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RESEARCH PAPER

TITLE:

INVESTIGATION OF GROWTH AND NUTRITION OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) IN SHERINGAL, DIR UPPER, KHYBER PAKHTUNKHWA, PAKISTAN

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INVESTIGATION OF GROWTH AND NUTRITION OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) IN SHERINGAL, DIR UPPER, KHYBER PAKHTUNKHWA, PAKISTAN

ABSTRACT

The study aimed to assess the growth and nutrition of Rainbow trout (*Oncorhynchus mykiss*) in a pond at the trout fish facility of Shaheed Benazir Bhutto University (SBBU) in Sheringal, District Dir Upper from December 2020 to August 2021. Fifty seedlings were obtained from Madyan trout hatchery in Swat and then transferred to the SBBU, Sheringal hatchery for research purposes. The physio-chemical parameters were monitored weekly. The average temperature ranged from 15.5℃ to 27.2℃, conductivity ranged from 0.04 to 0.06 S/m, dissolved oxygen levels varied from 1.24 to 3.2 mg/L, and pH ranged from 7.8 to 7.9. Initially, the Juvenile fish measured between 2.3 and 3.5 inches in size. In December, the fish were fed powdered food. For the rest of experiment, they were fed pellet food, with the pellet size increasing as the fish grew. At the end of each month, the length weight of the fish was measured. The fish did not grow consistently, as indicated by a slope of 2.1572 for the "B" value, which is below 3.0, indicating the negative allometric growth. The length-weight frequencies were determined monthly, showing continuous changes from one month to the next.

KEYWORDS: Rainbow Trout, Nutrition, Length, Weight, Frequency and Growth.

1. INTRODUCTION

Fishes are a diverse group of cold-blooded aquatic vertebrates that use gills to breathe and fins for movement. Scales are widely used as defensive armor, but their slim bodies allow them for easy movement in water (Perveen and Ullah, 2015). They are found in seas as warm as 42.5℃ and as cold as -2 ℃, their morphological sizes range from 8 millimeters (Gobi fish) to 12 meters (Whale shark) living in different habitats (Essetchi *et al*., 2003). There are 69,276 vertebrate species that have been identified, fish account for half of all vertebrates, with 33,900 different species (Nelson, 2006).

Fish accounts for 17% of all animal protein consumed by humans worldwide, it provides high-quality protein, amino acids, and essential minerals such as magnesium, calcium, zinc, iron, phosphorus, and vitamins A, C, and E (Shah *et al*., 2018). It also contains fatty acids, which are required for brain and body development. Omega-3 fatty acids prevent low birth weight and are also important for infant brain development (Finegold, 2009). Overall fisheries and aquaculture employ 59.6 million people, with catch fisheries employing 40.3 million and aquaculture employing 19.3 million people (Sumaila *et al*., 2011). In 2016, worldwide fish production was 171 million tons, with capture fisheries accounting for 91 million tons and aquaculture accounting for 80 million tons. While in 2017, worldwide fish exports were USD 152 billion. Since 2002, China has been the leading exporter of fish and fish products, with exports reaching a high of USD 20.5 billion in 2017 (FAO, 2018*).*

Pakistan has been admired for its aquatic riches, it contains about 79,200 km^2 of internal waters, a lateral coastal belt of 1120

km, and a special economic zone of 350 nautical miles covering an area of 290270 km^2, the country's fish biodiversity includes 800 maritime species and 193 freshwater species (Shah *et al*., 2018). There are 31 commercially important freshwater species that are cultivated, whereas there are 120 marine species that are not farmed (Laghari, 2018). In Pakistan, fishing employs 4,00,000 people directly and indirectly employs 6,00,000 people, in 2017, total production of fish was 6,58,486 tons, with detention fisheries accounting for 5,03,728 tons and aquaculture accounting for 1,54,757 tons. Between December 2016 and July 2017, the government has received USD 183 million from the transport of fish and fish yields (Shah *et al*., 2018).

Fisheries play an important part in the country's economy. Fisheries generate $80 billion in revenue each year. People who work in the fisheries sector earn an average of US$235 worldwide due to fisheries industry (Laghari, 2018*)*. The money earned from fishing is used to purchase new boats, ships and water craft for transportation (Sumaila *et al*., 2011). Rainbow trout (*Oncorhynchus mykiss*) is a fish that belongs to the Oncorhynchus genus, the Salmoninae subfamily, the Salmonidae Family, and the Salmoniformes order (Rehman *et al*., 2016).

In aquaculture, the Rainbow Trout (Oncorhynchus mykiss) is a widely grown fish species (Stickney, 1996). Millions of rainbow trout are raised for a number of reasons than just food; they are introduced into streams, lakes, ponds and rivers to enhance sportfishing opportunities in regions where they might not otherwise be present. Farmed for their meat as well as to improve or provide sportfishing options, rainbow trout contribute to a substantial amount of aquaculture production worldwide; in 2013, total production exceeded 810,000 tons (FAO, 2015).

In Pakistan, rainbow trout can be found in several places, such as Dir, Kohistan Upper Swat, Mansehra, Chitral and Shangla (Ahmad *et al*., 2014). Their dietary needs and nutritional requirements are identical to those of Atlantic salmon, particularly when it comes to feeds suitable for both freshwater and anadromous trout strains. The size of the fish greatly impacts the measurement and size of the pellets, which have high protein, fat, and calorie components.

Their diet comprises mainly of fish oil (FO) and fish meal (FM) with other of protein and fat, cereals and micronutrient additives provided (Cho *et al*., 1991).

In the current study various necessary conditions for the growth of rainbow trout (Oncorhynchus mykiss) were found. These parameters were examined throughout the study, with an emphasis on the important factors affecting growth of rainbow trout. The impacts of modifying food formulations were studied, and it was found that effectively increasing the proportion of some parameters while lowering the percentage of others was crucial to the growth of Rainbow trout.

2. MATERIAL AND METHODS

2.1 Study Area

District Dir upper lies in the northern part of KP, Pakistan in the middle of the Hindukush Mountain range. The district is bordered towards the north by Chitral, south by Dir lower, east by Swat and in west by Bajaur and Afghanistan. The latitude and longitude of

the district are 34º 10 N and 72º 20 E respectively (Ahmad *et al*.,2014).

Sheringal valley is situated in the North East of District Dir upper, about 36 km from the main.

G.T road of Dir-Chitral. The total area of Sheringal valley is about 870 km2. Temperature ranges from 0.7˚C to 32˚C. The mean annual rainfall varied between 700 mm to 1300 mm. (Khan *et al*., 2015).

2.2 Climate of the Research area

District Dir is having a humid subtropical climate. In District Dir upper the average high temperature in June and July are 30℃ to 32℃ while in District Dir lower it is quite hot. The winter season is very cold and serves. In December and January temperature fall below freezing point in District Dir upper and average temperature during these months is -2.5℃ while in District Dir lower and average temperature is -1.5℃. District Dir receives rainfall throughout the year. During December and March maximum precipitation is recorded, 1468.8 mm and 253.7 mm respectively. The relative humidity is quite high throughout the year (Hasan *et al*., 2013).

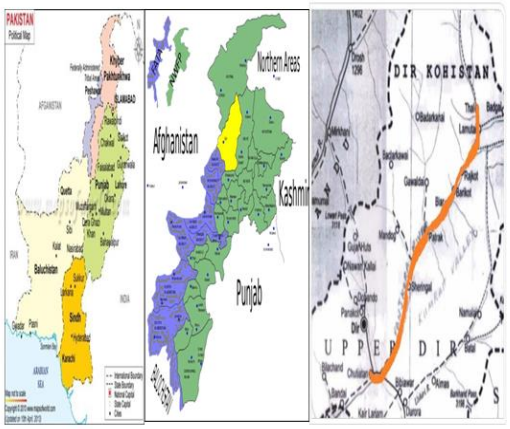

Fig.1A Fig.1B Fig.1C

Figure 1A: Map of Pakistan.

Figure 1B: geographic map of KP in (Yellow region presenting the study area of District Dir Upper).

Figure 1C: geographic map of the study area from Kumrat to Chukyatan.

2.3 Fisheries status in the area

The fish are considered to be the main source of protein in the research area. The fish in the area is also used for the betterment of economy. The area is very natural and attractive therefore tourists visit these mountainous regions and stay at different restaurants and use fish as a recreational food which positively affect the economy of the area.

2.4 Collection of fish specimens

Fishes were collected from the main hatchery of Shaheed Benazir Bhutto University Sheringal from December 2020 to August 2021. Scoop net was mainly used to catch the fish.

Figure 2.2 Collection of fish

2.5 Feeding protocol

There are different types of food but we provide surface floating food (fish meal) to fish because the fish saw easily and cached easily (Fig. 2.3A&B).

Figure 2.3A: Juvenile raceway Fig.2.3B: Juvenile Food Pellets

2.6 Composition of Food

The Prepared food was composed on the under mentioned ingredients in various percentages accordingly (Table 1).

Table 1. Food composition for Brown trout

S. No	Ingredients	Percentage
01	Fish meal	32%
02	Meat meal	12 %
03	Soybean meal	12 %
04	Flour	20 %

05	Rice polish	08 %
06	Dry milk	05 %
07	Yeast	02 %
08	Bone meal	01 %
09	Soybean oil	04 %
10	Vitamin-premix	0.55 %
11	Vitamin- C	0.075 %
12	Vitamin-minerals	0.075 %
13	Colane-chloride	0.2 %
14	BHT	0.1 %

2.7 Physiochemical Parameter of Water

The weekly physiochemical parameters of cement tank were observed in the morning throughout the experimental period. The temperature ranges from (15.5℃ to 27.2℃), Conductivity (0.04 to 0.06), Dissolved oxygen (1.24 to 3.2), pH (7.9 to 7.8).

Figure2.4 Water quality parameter

2.8 Measurement of growth

After 30 days of interval, all juveniles were collected from each cement tank by the help of scoop net and total length was measured in centimeters and wet body weight in grams by the help of digital weight balance scale and

released back immediately. We found three type of length including total length, fork length and standard length of fish.

2.9 Statistical Analysis

ANOVA was use to find linear regression, length frequency, weight frequency.
SPSS and Microsoft excel were also used.

3. RESULTS

The current study was carried out in Sheringal valley in the fisheries facilities (Trout Fish Ponds) at Shaheed Benazir Bhutto University, Sheringal, Dir Upper, Khyber Pakhtunkhwa, Pakistan. The study was aimed to investigate the impact of feeding on the growth rate of rainbow trout (*Oncorhynchus mykiss)*. In December 2020, fifty rainbow trout (finger lings) were procured from the same fish pond and transferred to a separate for an experiment and were reared till August, 2021. During this experimental period food was provided in powder form on a day in December and twice a day from January to August and the growth rate (length-weight) relationship was measured at the end of each month.

In the current study Rainbow trout specimens were given fish meals twice a day, at 8:00 a.m. and 4:00 p.m., due to their carnivorous nature. In December, the amount of food was 20 g in powder form due to the young stage, resulting in marked growth. The amount of food increased on a monthly basis in relation to fish growth from January to August, with amounts of 40 g, 60 g, 140 g, 300 g, 400 g, 600 g, 700 g, and 700 g, respectively. In the first two months the specimens were fed with small amount of food as compared to the remaining seven months due to the availability of natural food in the raceways.

3.1 Physio-Chemical Parameters

The physiochemical parameters of the pond were measure in the morning throughout the research. The average minimum and maximum temperature recorded ranged from 15.5℃ to 27.2℃, while the Conductivity ranged from 0.04 to 0.06 while the dissolved oxygen ranged from 1.24 to 3.2 and the minimum and maximum pH recorded were 7.8 to 7.9, respectively (Fig. 3.1).

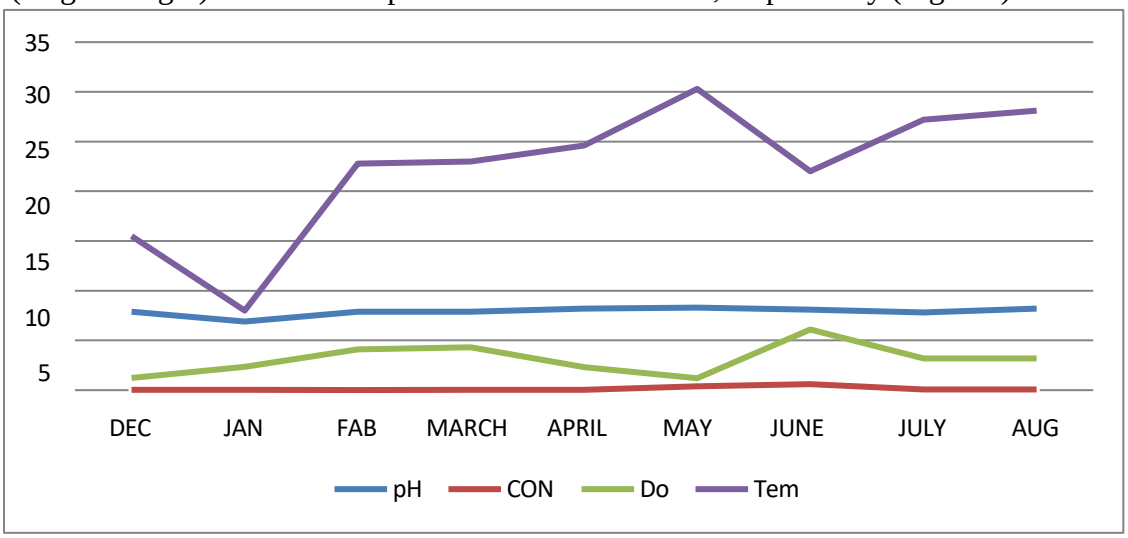

Fig 3.1. Physio-chemical parameters of water

3.2 Length-Weight Relationship

Length weight relationship of the rainbow trout was determined by using the formula; W = aLb where, W is the weight of fish in grams, L is the length of fish in millimeter, and "a" and "b" are constants (Shah *et al*., 2011). In December smallest and largest size of the specimen were 2.3 inches and 3.5 inches, respectively while the lowest and highest weights were 6g and 15g, respectively. The R^2 value was 0.680 and B value was 2.1572. The B value, which is less than 3, indicates that the growth of fishes is negative allometric as shown in Fig. 3.2A. In January the smallest and largest size of the specimens were 3 inches and 4.5 inches, respectively, while the lowest and highest weights were 13 g and 23 g, respectively. The R^2 value was 0.508 and the B value was 1.5735. Again, the B value being less than 3 indicates negative allometric which shows that the growth of fishes (Fig. 3.2B). In February, the specimen ranged in size from 4.2 inches and 6 inches, with weights ranging from 15 g to 54 g. The R^2 value was 0.752, and the B value was 3.0555, showing isometric growth of fishes (Fig. 3.2C).

In March, the smallest and largest size of the specimens were 4.3 inches and 6.7inches, respectively, while the lowest and highest weights were 20 g and 54 g. The R^2 value was 0.604, and the B value was 1.6926. Since the B value is less than 3, it indicates that the growth of fishes is negative allometric (Fig. 3.2D).

In April the smallest and largest size of the specimens were 5.7 inches and 7.6 inches, respectively, while the lowest and highest weights were 54 g and 69 g, respectively. The R^2 value was 0.604 and the B value was 0.5763. The B value of less than 3 indicates that the negative allometric growth in fishes (Fig. 3.2E).

In May, the smallest and largest sizes of the specimens were 6.9 inches and 9.3 inches, respectively, while the lowest and highest weights were 60 g and160 g, respectively. The R^2 value was 0.449 and the B value was 1.840. The B value is less than 3 indicating negative allometric growth in fishes (Fig. 3.2F).

In June, the smallest and largest size of the specimens measured 8.5 inches and 11.3 inches, respectively, with weights ranging from 110 g to 368 g. The R^2 value was 0.251, and B = 2.0528. The B value being less than 3 indicates a negative allometric growth of fishes (Fig. 3.2G). In July, the smallest and largest size of the specimens were 8.4 inches and 13.5 inches, respectively, while the lowest and highest weights were 141 g and 602 g, respectively. The R^2 value was 0.893, and the B value was 2.8431. Since the B value was less than 3, it indicates that the growth of fishes is negative allometric (Fig. 3.2H).

In August, the smallest and largest size of the specimens were 12 inches and 14.4 inches respectively, while the lowest and highest weights were 400 g and 685 g, respectively. The R^2 value was 0.637, and B value was 2.8598. The B value being less than 3 indicates that the growth of fishes is negative allometric (Fig. 3.2I). The differences in the slope B values among all months may be due to the fluctuation in seasons, environmental parameters, and physical conditions of the fish.

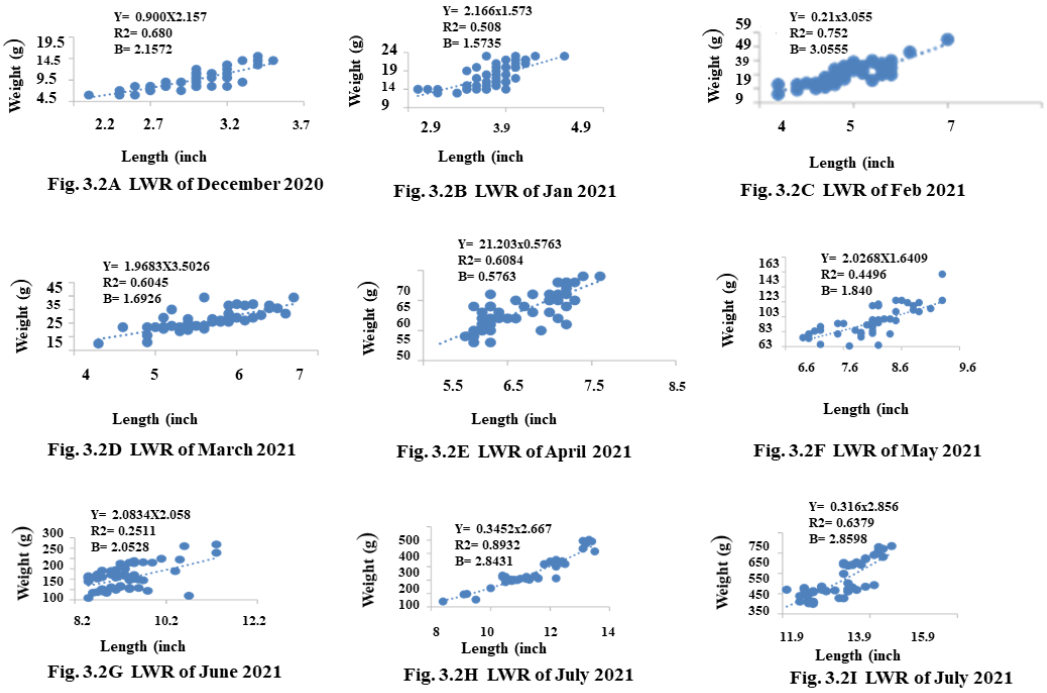

Fig 3.2. Length- weight Relationship

3. 3 Length Frequency

The length frequencies were measured by tape at the end of each month as shown in the following Fig 3.3.

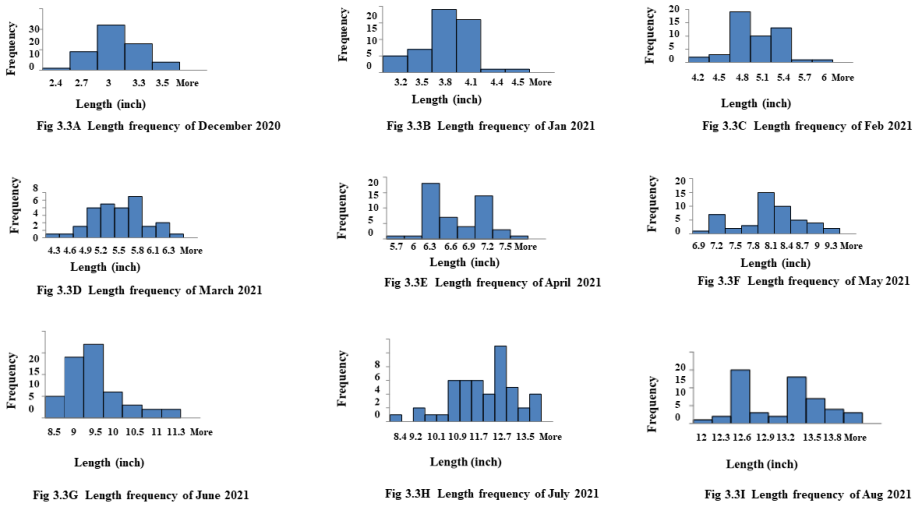

Fig 3.3. Length Frequencies

3.4 Weight Frequency

The weight frequency was measure by digital scale at the end of each month as shown in Fig 3.4

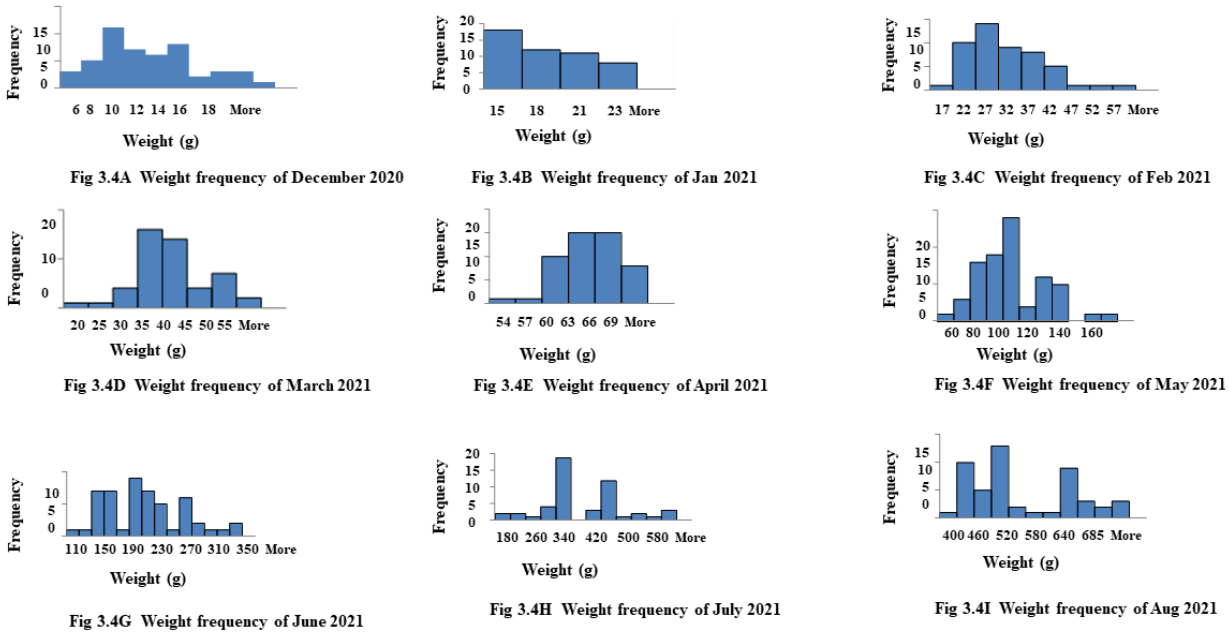

Fig 3.4A Weight frequency of December 2020

Fig 3.4B Weight frequency of Jan 2021

Fig 3.4C Weight frequency of Feb 2021

Fig 3.4D Weight frequency of March 2021

Fig 3.4E Weight frequency of April 2021

Fig 3.4F Weight frequency of May 2021

Fig 3.4G Weight frequency of June 2021

Fig 3.4H Weight frequency of July 2021

Fig 3.4I Weight frequency of Aug 2021

Fig 3.4. Weight Frequencies

4. DISCUSSION

Rainbow trout, a type of fish, is known for its exceptional nutritional value. It is a major protein source, contributing to 26.2% of animal meat consumption. It has quickly gained popularity as a staple food in Asia and emerging countries. Protein is required for normal growth and biological functions (Delgado *et al*., 2002). Rainbow trout feed on a variety of food including plankton and insects etc. (Cho *et al*., 1991; FAO, 2005a).

The current study was conducted in Sheringal valley in the fisheries facilities (Trout Fish Ponds) at Shaheed Benazir Bhutto University, Sheringal, Dir Upper, Khyber Pakhtunkhwa, Pakistan. The study aimed to investigate the impact of feeding on the growth rate of rainbow trout (*Oncorhynchus mykiss*). In December 2020, fifty rainbow trout finger lings were obtained from the same fish pond and transferred to a separate pond for the experiment and the fish were reared until August 2021. During this experimental period, food was provided in powder form once a day in December and twice a day from January to August. The growth rate (length-weight) relationship was measured at the end of each month.

In the current study the length weight relationship was measured. The maximum values of the length-weight relationship were below 3, indicating that the growth of

rainbow trout is negatively allometric (Fig. 3.2). A similar study conducted in the Kashmir valley also revealed length- weight relationship values 3, possibly due to the similar environmental conditions and food composition (Shah et al., 2011).

In this study, the artificial food with composition similar to natural food was provided. The average B value of 2.07 indicates negative allometric growth, suggesting that fish in the same raceway, under the consistent physio-chemical parameters, exhibit significant variation in size. In a study conducted at the trout fish hatchery, Madyan, District Swat, the use of artificial food supplemented with butylated hydroxyl toluene, vitamins and minerals resulted in efficient growth. This additive was found to be effective against blood diseases and indirectly promoted growth (Yaseen *et al*., 2016). The consistent results in both studies can be attributed to the use of the same food ingredients, similar environmental conditions, and consistent physiochemical parameters.

A similar study was conducted on the growth rate of rainbow trout at the same facilities and during the same period, under similar conditions. The growth value "b" was found to be 2.07, showing negative allometric growth pattern. However, the growth of rainbow trout was higher compared to brown trout due to their aggressive feeding behavior, quick, movement on the water surface and higher food intake (kizak *et al*., 2011).

Water temperature plays a significant role in controlling the growth frequency. In this study, the average minimum and maximum water temperatures ranged from 8°C to 30.3°C. McCauley and Casselman, (1980) suggested a range of 12°C to 15°C for optimal growth, while Quillet et al., (1992) recommended 15°C to 17°C. It was observed that rainbow trout grew more rapidly than brown trout. Similar rapid growth has been reported in various studies on rainbow trout by (Kurtoglu *et al*., 1998; Shepherd and Bromage, 1988).

The length weight relationship is a valuable measurement that facilitates the assessment of fish metamorphosis, gonad maturity, and feeding rate. It is a significant parameter in fishery biology and fish stock assessment (Abdurahiman *et al*., 2004). In the current study the average slope "b" for *Oncorhynchus mykiss* was estimated to be 2.07 (R^2= 0.59). This value of slope "b" is less than 3, indicating negative allometric growth. Similar results were obtained in other studies conducted by (king *et al*., 1995).

In the current study, the length-weight frequencies were determined on a monthly basis. In December 2020, the minimum and maximum lengths were 2.4 and 3.5 inches, respectively. Similarly, the lowest and highest weights were 06 g and 15g, respectively. In August 2021, the same values were determined as in the previous months. The minimum and maximum lengths were 12 and 14.4 inches, respectively. Likewise, the lowest and highest weights were 400g and 685g. These values indicate a significant growth in both length and weight of the fish over the nine-month of feeding period.

5. CONCLUSION AND RECOMMENDATION

The current study was conducted on the assessment of growth and nutrition of

rainbow trout, carnivorous specie. The findings suggest that a consistent artificial food with the same ingredients promotes efficient growth in captivity. It is recommended to provide powdered food during the juvenile stage and switch to pellets as the fish mature. In the first month, the growth rate was low due to turbidity of the water. The length increased by 8 cm in the first three months, and then by 1 inch for the remaining period. Similarly, the weight increased by 10 g in early stage and then by 30 g later on. The length-weight relationship value is 2.07, indicating negative allometric growth of the fishes. The minimum Y value was 2.07, and the maximum Y value was 10.28, indicating the linear regression of the fish.

Based on the significant findings, the fowling recommendation are suggested

- Detail study should be carried out on the internal parasites to reduce incidence of disease
- Alternate food should be provided to check the growth rate
- Water pollution should be reduced because it effects the growth of fish
- Illegal and over fishing should be banned
- Study the cross breeding of rainbow and brown trout

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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