

Farming of genetically improved strains of rainbow trout in Ganderbal district - Biological and economic perspective

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Abstract:

Rainbow trout (*Oncorhynchus mykiss*) is a species of freshwater fish belonging to the salmonid family. They are native to North America, particularly the Pacific Coast, and have been introduced to various parts of the world due to their popularity in recreational fishing and aquaculture. A comparative study on the biological and economical improvement of trout farmers in district Ganderbal was carried out by batching the farmers for raising the normal strain (NS) and the genetically improved strain (GIS) of rainbow trout for a period of 240 days (one cycle). The objective of the research was to ascertain the difference between NS and GIS, analyse biological parameters. The GIS farming reported the highest net weight gain (347.7±5.55), average daily weight gain (1.44±0.02), specific growth rate (1.75±0.001), and the lowest conversion ratio (1.22±0.007). The farming of GIS recorded a survival rate of 95.12±0.03, compared to the NS (89.0±0.38). The benefit-cost ratio was highest in GIS (2.26±0.02), compared to the NS (2.15±0.007), which justifies that GIS is a better performer than NS.

Keywords: benefit-cost ratio, economics, genetically improved strain, growth, rainbow trout.

Classification numbers: 3.1, 3.4

1. Introduction

Rainbow trout (*Oncorhynchus mykiss*) is a species of freshwater fish belonging to the salmonid family. They are native to North America, particularly the Pacific Coast, and have been introduced to various parts of the world due to their popularity in recreational fishing and aquaculture. These fish have a streamlined torpedo-shaped body, adorned with a distinctive pinkish-red stripe along their sides, reminiscent of a rainbow. Depending on their habitat and food availability, rainbow trout can vary in size, typically ranging from 16 to 24 inches in length and weighing between 0.9 to 3.6 kg. Rainbow trout are opportunistic feeders and are known for their diverse diet. They primarily consume aquatic insects, crustaceans, small fish, and fish eggs. In some habitats, they can also feed on terrestrial insects that fall into the water. Globally, rainbow trout are one of the most commonly farmed fish species, prized for their culinary appeal. They thrive in freshwater hatcheries and can be raised in ponds or raceways until they attain market size.

Rainbow trout was introduced to Kashmir waters approximately 100 years ago, but it was not until 2014 that trout cultivation was extended to the private sector. Trout is

a prized fish, which was bred and reared by the Department of Fisheries only, but with the aim to enhance production and create employment opportunities for unemployed youth, trout culture was emphasised in the private sector with a subsidy component under various centrally sponsored schemes from time to time. The Department of Fisheries, Government of Jammu and Kashmir, is a well-established department undertaking the culture and breeding of exotic cold-water fishes (brown and rainbow trout), and conservation of indigenous cold water fish species, including a broad variety of *Schizothoracines*. With the privatisation of trout, many entrepreneurs have come forward, who have established their trout units with financial support under various centrally sponsored schemes. Although there has been a boom in overall production, certain constraints restrict the growers to meet the challenges.

One of the grave challenges was the poor performance of rainbow trout in the private as well as government sectors in terms of growth, disease resistance, food conversion efficiency, and poor breeding performance. The reason was the inbreeding depression, which was due to continuous crossbreeding of the same stock, leading to homozygosity, due to which the morphometric, meristic, physiological,

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and biological parameters were gravely distorted, resulting in a loss of interest by the farmers due to low economic returns. The Department of Fisheries in 2018-2019 planned to import an all-female stock of genetically improved eyed ova of rainbow trout fish for raising as pure-line brooders for crossbreeding with the existing stock to increase heterozygosity among the livestock. The reason for investigating the impact of GIS is to establish a need to revive the NS and improve the heterozygosity by crossbreeding between GIS and NS. With an attempt to investigate the impact of crossbreeding the normal and genetically improved stock, the current research was carried out to assess the biological improvement in livestock, leading to economic improvement in district Ganderbal.

2. Materials and methods

During the present research work, the Mammar hatchery in district Ganderbal was selected as the sole source of rainbow trout fingerlings for the fish farmers of the district. The Mammar hatchery has a spring source, and 1.5-2.0 lakh fingerlings of rainbow trout are produced every year and supplied to various private as well as government-run units. The all-female stock of genetically improved trout was raised in the Mammar trout hatchery to keep records of growth performance and mortality, and a pure line was maintained for two years. The genetically modified brooders (all female) were crossbred with the existing male stock, and the progeny was reared in separate raceways.

The existing normal stock was bred as usual in November 2021, along with the genetically improved stock, which matures prior to the normal stock. The F1 generation of the genetically improved stock was raised in separate raceways and monitored regularly on all biological aspects. Forty farmers (in replicas of two) were selected, and the water was analysed for physiochemical characteristics. Twenty farmers were stocked with 2000 fingerlings (5 g each) of NS, and twenty farmers were stocked with genetically improved strains. The stocking was done in April 2022. The culture custom size ranged between 250-350 g. The feed was adjusted as a 2% ratio of the total biomass calculated on a fortnightly basis. Regular monitoring for disease occurrence, comorbidities, and physiochemical water parameters was evaluated regularly.

Water temperature was monitored daily at the inlet and inside the raceway. Dissolved oxygen (DO) and pH were monitored on a weekly basis at 10:00 AM using a portable data logger pH/ORP, DO, CD/TDS Meter, Lutron, Model No. WA-2015, Bench Type, RS23/USB.

Fish feed and feeding: Extruded pelleted non-sinking feed from a fish feed mill in Manasbal containing 33-35% crude protein (CP) was fed to all the stock at all locations during this study. Feeding rate was a maximum of 2% of body weight, which is within the recommended range (2-5%) of feeding rate in cages as suggested by F. Wynne (2015) [1]. Fish were fed to satiation during lower water temperature (10-13°C) conditions.

Various growth parameters were used to assess the changes in biological phenomena of the normal and genetically improved strains of rainbow trout.

Net weight gain (NWG) was calculated by the following formula:

$$\text{NWG} = \text{Final weight (g)} - \text{Initial weight (g)}.$$

Average daily weight gain (ADWG) was calculated by using the formula:

$$\frac{\text{Final weight (g)} - \text{Initial weight (g)}}{\text{Days}}$$

Average daily length gain (ADLG) was calculated using the formula:

$$\frac{\text{Final length (cm)} - \text{Initial length (cm)}}{\text{Days}}$$

Specific growth rate (SGR) was calculated using the formula:

$$\frac{\ln \text{final weight (g)} - \ln \text{initial weight (g)}}{\text{Days}} \times 100$$

Food conversion ratio (FCR) was calculated using the formula of I. Okumus, et al. (1999) [2]:

$$\frac{\text{Total feed (g)}}{\text{Weight gain (g)}}$$

Food conversion efficiency (FCE) was calculated using the formula:

$$\frac{\text{Biomass (g)}}{\text{Total feed intake (g)}}$$

Condition factor: The coefficient of condition K was calculated by using the Fulton equation [3]: $K = W/L^3 \times 100$, where W = weight in grams, L = length in mm, and 100 is a factor to bring the value of K near unity. CF was calculated using the following formula:

$$\frac{\text{Final weight (g)}}{(\text{Final length})^3 \text{ cm}} \times 100$$

Survival (%): Survival of fish was considered as the remaining fish after deducting the number of died, missing, or escaped. Survival was calculated using the following formula:

$$\frac{\text{Total number of live animals present}}{\text{Total number of animals stocked}} \times 100$$

The benefit-cost ratio was calculated using the following formula:

$$\frac{\text{Total income}}{\text{Total cost}}$$

3. Results

The fingerlings (average weight = 5 g) from NS and GIS were transported with full quarantine to the selected raceways and stocked with full care after proper acclimatisation. The water quality parameters were almost the same at all the farm sites, the water source being the spring source, with a good gradient, the oxygen concentration fluctuated between 8-9 ppm. All the raceways (50 m³) had more or less the same flow rate. The sampling for enumeration of growth parameters was done on a weekly basis, and the ration was decided on a 2% basis of the total biomass.

The growth parameters measured during the present research work are summarised in Fig 1. Results revealed that the net weight gain was on the higher side in the GIS group with an average of 347.7±5.55, compared to the NS group which recorded a net weight gain of 232.8±4.28, with a variance of 4422.041 (Fig. 2). Similar patterns of changes were reported in average daily weight gain, with a value of 1.44±0.02 in the GIS group and a lower value of 0.96±0.01 in the NS group with a variance of 0.076 (Fig. 3). The fish length aspects showed a similar pattern of changes, with not much difference in the total length because of the increase in the overall girth of the fishes of the GIS group, which eventually led to an increase in weight.

The total length gain was comparatively higher (21.7±0.56) in the GIS group than NS (17.45±0.63) with a variance of 6.26. There was no significant difference in the length gain because of the muscle weight in the GIS group, which resulted in a higher body girth ratio compared to the NS group. Average daily length gain showed a similar pattern with higher values (0.08±0.002) in the GIS group than the NS group (0.07±0.02), with a variance of 0.0001. Specific growth rate is one of the fundamental growth parameters to assess the changes in a particular test set. During the present experimental period, specific growth rate values were higher (1.75±0.001) in the GIS group compared to the NS group (1.59±0.01) with a variance of 0.008 (Fig. 4). Specific growth rate indicated better growth performance of the genetically improved strains of rainbow trout in flow-through systems.

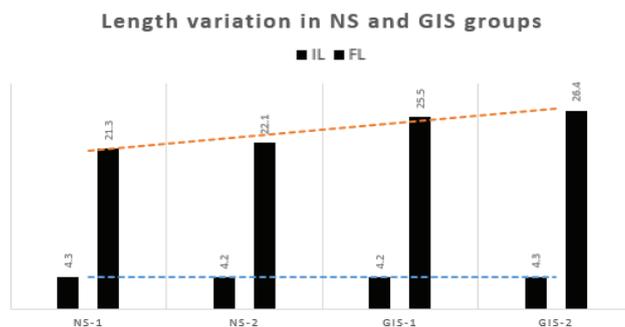


Fig. 1. Length variations in normal strain and genetically improved strains of Rainbow trout.

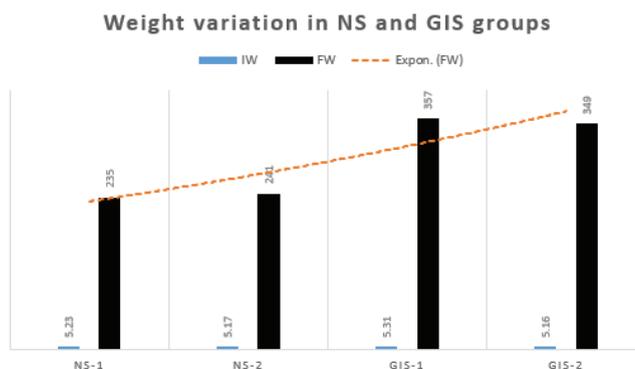


Fig 2. Weight variations in normal strain and genetically improved strains of Rainbow trout.

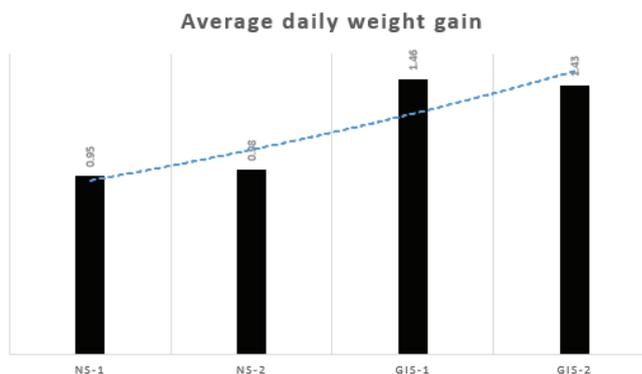


Fig 3. Average daily weight gain in normal strain and genetically improved strains of Rainbow trout.

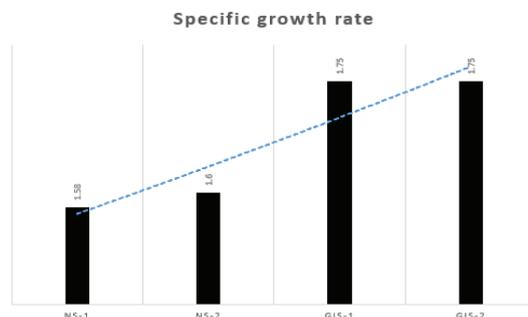


Fig 4. Specific growth rate in normal strain and genetically improved strains of Rainbow trout.

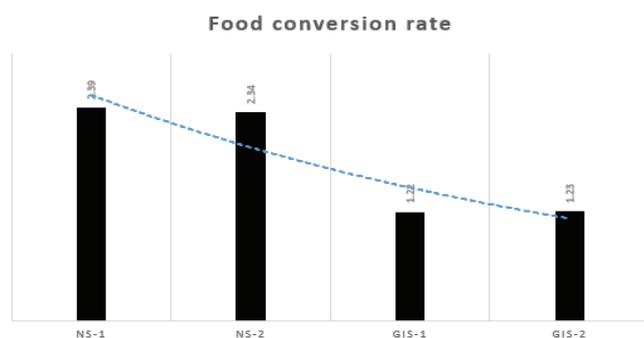


Fig 5. Food conversion rate in normal strain and genetically improved strains of Rainbow trout.

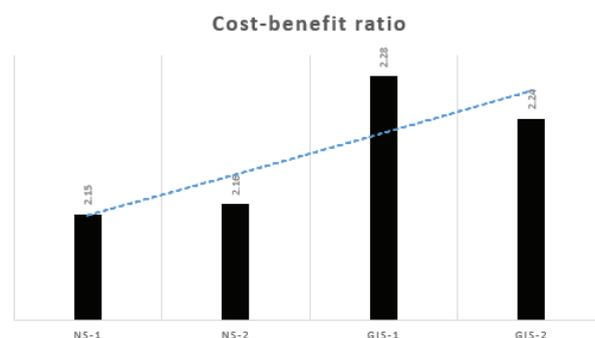


Fig 9. Cost-benefit ratio in normal strain and genetically improved strains of Rainbow trout.

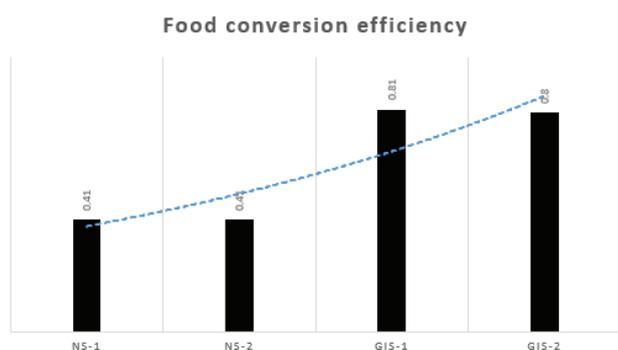


Fig 6. Food conversion efficiency in normal strain and genetically improved strains of Rainbow trout.

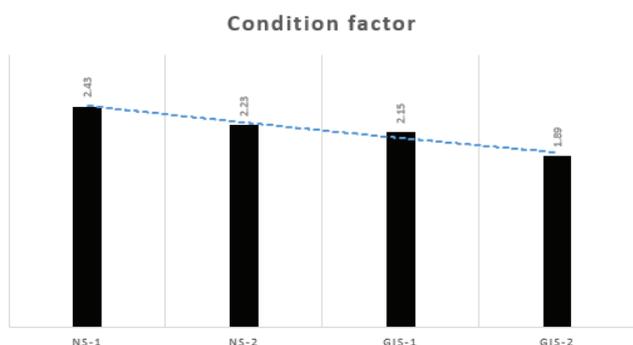


Fig 7. Condition factor in normal strain and genetically improved strains of Rainbow trout.

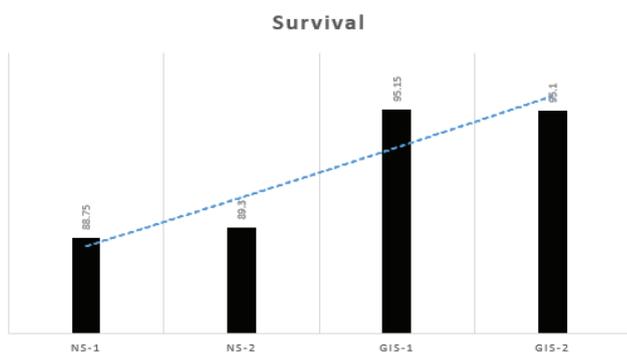


Fig 8. Survival in normal strain and genetically improved strains of Rainbow trout.

Food conversion ratio is an important parameter that describes the efficiency of the fish to convert and assimilate the maximum of the feed contents for overall development. A lower conversion ratio is an indicator of the profitability of fish farming. During the present research period, the lowest conversion ratio (1.22 ± 0.007) was reported in the GIS group compared to the NS group (2.36 ± 0.03), with a variance of 0.43 (Fig. 5), depicting the efficiency of the GIS group. Food conversion efficiency is, in contrast, the efficiency of the fish to convert the assimilated food into the muscle mass, which was reported to be higher (0.80 ± 0.007) in the GIS group compared to the NS group (0.41 ± 0.0), with a variance of 0.05 (Fig. 6).

Condition factor is a numerical value given to a trout or salmon that reflects its condition. This value is arrived at using a mathematical formula that takes into account both the weight and length of the fish. A well-conditioned fish has a high condition factor, while one in poor condition has a low factor. A higher CF value was reported in the GIS group (2.33 ± 0.14) compared to the NS group (2.02 ± 0.18), with a variance of 0.049 (Fig. 7). No wider differences in the CF value were reported in the two groups because of the same diet plan, same feed ingredients, and the same water quality. The survival (%) was as high as 95 ± 0.03 in the GIS group compared to the NS group (89.0 ± 0.38), with a variance of 12.45 (Fig. 8), depicting the hardiness of the GIS group, which was the mandate of the Department while importing the germplasm.

The benefit-cost ratio is a ratio used in a cost-benefit analysis to summarise the overall relationship between the relative costs and benefits of a proposed project. Benefit-cost ratio can be expressed in monetary or qualitative terms. If a project has a benefit-cost ratio greater than 1.0, the project is expected to deliver a positive net present value to the enterprise. Although trout farming in Kashmir has been a profitable venture, the losses to the farmer occur due to high conversion ratio and low survival rates. In order to curb these shortfalls, the GIS trout was introduced, which during this experiment reported higher values of 2.26 ± 0.02 in the GIS group compared to the NS group (2.15 ± 0.007), with a variance of 0.003 (Fig. 9). The calculations led to the conclusion that GIS rearing farmers had a 27% profit margin as a bonus compared to the NS farmers who are making a good profit from the enterprise.

4. Discussion

The physicochemical parameters of water play a dynamic role in the metabolic performance of rainbow trout, which also depends on different life stages. Temperature plays a pivotal role in determining the metabolic performance of the fish [4, 5]. In some studies, where rainbow trout has been reported to show negative allometric growth, has been explained has been attributed to the different life stages [6, 7]. In Indian conditions, K.D. Joshi, et al. (2005) [8] reported average growth of 200 g in 12 months at the thermal regime of 4.5-20°C. In another research work in the central Himalayas, average growth was recorded as 300 g (range 260-400 g) at a thermal regime of 5.0-22°C [9]. Several authors have reported higher growth rates at an optimum higher temperature [10], but beyond the optimum temperature, oxygen depletion occurs, which tells upon the fish metabolism [11-13].

Although there has been no work on the comparison between growth performance of genetically improved strain and the NS in the Kashmir valley. It is the first time that the cross-breeding to improve heterozygosity has been done in the Department of Fisheries. The final weight gain and average daily weight gain reported during the present research work cannot be correlatively compared with other works because of the uniqueness of the differentiation between the normally bred Kashmiri trout and the cross-bred genetically improved strains. However, more or less similar somatic growth parameters have been reported by K.D. Hopkins (1992) [14]; M. Kayim, et al. (2007) [15] and I. Ahmad, et al. (2019) [7].

S.L. Reza, et al. (2014) [16], while working on a comparison of the daily diet by weight in rainbow trout (*Oncorhynchus mykiss*) with concentrate feed to achieve a minimum conversion ratio reported that the food conversion rate and the efficacy lie with the strains, which was further documented [17, 18]. In intensive rainbow trout culture systems, the optimum feed conversion ratio is between 1 and 2, for commercial dry feed. The values of feed conversion ratio for both groups in the present study were within the ranges reported for commercial feed by other investigators [19, 20]. It was observed that the feed conversion ratio increased with increasing fish weight, and it was the best at the small size group. As it has been observed in the small size group, rainbow trout are able to utilise their feed very efficiently [21, 22].

For the well-being of the trout, the condition factor is expected to be higher than 1.0 [23]. According to C. Barnham, et al. (2003) [3], if the K value is 1.60; 1.40; 1.20; 1.0 and 0.80, these indicate excellent and trophy-class fish; a good and well-proportioned; a fair; poor long and thin; and finally extremely poor fish having disproportional large head and narrow skinny body, respectively. The condition factor is frequently used in evaluating the general health of the fish, on an individual and population level [24]. Since they include many stages of processes in the organism at numerous levels of organization, indices like Fulton's condition factor can indicate the nutritional status of individuals and the general health status of fish [25]. The condition factor presents a degree of the individual's response to the influences coming from

the environment such as the quantity and quality of nutrients, the presence of pathogens, pollutants, and toxic substances, which can result in a change in the mass of individuals and organs compared to individuals from the unchanged environment. The value of the condition factor is an expression of the physical condition of the fish and it is suitable for comparison of individuals of the same species and demonstrates differences in relation to sex, season, and place of sampling [26].

The cost of feed and seed emerges as critical factors in trout production, collectively absorbing almost 70% of the production costs, as pointed out by B. Tuburan, et al. (2001) [27], O. Oluwemimo, et al. (2013) [28], and I.E. Ele, et al. (2013) [29]. J. Lazard, et al. (2010) [30] also highlights the numerous challenges trout face, including environmental, social, and economic constraints. Given that trout are often cultured in intensive systems, it is imperative to implement better management practices to reduce production costs and mitigate environmental damage. Many authors have reported a benefit-cost ratio of more than 2.00 [31-35], which lends further support to our findings.

5. Conclusions

The findings of the present research revealed that:

- The introduction of GIS of rainbow trout in Kashmir has improved the economic status of the trout farmers.
- The GIS showed better growth, food conversion efficiency, and other morphometric characteristics, which are appealing to the consumers.
- The benefit-cost ratio in the case of GIS is better than the NS, although that culture is also profitable.

CRedit author statement

Shyambir: Conceptualisation, Validation; Salman Rauoof Chalkoo: Data curation, Writing - Original draft preparation, Data analysis.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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