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ON-STATION GROWTH PERFORMANCE OF RAINBOW TROUT FINGERLINGS WITH DIFFERENT STOCKING DENSITIES

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ABSTRACT: A study was conducted to evaluate the performance of Rainbow trout (*Oncorhynchus mykiss*) fingerlings with different stocking densities under station conditions at Trout breeding centre, Haa. The trout fingerlings with initial average weight of 9.78 ± 0.67 g were grown in different stocking densities of SD_{10}, SD_{15} and SD_{20} with 10 kg/m^3, 15 kg/m^3 and 20 kg/m^3 fingerlings respectively. The fingerlings were reared in the tanks of capacity 0.7452 m^3 for the duration of 107 days. The parameters like mean weight gain, mean length gain, Specific Growth Rate (SGR), Feed Conversion Ratio (FCR) and survival of the fingerlings stocked at different densities were assessed during the study period. The result indicated that there was a significant difference ($P < 0.05$) in the mean final weight of the fingerlings raised in different tanks. The mean final weight was recorded highest at SD_{10} with 59.16 ± 1.98 g followed by SD_{15} with 50.86 ± 8.61 g and SD_{20} with 42.26 ± 6.62 g respectively. Moreover, the highest mean weight gain was obtained from the fingerlings with SD_{10} followed by SD_{15} and SD_{20} with 49.38 g, 41.08 g and 32.44 g respectively. The higher growth rate was observed in the fingerlings with lower densities. Though not significant, the mean final length of the fingerlings was also recorded highest at SD_{10} (15.69 ± 1.74 cm) followed by SD_{15} and SD_{20} with 14.58 ± 1.32 cm and 13.96 ± 1.23 cm respectively. The survival of fingerlings was recorded higher with lower stocking density and FCR was also in favour of the lower density. Besides, the finding was also indicative that SGR was better in fingerlings with lower stocking density. It is suggestive that stocking density had significant effect on mean final weight, mean final length, SGR and FCR of the fingerlings. Thus, the study concludes that for optimal growth of trout fingerlings, the stocking density of (10kg/m^3) is recommended in trout hatcheries under Bhutanese rearing conditions to optimize production for higher returns.

Keywords: Feed conversion ratio; fingerlings; mean final weight; stocking densities; Rainbow trout; survival rate.

1 INTRODUCTION

Aquaculture in Bhutan began in the early 1980's with the introduction of carp fish species. The fish seed production centre at Gelephu under Sarpang Dzongkhag as regional centre for aquaculture under Department of Livestock (DoL) was established to breed and supply carp fingerlings to fish farmers mostly located in the southern belts. The carp fingerlings were supplied to the interested farmers to boost table fish production in the country. However, it was only in 2008, that Rainbow trout was first introduced in Bhutan at the erstwhile National Cold Water Fishery Centre in Haa. The Trout Breeding Centre within the National Research & Development Centre for Riverine & Lake Fisheries is mandated to produce and supply Rainbow trout fingerlings for table fish production in the country. In the year 2021-2022 alone, the Trout Breeding Centre at Haa produced 257,734 fingerlings (DoL 2021).

With the growing popularity of Rainbow trout farming in Bhutan, there is an increasing demand for fish fingerlings. Besides, with the increasing demand for trout meat as it fetches the premium price in the market, many youths and laid off employees are coming forward for the trout enterprise development. Owing to this reason, a concerted focus has to be given by the Trout Breeding Centre to accelerate fingerlings production capacity to keep up with growing demand. One of the interventions to enhance fingerling production capacity at the centre is through optimising production parameters such as the stocking density. Stocking density is an important parameter in fish farming and has direct effects on the growth and survival of fish. The growth rate and stocking density share a reciprocal relationship (Hasan et al. 2010). Relatively fewer fish in a pond of similar size have access to more space, food and dissolved oxygen, all of which are essential for increase in growth.

However, until date, very limited scientific information is available in the country on the optimal stocking densities of trout fingerlings for better growth and productivity. The current practice of stocking fish at the Trout Breeding Centre is not based on scientific knowledge, however, it is adapted from the experience and some trials conducted at the Centre. In order to maximize economic returns, it is imperative that ponds be stocked at optimum stocking densities for better growth and overall productivity. Thus, this study was designed to evaluate the growth performance of Rainbow trout fingerlings with different stocking densities at Trout Breeding Centre, Haa which will provide empirical evidence for stocking the optimal fingerlings for better growth and higher returns. It is hypothesized that survivability and growth will be higher in tanks with relatively lower stocking densities, and vise-versa.

2 MATERIALS AND METHODS

2.1 Experimental Design

The study was conducted at Trout Breeding Centre, Haa which is located at an elevation of 2700 m above the sea level. The study period was for the duration of 107 days commencing from September 2021 to December, 2021. Three rearing tanks of dimension 1.8 m × 1.8 m × 0.23 m with water volume of 0.7452 m^3 were used for the experiment. The tanks were stocked at stocking densities 10kg/m^3, 15 kg/m^3 and 20 kg/m^3 and named as SD_{10}, SD_{15} and SD_{20}. During the experimental period, the trout fingerlings were fed with pelleted trout feed from BioMar at feeding rate which was based on average body weight and water temperature provided in the BioMar company's standard feeding marketing literature. The feeding percentage ranged from 1.16 to 1.67 of their body weight. The feeding frequency was 4-5 times a day for 46 days and decreased to 3 times/day for the remaining trial period.

2.2 Water quality parameters

Water quality parameters such as dissolved oxygen, pH and temperature were taken on daily basis using the HANNA Instruments. This was done in order to maintain an optimum water conditions for the growth of the fingerlings.

2.3 Data Collection

The parameters such as body weight and body length were collected on every fortnight basis. In total, 30 samples were taken from each tank and at a time 5 numbers of samples were taken for the measurements. A digital weighing balance (0.1 – 500g) and measuring scale mounted on a wooden board (0 – 30 cm; to nearest mm) were used for measurement of the information.

2.3.1 Growth, survival, feed conversion ratio and other parameters

The growth, survival and feed conversion by the fingerlings were assessed from each experimental tank by determining the mean weight gain (g), mean length gain (cm), specific growth rate (%) and feed conversion ratio. These parameters were calculated using the following formulas;

i. Mean weight gain (g)

$$\text{Weight gain (g)} = Weight_{mfw} - Weight_{miw}$$

Where $Weight_{mfw}$ is mean final weight and $Weight_{miw}$ is mean initial weight.

ii. Mean length gain (cm)

$$\text{Length gain (cm)} = Length_{mfl} - Length_{mil}$$

Where Length $_{mfl}$ is mean final length and Length $_{mil}$ is mean initial length.

iii. Specific Growth Rate-SGR (% body wt. gain/day)

*SGR (%) = ((Log$_n$ final fingerling wt. – Log$_n$ initial fingerling wt.)/Time interval) * 100*

iv. Survivability Rate (%)

*Survivability (%) = (Number of fingerlings survived at the end of the experiment/ Number of live fingerlings at the beginning of the experiment) * 100*

v. Feed Conversion Ratio (FCR)

*FCR = (Total feed consumed/Total weight gained) * 100*

2.3.2 Statistical Analysis

The data were analysed using One-way ANOVA followed by post-hoc test in SPSS. The results obtained from the study are expressed as mean ± standard deviation.

3 RESULTS AND DISCUSSION

Water quality parameters ranged from; temperature 9.37 ± 0.26°C, dissolved oxygen 5.57 ± 0.48 and pH 7.51 ± 0.1 during the study period. The survival rate in the three tanks were 98.92 %, 98.49 % and 98.89 % respectively. The result indicated that there was a significant difference ($P < 0.05$) in the final weight of the fingerlings raised in different tanks (**Table 1**) The final weight was observed highest at SD_{10} with 59.16 ± 1.98 g followed by SD_{15} with 50.86 ± 8.61 g and SD_{20} with 42.26 ± 6.62 g respectively. Moreover, the final length of the fingerlings was also recorded the highest at SD_{10} followed by SD_{15} and SD_{20} with 15.69 ± 1.74 cm, 14.58 ± 1.32 cm and 13.96 ± 1.23 cm respectively. The highest mean weight gain was obtained from the fingerlings with SD_{10} followed by SD_{15} and SD_{20} with 49.38 g, 41.08 g and 32.44 g respectively. The finding also revealed the highest mean length gain of 7.25 cm in the fingerlings with SD_{10} when compared to 6.25 cm and 5.62 cm for SD_{15} and SD_{20}. Besides, the specific growth rate was also observed higher (3.6 %) in the fingerlings with SD_{10} compared to SD_{15} (3.4 %) and SD $_{20}$ (3.2 %). However, FCR was lowest recorded in the fingerlings with SD_{10} when compared to SD_{15} and SD_{20}.

The survival rate of the fingerlings was recorded highest at SD_{10} and lowest in SD_{20}. This result supports the initial hypothesis of the study wherein survivability and growth changes are inversely proportional with the stocking density. The current study is in consistent with the findings of Timalsina et al. (2017) and Moradyan et al. (2012) who observed that with the increasing stocking densities, the survival rate of fingerlings decreases. The high stocking densities often result into increased disease outbreak, retarded growth and

Table 1: Stocking density, stock number, mean weight, SGR, FCR, biomass, survival of rainbow trout fingerlings reared in different tanks

Parameters	**SD_{10}**	**SD_{15}**	**SD_{20}**
Stocking density (kg/m^3)	10	15	20
Fingerlings per tank (nos)	841	1129	1449
Mean initial weight (g)	$8.81±0.93^a$	$9.9±0.97^a$	$10.3±1.24^a$
Mean final weight (g)	$59.16±1.98^a$	$50.86±8.61^b$	$42.26±6.62^c$
Mean final length (cm)	$15.69 ± 1.74^a$	$14.58 ± 1.32^a$	$13.96 ± 1.23^a$
Initial biomass (kg/tank)	7.4	11.17	14.29
Final biomass (kg/tank)	49.10	56.56	60.04
SGR (% / day)	3.6	3.4	3.2
FCR	0.76	0.84	0.98
Survival rate (% of initial stock)	98.92	98.49	98.13

Different superscripts in the same row are significantly different ($p < 0.05$)

subsequent mortality of fingerlings. On the other hand, much lower stocking density can lead to underutilization of the resources, thereby reducing the economic returns. In contract, Nahar et al. (2021) and Rahman et al. (2017) demonstrated that economic returns was better with high stocking density. Ellis et al. (2002) researched on the effects of stocking density on productivity, health, body condition and stress level and found that stocking density is directly proportional to fin erosion and inversely related to feed intake and growth. Sirakov and Ivancheva (2008) observed that growth of the fingerlings was significantly reduced at high density whereas FCR and survival rate were better with low stocking density. Zahedi et al. (2019) also observed that growth among rainbow trout fingerlings grown at different densities varied significantly. In the present study, the FCR from the fingerlings was very low ranging between from 0.76 – 0.98, possibly because of the fact that FCR is calculated by taking the dry weight of the feed and wet weight of the fish. FCR for fingerling or small fish is generally lower than larger size fish even within the same species. It is also influenced by the rearing conditions of the farm (USAID. 2017. Technical Bulletin). In contrast to the current study, North et al. (2006) demonstrated that stocking density did not significantly affect growth or mortality in rainbow trout juvenile. Moreover, Moradyan et al. (2012) also found that stocking density did not significantly affect the final mean weight and SGR.

A stocking density of 2 kg/m^3 to 80 kg/m^3 is generally practiced in North America and Europe while commercial farms use density ranging from 15 to 40 kg/m^3 (Ellis et al. 2002). However, these findings are from studies conducted at different research sites wherein factors affecting growth will be different from that of the current study. Based on the findings of the current study, it is best to stock the trout fingerlings at 10 kg/m^3 in the TBC for the optimal growth. The significant effect of stocking density on the final weight and final length of fingerlings among the three tanks in the current study could be attributed to the differences in energy expenditure. At lower density, the fingerlings have better ability to see the feed and need not waste energy on competing for food and space while there is loss of energy for feeding and space in higher densities (Sirakov and Ivancheva 2008).

Studies have shown that stocking density has a negative effect on the fins (North et al. 2006, Stejskal 2019). Fin damage is an indicator of unsuitable rearing conditions particularly rising from high stocking density. However, in the present study, no differences were observed in the fin condition of fish stocked at different densities. The current study demonstrates that fish growth, survival, FCR and SGR are all affected by stocking density. This study suggests that rainbow trout growth is indeed dependent on stocking density and that growth rate is higher at relatively lower stocking densities. Besides, the study also recognizes the optimal stocking density for maximizing economic returns for growing rainbow trout fingerlings under Bhutanese conditions. Additionally, this study provides clear scientific basis for rearing rainbow trout under different stocking densities which will be instrumental for determining future production parameters to optimize the production potential in trout farming.

4 CONCLUSIONS & RECOMMENDATION

The demand for Rainbow trout fingerlings is increasing over the years as there is growing popularity of trout farming in the country since trout meat fetches the premium price in the market. The optimal stocking densities of trout fingerlings in a hatchery is crucial to enhance fish seed production. The current research, being first of its kind in the country, made an attempt to document the growth performance of Rainbow trout fingerlings with different stocking densities under Bhutanese research station condition. This study assessed the critical parameters like mean weight gain, mean length gain, specific growth rate, feed conversion ratio and survivability on trout fingerlings for a period of 107 days. From the findings, it is evident that growth, survivability and other variables of trout fingerlings were found better in the tank which had relatively lower stocking densities. The growth performance of trout fingerlings was found significantly affected with stocking densities. Higher growth rate was observed in the fingerlings with lower densities. Thus, the study concludes that for optimal growth of trout fingerlings, the stocking density of

10kg/m^3 is recommended in trout hatcheries under Bhutanese rearing conditions to optimize production for higher returns.

Study limitations

The study had some limitations during data collection. The water quality parameters were not monitored separately in the three tanks but was checked at the inlet and the information was applied for all the tanks. This was done bearing in mind that there is water exchange throughout the day in a flow through the system and it is very unlikely that water quality parameters will differ in the three tanks. Besides, five samples were taken at a time from the tank and was divided by the number of samples to determine the weight of one sample. Thus, there could be a chance of minor differences in the final weight of the fingerlings provided taken individually.

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