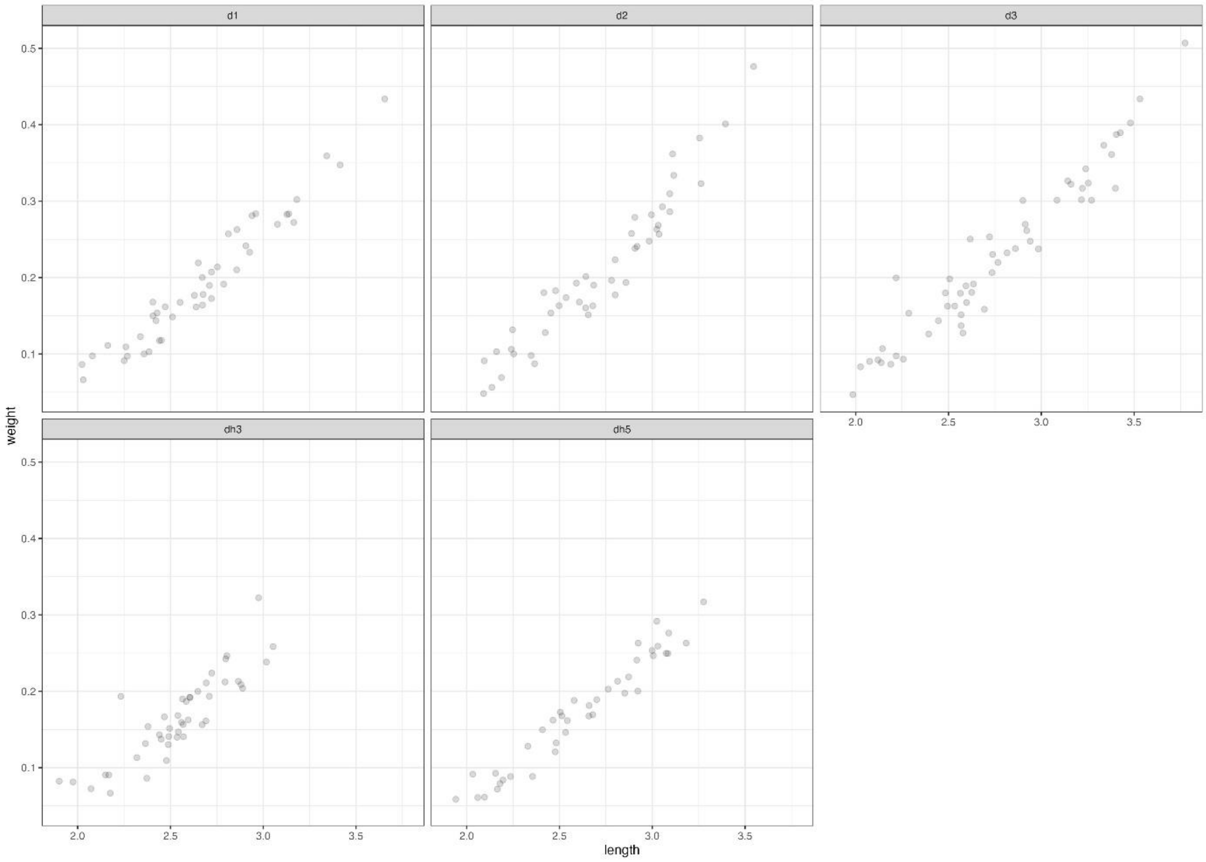

Figure 3. Scatter plots of weight-length graphs from the trials conducted to test the effect of water renewal rates on the growth of *A. multispinis* fry. Weight (=gr), length (= cm). d1: daily 10% water renewal, d2: daily 20% water renewal, d3: daily 30% water renewal, dh3: weekly 30% water renewal, dh5: weekly 50% water renewal.

In all the graphs (Figure 3), a clear positive relationship between length and weight is observed. This indicates that as the length of the *A. multispinis* fry increases, their live weight also increases during the growth process. Generally, individuals with greater total length also have higher live weights. Interpreting these graphs (Figure 3) is crucial to understand which of the water renewal groups (d1, d2, d3, dh3, dh5) exhibited better growth. For example:

- **d3**: This group shows a more pronounced positive trend compared to the others. This suggests that the water renewal rate applied in the d3 group has a slightly more favorable effect on the growth of the fry than the other groups.

- **dh3 and dh5**: The growth trends in these two groups appear less pronounced than in the others. This indicates that the effect of water renewal may vary, and some water renewal rates might be less effective on growth.

Looking at the point distribution in the graphs (Figure 3), it becomes clear how consistent the growth data is for each water renewal group. For instance, in the d1 and d2 groups, the points are more closely clustered, while in the other groups, there is a wider distribution. This suggests that some water renewal groups yield more consistent results in the growth process of the fry. Therefore, the effects of different water renewal rates on the growth of *A. multispinis* fry are clearly observed in these graphs (Figure 3), particularly highlighting the more positive effects of the water renewal rate in the d3 group on growth.

In this experiment, when examining the relationship between water change and the survival rates of fry, no statistical difference was observed between the groups (p=0.872). At the beginning of the experiment, 20 fry were stocked in each replicate tank. The number of fry remaining in each group at the end of the experiment is presented in the table below (Table 6).

Table 6. Descriptive statistics for the number of fry remaining in the groups at the end of the experiment (P = 0.872).

Group	n	min	max	median	iqr	mean	sd	se	ci
d1	3	14	16	15	1	15	1	0,577	2,484
d2	3	13	17	15	2	15	2	1,155	4,968
d3	3	13	16	15	1,5	14,667	1,528	0,882	3,795
dh3	3	11	17	16	3	14,667	3,215	1,856	7,985
dh5	3	11	16	13	2,5	13,333	2,517	1,453	6,252

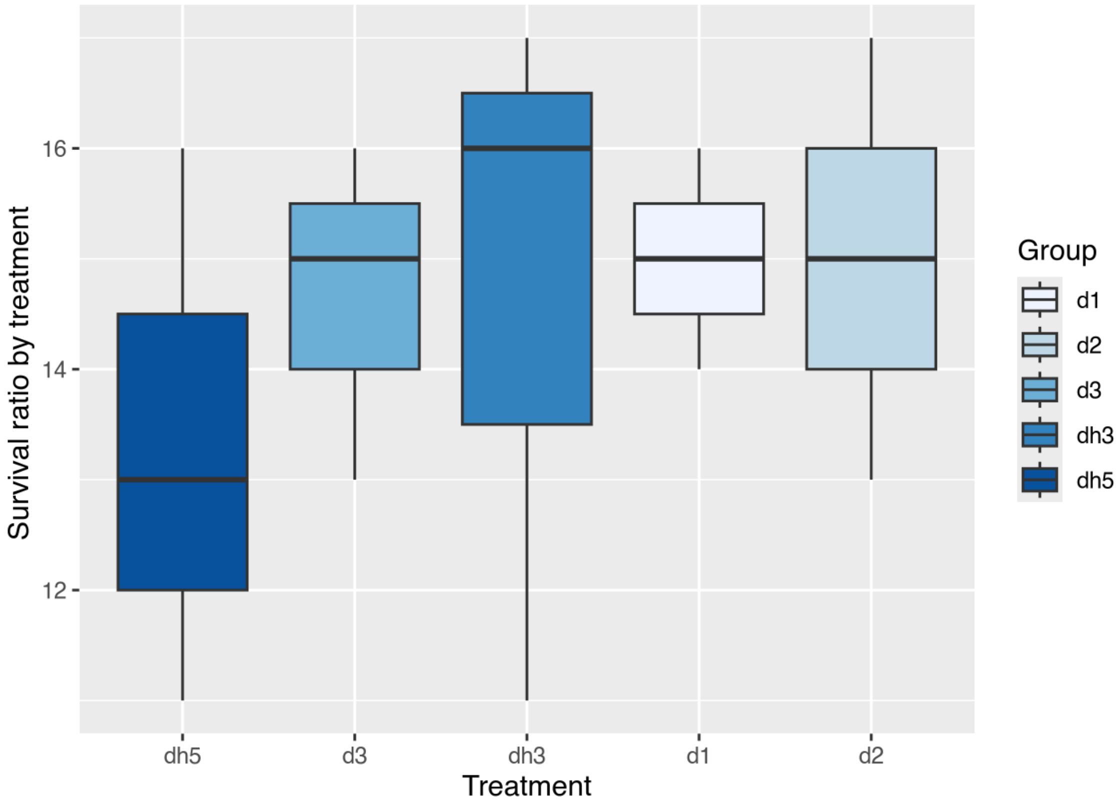

Figure 4. Survival rates in the groups as fry count at the end of the experiment.

The final status of the number of surviving fry at the end of the experiment is shown in Figure 4. Accordingly, the survival rates in the replicate tanks ranged from 55% to 85%. However, when looking at the group averages, the survival rates were found to be 75%, 75%, 73.3%, 73.3%, and 66.65% for groups d1, d2, d3, dh3, and dh5, respectively. Therefore, the statistical analysis (one-way ANOVA) determined that there was no significant difference among the groups in terms of survival rates at the end of the experiment (P = 0.872).

4. Discussion

In this study, the effects of different water renewal rates on the growth of *A. multispinis* juveniles were investigated. The findings indicate that the current breeding practices need to be reviewed and improved. The research results revealed that water renewal rates have a significant impact on the growth of *A. multispinis* juveniles. It was observed that higher water renewal rates enhance the growth performance of the fish and do not negatively affect their survival rates. Water renewal rates were found to be effective in the growth of *A. multispinis* juveniles. Higher water renewal rates positively influenced the health and growth of the fish by improving water quality. A study by Demeke and Tassew (2016) reported that water quality is a primary factor that should be prioritized for healthy fish farming. Additionally, it has been reported that water quality is directly related to growth retardation and increased stress levels in fish. In this context, optimizing water renewal rates could be an effective strategy to enhance the growth performance of *A. multispinis*. Increasing water renewal rates also helps balance the pH level of the water, which is important for the health of the fish (Jana & Sarkar, 2005).

It has been observed that traditional methods commonly used in *A. multispinis* farming in Turkey are not supported by modern scientific findings. It is understood that current producers are reluctant to adopt new methods based on their past experiences. However, this study emphasizes the importance of implementing new methods. Optimizing stock density and water renewal rates can increase production efficiency and provide economic gains.

Among the limitations of traditional methods are factors such as the lack of regular monitoring of water quality and the disregard for stock density. This situation can negatively affect the health of the fish and exacerbate the problems faced by producers. The adoption of modern aquaculture techniques can help overcome these issues. Regular monitoring of water quality and the application of appropriate water renewal rates can positively influence the health and growth of the fish (Timmons & Ebeling, 2010). It is known that water renewal rates are directly related to growth, especially in fish farming conducted in recirculating aquaculture systems. Therefore, the importance of periodic water renewals during the farming process is significant.

In this study, where the effects of water renewal rates on the growth of *A. multispinis* juveniles were observed, statistical differences among the groups were noted based on the collected data. On the other hand, as seen in the figures (Figures 2, 3), the fish in tanks with a daily 30% water renewal (d3) were observed to perform better in terms of length and weight compared to the other groups. At the end of the trial, the total length obtained in this group (2.75±0.24 cm) was greater than that of all the other groups (Table 2). Similarly, the average final live weight of this group (0.23±0.05 g) was also found to be higher than that of the other groups (Table 4).

In this research, based on the values of water renewal rates tested, it was observed that *A. multispinis* juveniles grew better with a daily water renewal rate of 30% (d3 group). In all groups of the water renewal trial, a stocking density of 5 juveniles/L was implemented. It is believed that future trials should observe the effects of a stocking density of 1 juvenile/L with daily 30% water renewals. The simultaneous application of these two techniques may allow for higher performance in growing *A. multispinis* juveniles.

Previous studies have reported that periodic water renewal practices accelerate the growth of fish. For example, a study reported that increasing water renewal rates increased the growth rate of fish by 20% (El-Saidy & Hussein, 2015). Ammonia is a compound that forms as a result of fish waste products and the decomposition of nutrients. High ammonia levels can lead to poisoning and fatal outcomes in fish. Nitrite is produced during the bacterial conversion of ammonia and causes the formation of methemoglobin in fish blood, reducing oxygen-carrying capacity. A study by Bulbul Ali and Mishra (2022) demonstrated that increasing water renewal rates significantly reduced ammonia and nitrite levels. Wendelaar Bonga (1997) showed that higher water renewal rates decreased stress levels in fish and improved their overall health. Another study indicated a correlation between fish stress levels and water renewal protocols (Zhang et al., 2025). Pottinger (2008)'s study found that increasing water renewal rates enhanced fish growth rates by 30%. Furthermore, water renewal rates can also affect the reproductive success of fish. Poor water quality can disrupt reproductive cycles and decrease the survival rates of juvenile fish. Alabaster and Lloyd (2013) found that increasing water renewal rates improved reproductive success by 25%.

In conclusion, the effects of water renewal rates on growth in *A. multispinis* farming are important factors to consider in the cultivation of this species. This study highlights the need to review and improve current farming practices. Future research can contribute to identifying best practices in *A. multispinis* breeding by more comprehensively examining the effects of different water renewal rates. Additionally, developing training programs for producers can encourage the adoption of modern methods and increase efficiency within the industry.

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Compliance with Ethical Standards

The study protocol was approved by local ethics committee of animal trials of the Çanakkale Onsekiz Mart University in the meeting dated 23.12.2022 with the decision number 2022/12-01.

Conflict of Interest

The authors declare that there is no conflict of interest.

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