Effect of Different Feeding Frequencies on the Survival Rate of Rainbow Trout (*Oncorhynchus mykiss)*

Inam Khan[*], Inayat Ullah[†], Muhammad Arif[‡], Abdullah Khan[§], Hilal Ahmad[**]

Abstract

Feeding frequency significantly impacts the survival rates of juvenile fish in aquaculture. This study investigated the effects of different feeding frequencies on rainbow trout fry with an average weight of 3 grams each at the Nagoha Biodiversity Center, Barikot (Swat). A total of 45,000 fry were distributed across five raceways and subjected to feeding frequencies of 8, 4, 3, and 2 times per day. The findings revealed varying survival rates across feeding frequencies. Fry fed 8 times per day exhibited an average survival rate of 98.7% (range 96.3% to 99.9%). Fry fed 4 times per day showed a slightly higher rate of 98.8%. Fry fed 3 times per day had a survival rate of 91.1% and those fed 2 times per day had a survival rate of 98.7%. The higher survival rate for 4 feedings/day compared to 8 feedings/day may be attributed to reduced stress from less frequent handling, better water quality due to less frequent feeding or potential overfeeding in the 8 feedings/day group. These findings highlight the importance of optimizing feeding strategies to maximize fry survival in aquaculture.

Keywords: Rainbow Trout, Mortality, Fry, Feeding frequencies, Raceways, Aquaculture.

Introduction

Salmonid fishes, specifically members of the genus *Salmo*, originated in the Atlantic Ocean around 60 million years ago (Lecaudey et al., 2018). The trout family is distributed worldwide. Salmonidae is a family of 206 species. The family includes the lake, rainbow, brown, and brook trout among common fish (Budy et al*.,* 2009). The rainbow trout is found in cold-water rivers and lakes throughout the Pacific coast of North America and Asia. It has been introduced to approximately 82 countries worldwide, primarily in regions where the environmental conditions favorable to its growth and production are present. Compared to other species of trout, rainbow trout are more adaptable to a wide variety of environmental changes (Sarkheil et al., 2014).

---

[*]Department of Zoology, University of Swat, Saidu Sharif 19200, Pakistan. inamkhan0505@gmail.com

[†]Corresponding Author: Department of Chemical and Life Sciences, Qurtuba University of Science & IT, Peshawar 25100, Pakistan, inayatullah.zoofish@gmail.com

[‡]Department of Zoology, University of Swat, Saidu Sharif 19200, Pakistan, arifkhan03428169@gmail.com

[§]Department of Zoology, Bacha Khan University Charsadda, Charsadda 24420, Pakistan. abdullahsheikh161811@gmail.com

[**]Department of Zoology Abdul Wali Khan University Mardan, Mardan 23390, Pakistan. hilalzooologist@gmail.com

Growth performance and feed conversion efficiency are two of the most important indicators of success in aquaculture. Nutrition is a crucial factor that allows farmed fish to express their maximum genetic potential for growth and reproduction. However, growth is impacted by several other factors (i.e., fish behavior, feed quality, ration size, feeding rate, environmental conditions such as temperature). Because feed costs can account for 40% to 60% of total operating costs in intensive aquaculture systems, the feed budget directly impacts profit and sustainability of fish farming. Providing nutritionally balanced diets and feeding properly are crucial tactics to attain efficient and sustainable aquaculture production. Ideally, commercial feeds ought to be nutritionally complete and have high palatability, to minimize discard and to maximize conversion of feed into body mass consistently (Dediu et al., 2011).

Feeding frequency analysis is one of the fundamental factors in aquaculture, because the most appropriate feeding can improve growth performance and feed consumption efficiency, lower farm feeding costs, and be beneficial in all ways for farming. That means feeding frequency is an essential variable that may indirectly affect digestion and absorption of diet, thereby determining synchronization of diet efficiency with appetite. Improved feed efficiency will indeed play a central role in moving the aquaculture industry to sustainability and towards cost-reducing production practices (Nahayat et al., 2024).

To maximize development and feed conversion efficiency, as well as to obtain a financial advantage, aquaculture requires the application of suitable feeding management. When animals are starved or have insufficient food for a while before receiving adequate nourishment, they display compensatory growth, which causes them to grow more quickly than animals that are fed continuously. Low growth and feed conversion efficiency, as well as ineffective feeding or feeding techniques, have been noted as possible contributors to increased labor expenses. As a management tool, this approach has been suggested to lower feeding expenses. Various forms of fasting or restricted feeding have been utilized to study compensatory growth in a variety of fish species. During compensatory growth stages, fish exhibit higher feed conversion efficiency and excessive hunger, which may be contributing causes to their rapid growth (Guzel & Arvas, 2011).

The primary objective of this study was to investigate how varying feeding frequencies influence the survival of *Oncorhynchus mykiss* fry (average weight: 3 grams) in aquaculture. Specifically, the research aimed to compare survival rates across feeding frequencies of 8, 4, 3, and 2 times per day to identify the most effective strategy for optimizing fry survival. Additionally, the study sought to highlight the importance of balancing feeding frequency with environmental stability to enhance aquaculture practices and improve economic sustainability.

Materials and Methods

Study Area

The study was conducted at Nagoha Biodiversity Centre, Barikot Swat KP, Pakistan. Which is situated 34.6986° North and 72.2016° East. It is recently established for research in fisheries.

Sample Processing

During this study period, a total 45,000 *Oncorhynchus mykiss* fingerlings were transferred from the upper Swat Madyan fish farm. Each fingerling was placed in a distinctive polythene bag that was filled with water. With extreme caution and a dedicated truck, a team of skilled professionals transported the bags containing fry to the Biodiversity Center in Nagoha, Barikot Swat. The fry were raised in five distinct raceways. 9,000 fingerlings were placed in each of the five raceways. The raceways division was used to research fingerling survival rates at different feeding frequencies.

Food Used

The diet used in this study consisted of a combination of starter feed (96%), egg yolk (3%), and cooking oil (2 cc per feeding session). This composition was designed to mimic the natural diet of rainbow trout while ensuring nutritional balance (Data given in Table 1).

Table 1: Raceways treated with different amount of food.

Race way	Frequency	Duration (in Days)	Starter (in g)	Cooking Oil	Egg Yolk (in g)	Artificial Food (In g)
A	8	09	90	2cc	15	0.3
	4	04	45	2cc	10	0.3
	3	02	22.5	0cc	6	0
	2	07	12	0cc	3	0
B	8	09	90	2cc	15	0
	4	04	45	2cc	10	0
	3	02	22.5	0cc	6	0
	2	07	12	0cc	3	0
C	8	09	67.5	2cc	15	0.3
	4	04	34	2cc	10	0.3
	3	02	17	0cc	6	0
	2	07	8.5	0cc	3	0
D	8	09	67.5	2cc	15	0
	4	04	34	2cc	10	0

	3	02	17	0cc	6	0
	2	07	8.5	0cc	3	0
E	8	09	100	2cc	15	0.3
	4	04	50	2cc	10	0.3
	3	02	25	0cc	6	0
	2	07	12.5	0cc	1	0

Results

The daily mortality rate (DMR) and daily survival rate (DSR) were used as the study's two primary data points. Every day, the dead Fry were removed from the Raceways to prevent pollution of the water. The deceased Fry were easily identified since most of their body parts had been eaten away, and they had swollen anal fins with blood clots and appeared to be motionless when they settled down at the water's edge. In order to determine the daily death rate over time, dead fry have been calculated as follows:

$$DMR = \frac{Dead\ fry\ during\ the\ period}{Total\ stock \times Number\ of\ days} \times 100$$

Similarly, survival rate was calculated by the following formula:

$$DSR = \frac{Total\ No - No\ of\ dead}{Total\ No} \times 100$$

Data findings at Biodiversity Center Nagoha (18°C)

At the biodiversity center Nagoha Swat, 45,000 Fry were raised in 5 raceways at 18 degrees Celsius. A total of 12,836 fry were recorded as dead. After eight feedings a day for 22 days, the average daily survival ranged from 96.3% to 99.9%. After four feedings over four days, the average survival rate was 98.8%. When feeding three times a day for approximately two days, the average daily survival rate was 91.1%; when feeding twice a day for seven days, the average daily survival rate was 98.7%. Inappropriate water temperature and lower research area elevation could be the cause of the rearing failure. It could also be related to the fry that came from fish that are adapted to colder, higher elevation water. The inability to raise Fry could also be due to inexperienced staff and inadequate water quality.

Data Findings on Eight Times Feeding

The Fry were given eight feedings a day throughout the 22-day feeding trial. The overall survival varied among treatments; however, the daily survival was typically between 96.3% and 99.9% with a mean daily survival of 98.7%. Most average daily mortality rates were low, generally between 0.1% and 2.6%, with post-feeding spikes. Overall, the highest mortality was recorded on February 6 and February 7 for the Treatment A and E groups. Spikes in mortality may be due to environmental factors and/or stress (Results given in Table 2).

Table 2: Results of rainbow trout fry reared at 18°C in Nagoha, Swat, with eight daily feedings.

Date (2024)	A			B			C			D			E		
	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate
Jan. 28	21	0.2333	99.7667	39	0.4333	99.5667	5	0.0556	99.9444	23	0.2556	99.7444	97	1.0778	98.9222
Jan. 29	27	0.3000	99.7000	65	0.7222	99.2778	30	0.3333	99.6667	42	0.4667	99.5333	98	1.0889	98.9111
Jan. 30	29	0.3222	99.6778	71	0.7889	99.2111	11	0.1222	99.8778	66	0.7333	99.2667	149	1.6556	98.3444
Jan. 31	56	0.6222	99.3778	37	0.4111	99.5889	15	0.1667	99.8333	41	0.4556	99.5444	124	1.3778	98.6222
Feb. 01	43	0.4778	99.5222	125	1.3889	98.6111	18	0.2000	99.8000	99	1.1000	98.9000	195	2.1667	97.8333
Feb. 02	94	1.0444	98.9556	67	0.7444	99.2556	36	0.4000	99.6000	3	0.0333	99.9667	138	1.5333	98.4667
Feb. 03	264	2.9333	97.0667	173	1.9222	98.0778	13	0.1444	99.8556	107	1.1889	98.8111	313	3.4778	96.5222
Feb. 04	234	2.6000	97.4000	297	3.3000	96.7000	18	0.2000	99.8000	28	0.3111	99.6889	329	3.6556	96.3444
Feb. 05	92	1.0222	98.9778	183	2.0333	97.9667	24	0.2667	99.7333	61	0.6778	99.3222	181	2.0111	97.9889
Feb. 06	322	3.5778	96.4222	459	5.1000	94.9000	37	0.4111	99.5889	98	1.0889	98.9111	586	6.5111	93.4889
Feb. 07	178	1.9778	98.0222	253	2.8111	97.1889	11	0.1222	99.8778	55	0.6111	99.3889	351	3.9000	96.1000
Feb. 08	204	2.2667	97.7333	268	2.9778	97.0222	31	0.3444	99.6556	39	0.4333	99.5667	234	2.6000	97.4000
Feb. 09	161	1.7889	98.2111	140	1.5556	98.4444	42	0.4667	99.5333	54	0.6000	99.4000	234	2.6000	97.4000
Feb. 10	131	1.4556	98.5444	255	2.8333	97.1667	18	0.2000	99.8000	71	0.7889	99.2111	219	2.4333	97.5667
Feb. 11	66	0.7333	99.2667	188	2.0889	97.9111	18	0.2000	99.8000	58	0.6444	99.3556	83	0.9222	99.0778
Feb. 12	94	1.0444	98.9556	167	1.8556	98.1444	57	0.6333	99.3667	151	1.6778	98.3222	115	1.2778	98.7222
Feb. 13	102	1.1333	98.8667	172	1.9111	98.0889	103	1.1444	98.8556	231	2.5667	97.4333	108	1.2000	98.8000
Feb. 14	54	0.6000	99.4000	111	1.2333	98.7667	73	0.8111	99.1889	153	1.7000	98.3000	55	0.6111	99.3889
Feb. 15	59	0.6556	99.3444	94	1.0444	98.9556	114	1.2667	98.7333	139	1.5444	98.4556	71	0.7889	99.2111
Feb. 16	47	0.5222	99.4778	95	1.0556	98.9444	127	1.4111	98.5889	229	2.5444	97.4556	69	0.7667	99.2333
Feb. 17	33	0.3667	99.6333	90	1.0000	99.0000	203	2.2556	97.7444	236	2.6222	97.3778	47	0.5222	99.4778
Feb. 18	16	0.1778	99.8222	57	0.6333	99.3667	142	1.5778	98.4222	159	1.7667	98.2333	18	0.2000	99.8000

Data Findings on Four Times Feeding

In the group fed four times per day, fry exhibited the highest survival rate, averaging 98.8%. This frequency appeared to provide an optimal balance between sufficient feed availability and reduced handling stress. The relatively high survival compared to other feeding regimes suggests that four daily feedings ensured proper nutrient intake while maintaining better water quality and minimizing the risks of overfeeding. (Results given in Table 3).

Data Findings on Three Times Feeding

Over the course of two days, Fry were fed three times per day at a maintained temperature of 18 °C. In total, there were 1,107 fry fatalities across all treatment groups, as shown in Table 4. The average daily mortality was calculated to be 6.15% which in turn gives an average survival rate of 91.1%. The highest level of mortality during the experiments occurred during Treatment B on 10/02/24 (2.83%), with the lowest batched mortality from Treatment C (0.20%) survived both days of treatment (Results given in Table 4).

Data Findings on Two Times Feeding

A total of 3,791 rainbow trout Fry died after being fed at 18°C twice a day over a period of 7 days. The average daily mortality rate was 1.3% and the average survival rate was 98.7% (Results given in Table 5).

Table 3. Survival outcomes of rainbow trout fry reared at 18 °C with four daily feedings.

Date (2024)	A			B			C			D			E		
	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate
Feb. 6	322	3.5778	96.4222	459	5.1000	94.9000	37	0.4111	99.5889	98	1.0889	98.9111	586	6.5111	93.4889
Feb. 7	178	1.9778	98.0222	253	2.8111	97.1889	11	0.1222	99.8778	55	0.6111	99.3889	351	3.9000	96.1000
Feb. 8	204	2.2667	97.7333	268	2.9778	97.0222	31	0.3444	99.6556	39	0.4333	99.5667	234	2.6000	97.4000
Feb. 9	161	1.7889	98.2111	140	1.5556	98.4444	42	0.4667	99.5333	54	0.6000	99.4000	234	2.6000	97.4000

Table 4. Survival results of rainbow trout fry reared at 18 °C with three daily feedings

Date (2024)	A			B			C			D			E		
	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	f Dead Fry	Mortality Rate	Survival Rate
Feb. 10	131	1.4556	98.5444	255	2.8333	97.1667	18	0.2000	99.8000	71	0.7889	99.2111	219	2.4333	97.5667
Feb. 11	66	0.7333	99.2667	188	2.0889	97.9111	18	0.2000	99.8000	58	0.6444	99.3556	83	0.9222	99.0778

Table 5. Survival outcomes of rainbow trout fry maintained at 18 °C with two daily feedings.

Date (2024)	A			B			C			D			E		
	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate	Dead Fry	Mortality Rate	Survival Rate
Feb. 12	94	1.0444	98.9556	167	1.8556	98.1444	57	0.6333	99.3667	151	1.6778	98.3222	115	1.2778	98.7222
Feb. 13	102	1.1333	98.8667	172	1.9111	98.0889	103	1.1444	98.8556	231	2.5667	97.4333	108	1.2000	98.8000
Feb. 14	54	0.6000	99.4000	111	1.2333	98.7667	73	0.8111	99.1889	153	1.7000	98.3000	55	0.6111	99.3889
Feb.15	59	0.6556	99.3444	94	1.0444	98.9556	114	1.2667	98.7333	139	1.5444	98.4556	71	0.7889	99.2111
Feb. 16	47	0.5222	99.4778	95	1.0556	98.9444	127	1.4111	98.5889	229	2.5444	97.4556	69	0.7667	99.2333
Feb. 17	33	0.3667	99.6333	90	1.0000	99.0000	203	2.2556	97.7444	236	2.6222	97.3778	47	0.5222	99.4778
Feb. 18	16	0.1778	99.8222	57	0.6333	99.3667	142	1.5778	98.4222	159	1.7667	98.2333	18	0.2000	99.8000

Graphical Analysis of the Results

Figure 1 shows that in Raceway E, event duration decreases at a frequency of 4, then increases as frequency goes up, with the longest duration at the highest frequency. Figure 2 shows the changes in events' timing in relation to various grams of starters consumed for different raceways. Time for every raceway (denoted by letters A to E) starts with fewer grams of the starters and finishes with more grams. Figure 3 shows that Raceway E increases its consumption of artificial food with higher egg yolk amounts, while Raceway D maintains a constant low level of artificial food consumption regardless of the egg yolk quantity. Figure 4 shows that Raceway E's artificial food intake increases with more egg yolk, while Raceway D's intake remains constant regardless of egg yolk amount. Figure 5 shows that Raceway E's consumption of artificial food increases sharply with more egg yolk, reaching a plateau, while Raceway D's consumption remains consistently low regardless of egg yolk amount.

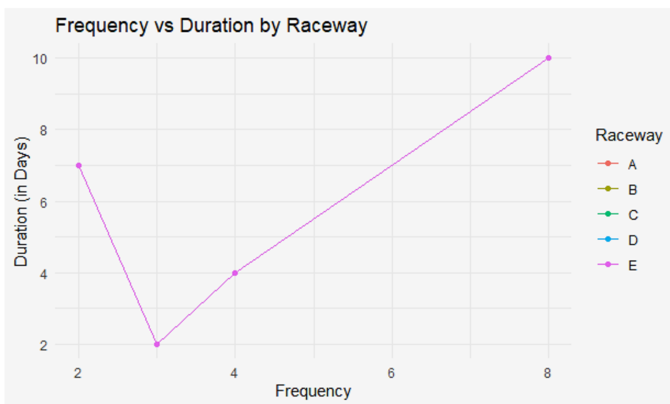

Figure 1: Variation of event duration with frequency for race way.

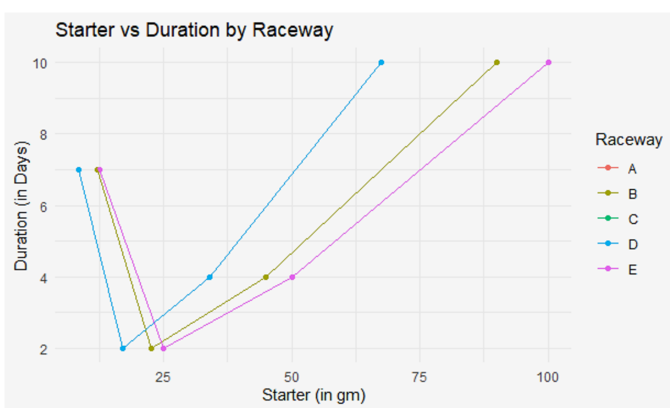

Figure 2: Event Duration vs. Starter Amount by Raceway.

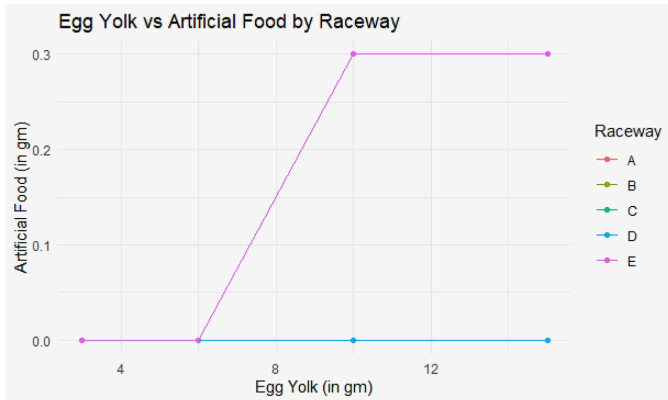

Figure 3: Egg Yolk vs Artificial Food Consumption by Raceway.

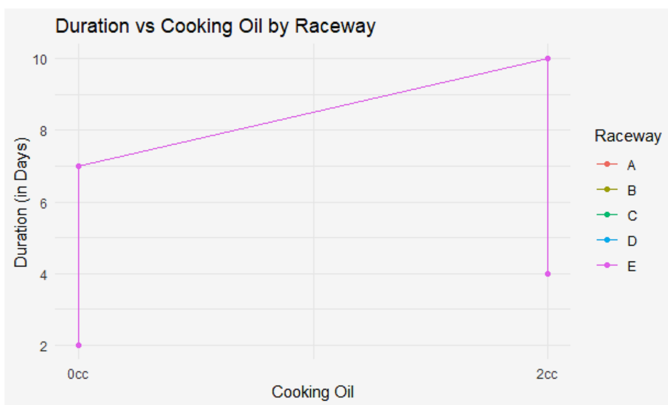

Figure 4: Relationship Between Egg Yolk and Artificial Food Intake by Raceway.

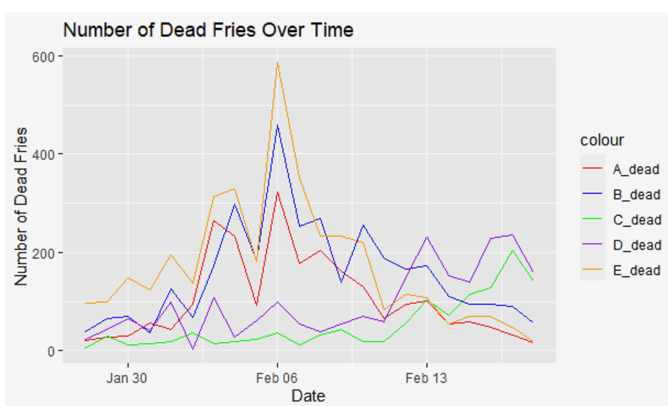

Figure 5: Egg Yolk vs. Artificial Food Consumption Across Raceways.

Figure 6 shows the daily mortality rates for five categories (A, B, C, D, and E) from January 30 to February 13. The data reveals significant spikes, particularly for Category E around February 6, while Category C maintains a consistently low rate throughout the period. Figure 7 shows the survival rates for five categories (A, B, C, D, and E) from January 30 to February 13. Survival rates are generally high, with Category C consistently near 100%. Notable dips occur around February 6, especially for Categories B and E, which drop to around 94-95%. Despite fluctuations, all categories recover towards the end of the period. Figure 8 shows the daily mortality rates for five groups (A, B, C, D, E) from February 6 to February 9. Group E starts highest at 6%, followed by Group B at 4%, with both showing a steady decline. Group A starts around 2% and decreases, while Groups C and D remain stable below 2% throughout the period. Figure 9 shows the daily mortality rates for five groups of rainbow trout fry (A, B, C, D, E) from February 10 to February 11. Group B and E have the highest starting rates but show a downward trend. Groups A and D start around 1% and also decline, while Group C remains consistently low near 0%.

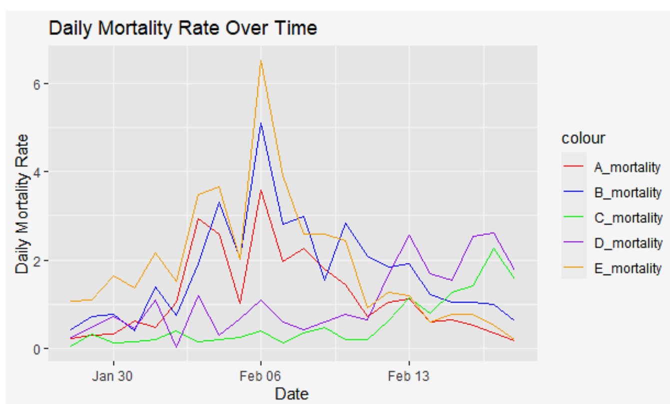

Figure 6: Daily Mortality Rates for Different Categories Over Time.

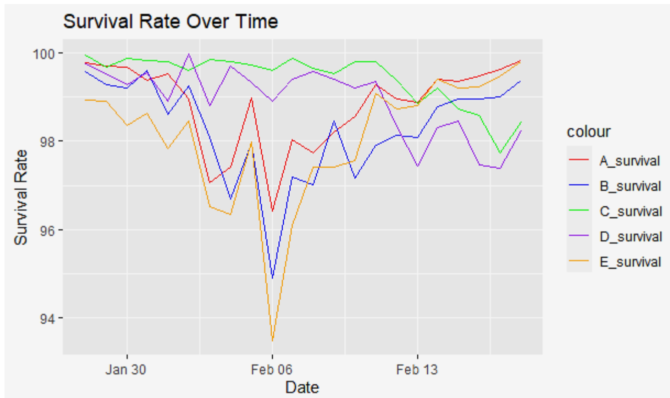

Figure 7: Survival rates for different categories over time.

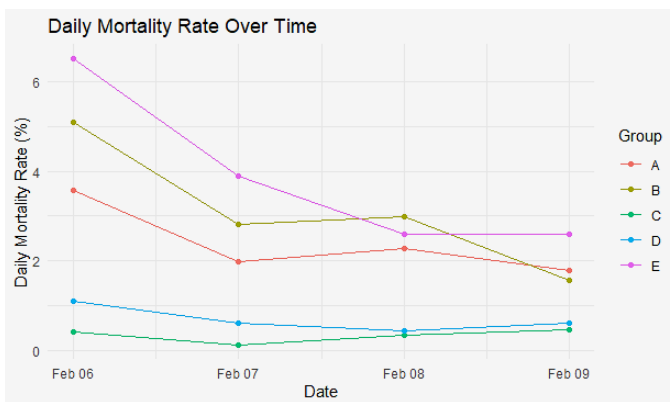

Figure 8: Daily mortality rate rates by groups from February 6 to 9.

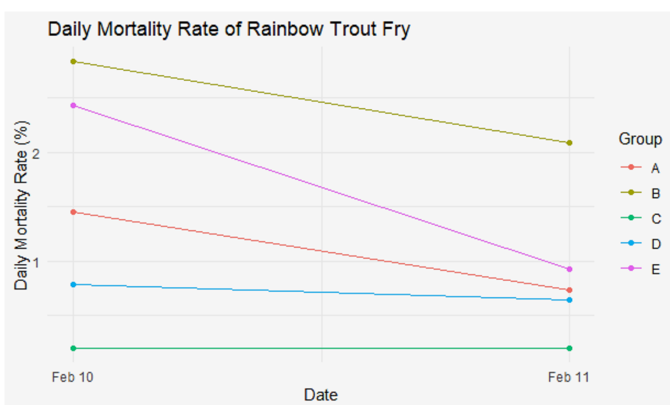

Figure 10: Daily mortality rate of rainbow trout fry from February 10 to 11.

Discussion

The findings reveal that feeding frequency significantly affects the survival rates of rainbow trout fry, with the 4-feedings/day group achieving the highest survival rate (98.8%), closely followed by the 2-feedings/day and 8-feedings/day groups (98.7%). The 3-feedings/day group showed the lowest survival rate (91.1%). This outcome can be attributed to several factors. First, frequent feeding (8 times/day) may increase stress due to handling or environmental disruptions, negatively affecting fry survival. Second, less frequent feeding likely improved water quality by reducing waste accumulation and preventing oxygen depletion caused by overfeeding. Lastly, fry in the 4-feedings/day group may have utilized nutrients more efficiently, avoiding the metabolic strain associated with overfeeding, thereby enhancing their overall survival. Therefore, these results highlight the importance of optimizing feeding strategies to balance nutrient availability and environmental stability for maximizing fry survival in aquaculture.

The management of fish nutrition is a crucial responsibility of fish farmers in order to produce fish of the highest quality and size. The guidelines provided by feed companies will result in a gradual improvement in fish quality. Since 40–50% of fish production costs are associated with feed, consideration should be devoted to waste level, feed intake, feed distribution, feeding behavior, and feed consumption (Fox et al., 2018). The trial groups' average weights increased, while group GF-NF showed the lowest degree of weight gain, indicating a reduced compensatory growth. There was no statistically significant difference in average weights between the groups that received food every day of the week, Monday and Thursday, and Saturday and Sunday (GSat-Sun), when food was not provided ($P>0.05$). According to reports, animals can make up for lost food when it comes to trout when it is not fed for two days out of the week, either consecutively or separated by two or three days. Research conducted on several fish species that experienced a loss of body mass due to malnutrition revealed that the variation in weight may be compensated for by eating more when the fish were given food again (Abdel-Tawwab et al., 2006; Bascinar et al., 2008).

The rainbow trout fish is carnivorous in nature. In the current study, the artificial food provided had a composition similar to the natural diet. The average B value is 2.07 which is negative allometric. This shows that the growth of fish in the same raceway under the same physio-chemical parameter is not uniform and varies greatly in size. Whereas in a similar study conducted at the trout fish hatchery, Madyan, District Swat the same artificial food with an addition of butylated hydroxyl toluene, vitamins and minerals. These resulted an efficient growth because the additive was useful against the blood diseases and effected the growth indirectly (Yaseen et al., 2016).

The length-weight relation of rainbow trout was calculated in this study using formula W = aLb, where W is the fish's weight in grams, L is the fish's length in millimeters, and "a" and "b" are constants, the maximum values of the length weight relationship were below 3 which indicate that the growth of rainbow trout is negative allometric while similar study has been carried out in Kashmir valley by (Shah et al., 2011) in which the length weight relationship values recorded is also below 03. This may be due to the same environmental conditions and same food composition.

The present study's observed influence of feeding level on feed efficiency ratio suggests that a more thorough examination is needed to determine how dietary input is converted to fish biomass. Numerous variables, including feed composition, fish size and life stage, amino acid intakes, and the effectiveness of this amino acid retention, all have an impact on the feed efficiency ratio.

When compared to terrestrial monogastric animal feeds (such as those for pigs and poultry), one of the more distinctive aspects of fish feeds is the significant variation in their nutritional makeup. In addition to species and life stages for which they are designed (trout vs. tilapia, starter vs. grower feed), the composition of fish feeds (i.e., CP, lipid, starch, and energy levels) varies depending on a wide range of other factors, including manufacturer preferences, restrictions related to manufacturing, the environment, and customer needs, the state of the economy, fish price, etc.) (Bureau et al., 2006).

Among the trial groups group, GF-NF showed the least weight gain despite an overall increase in average weight, indicating less compensatory growth. Between the groups that received food every day of the week, those that did not receive food on Monday and Thursday of the week, and those that did not receive food on Saturday and Sunday of the week, there was no statistically significant difference in average weights (GSat-Sun) ($P>0.05$). The animals are said to be able to make up for it if they are not fed trout for two days out of the week, either back-to-back or separated by two or three days. Research conducted on a range of fish species that experienced a loss of body mass due to starvation revealed that the weight difference may be compensated for by eating more when the fish were given food again (Blake & Chan 2006; Sevgili, 2007).

The control group had the lowest feed conversion rate, whereas the group that received feedings every other day had the highest feed conversion rate, according to a comparison of the average feed conversion ratios across the trial groups. Groups GMon-Thu and GSat-Sun were found to have comparable feed conversion rates (Nikki et al., 2004). It's revealed that the group that had not been fed on Wednesdays and Sundays had the lowest FCR, while GF-NF had the highest FCR. Numerous fish species have shown unusual growth following various events, including starvation, restricted food intake, illness, and so on (Sevgili et al., 2013).

It has been attempted to demonstrate how trout culture in flow-through raceways with optimal feeding greatly impacts fish biomass in particular and water quality generally from an economic standpoint. On the other hand, it has been noted that excessive stocking and unrealistic feeding practices result in low output and severely worsened water quality (Bonislawska et al., 2013; Caramel et al., 2014). Adopting appropriate management techniques and having solid technical knowledge are key factors that influence the regulatory regime that affects the production of freshwater trout (Singh, 2020).

It is evident from our observations of the geographical variations in the physical and chemical characteristics of water in response to various feeding schedules and stocking densities that intensive feeding practices cause an accumulation of nitrogenous waste in raceways, which impairs development and fitness. In the current study, feeding schedule II considerably enhanced N/P discharge on a weight gain basis. The majority of effluents are disposed of in the aquatic environment by feed, according to the amount of free CO_2, ammonia, nitrate, and PO_4 exported via FS-II. A proper feeding plan and the formulation of nutrients for high-quality feed based on the energy requirements of the fish can both help to limit this waste output (Jean et al., 2018; Brezas & Hardy, 2020).

ADG and SGR (%) have been used to study the growth of raised rainbow trout under two feeding regimes. These methods are quick and simple to use, and they are frequently used to compare the findings of nutrition and growth studies (Lugert et al., 2014). The study's findings show that effective feeding practices not only provide rainbow trout with the nutrients they need, but also reduce water pollution, which improves trout productivity and fish welfare (Liu et al., 2016).

In order to maximize stockings, the amount of feed provided and the feeding schedule employed have made sure that every fish has access to food and is satisfied, which eliminates the need for rivalry and hostility (Zahedi et al., 2019). The study's conclusions have taken into consideration variables including fish size fluctuation, quantity, and hunger as well as the best way to feed the fish. The rainbow trout feeding schedule has been refined to reduce rivalry and, consequently, hostility while ensuring that every fish has access to food. Temperature and other seasonal and environmental conditions have been discovered to have an impact on daily meal consumption.

Conclusion

This study demonstrates that feeding frequency significantly impacts the survival rates of rainbow trout fry. Feeding 4 times per day resulted in the highest survival rate (98.8%) suggesting that this frequency optimizes nutrient availability and environmental stability. These findings have important implications for aquaculture practices, emphasizing the need to balance feeding frequency with environmental conditions. Future research should explore additional factors, such as water quality and fry health, to further refine feeding strategies.

References

Abdel-Tawwab, M., Khattab, Y. A., Ahmad, M. H., & Shalaby, A. M. (2006). Compensatory growth, feed utilization, whole-body composition, and hematological changes in starved juvenile Nile tilapia, Oreochromis niloticus (L.). *Journal of Applied Aquaculture*, *18*(3), 17-36.

Blake, R. W., & Chan, K. H. S. (2006). Cyclic feeding and subsequent compensatory growth do not significantly impact standard metabolic rate or critical swimming speed in rainbow trout. *Journal of Fish Biology*, *69*(3), 818-827.

Brezas, A., & Hardy, R. W. (2020). Improved performance of a rainbow trout selected strain is associated with protein digestion rates and synchronization of amino acid absorption. *Scientific reports*, *10*(1), 4678.

Bureau, D. P., & Hua, K. (2008). Models of nutrient utilization by fish and potential applications for fish culture operations. *Mathematical Modelling in Animal Nutrition*, 442-461.

Bureau, D. P., Hua, K., & Cho, C. Y. (2006). Effect of feeding level on growth and nutrient deposition in rainbow trout (Oncorhynchus mykiss Walbaum) growing from 150 to 600 g. *Aquaculture research*, *37*(11), 1090-1098.

Dediu, L., Cristea, V., Mocanu, M., Dicu, D., Docan, A., & Grecu, I. (2011). The effect of feeding frequency on growth performance of rainbow trout fingerlings reared in recirculating system. *Aquaculture, Aquarium, Conservation & Legislation*, *4*(2), 141-145.

Fox, M., Mitchell, M., Dean, M., Elliott, C., & Campbell, K. (2018). The seafood supply chain from a fraudulent perspective. *Food Security*, *10*(4), 939-963

Guzel, S., &Arvas, A. (2011). Effects of different feeding strategies on the growth of young rainbow trout (Oncorhynchus mykiss). *African Journal of Biotechnology*, *10*(25), 5048-5052.

Jean-Marc, R., Alexis, G., Dominique, H., Martine, P., & Marc, R. (2018). Feeding the river: the fate of feed-pellet-der ived material escaping from land-based trout farms. *Aquaculture*, *495*, 172-178.

Lecaudey, L. A., Schliewen, U. K., Osinov, A. G., Taylor, E. B., Bernatchez, L., & Weiss, S. J. (2018). Inferring phylogenetic structure, hybridization and divergence times within Salmoninae (Teleostei: Salmonidae) using RAD-sequencing. *Molecular phylogenetics and evolution*, *124*, 82-99.

Liu, Q., Hou, Z., Wen, H., Li, J., He, F., Wang, J., ... & Wang, Q. (2016). Effect of stocking density on water quality and (growth, body composition and plasma cortisol content) performance of pen-reared rainbow trout (Oncorhynchus mykiss). *Journal of Ocean University of China*, *15*, 667-675.

Lugert, V., Thaller, G., Tetens, J., Schulz, C., & Krieter, J. (2016). A review on fish growth calculation: multiple functions in fish production and their specific application. *Reviews in aquaculture*, *8*(1), 30-42. *Reports*, *10*(1), 4678

Nahayat, M., Zakeri, M., Salati, A. P., & Ghasemi, A. (2024). Effects of feeding frequency on production indices in rainbow trout (Onchorhynchus mykiss). *Journal of Marine Science and Technology*, *23*(3), 12-21.

Nikki, Jyrki, Juhani Pirhonen, Malcolm Jobling, and Juha Karjalainen. "Compensatory growth in juvenile rainbow trout, Oncorhynchus mykiss (Walbaum), held individually." *Aquaculture* 235, no. 1-4 (2004): 285-29.

Sarkheil, M., Rafiee, G., Amiri, B. M., &Farhangi, M. (2014). Effect of different concentrations of waterborne sodium on the hatching rate and ions content of rainbow trout (*Oncorhynchus mykiss*) eggs. *Turkish Journal of Fisheries and Aquatic Sciences*, *14*(1).

Sevgili, H. (2007). *Effects of different feeding restriction methods on quantitative and qualitative performance criterions in rainbow trout (Oncorhynchus mkiss)* (Doctoral dissertation, PhD Thesis, Ege Universty).

Sevgili, H., Hoşsu, B., Emre, Y., & Kanyılmaz, M. (2013). Compensatory growth following various time lengths of restricted feeding in rainbow trout (*Oncorhynchus mykiss*) under summer conditions. *Journal of Applied Ichthyology*, *29*(6), 1330-1336.

Shah, T. H., Balkhi, M. H., Najar, A. M., &Asimi, O. A. (2011). Morphometry, length-weight relationship and condition factor of farmed female rainbow trout (*Oncorhynchus mykiss*) in Kashmir. *Indian Journal of Fisheries*, *58*(3), 51-56.

Singh, A. K., & Srivastava, S. C. (2021). Improved feeding strategy to optimize growth and biomass for up-scaling rainbow trout *Oncorhynchus mykiss* (Walbaum 1792) farming in Himalayan region. *Aquaculture*, *542*, 736851.

Wood, J., & Budy, P. (2009). The role of environmental factors in determining early survival and invasion success of exotic brown trout. *Transactions of the American Fisheries Society*, *138*(4), 756-767.

Yaseen, Q. K., Rehman, H. U., Naeem, M., & Ahmad, M. (2016). Artificial feed for rainbow trout (*Oncorhynchus mykiss*) in district Swat Khyber Pakhtunkhwa, Pakistan. *Journal of Entomology and Zoology Studies*, *4*(5), 155-158.

Zahedi, S., Akbarzadeh, A., Mehrzad, J., Noori, A., & Harsij, M. (2019). Effect of stocking density on growth performance, plasma biochemistry and muscle gene expression in rainbow trout (*Oncorhynchus mykiss*). *Aquaculture*, *498*, 271-278.