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EFFECT OF STOCKING DENSITY ON PERFORMANCE OF CULTIVABLE CARPS IN SOUTHERN BHUTAN

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ABSTRACT: The effect of different stocking rates on growth performance of two fish species namely Rohu (*Labeo rohita*) (Hamilton 1882) and Cauvery white carp (*Cirrhinus mrigala*) (Hamilton 1822) was evaluated in 180 days of culture period. Four different treatments were evaluated. The treatments were stocking rates of two fish m^{-2} as T1, four fish m^{-2} as T2, six fish m^{-2} as T3 and eight fish m^{-2} as T4. The experiment was conducted in National Research and Development Centre for Aquaculture, Gelephu, Bhutan. All other management aspects such as feeding, manuring, fertilization and liming were same for all treatment ponds. The initial average weight and length of Rohu was 8.10 g and 8.74 cm, respectively, whereas the initial average weight and length of Cauvery white carp was 7.49 g and 9.20 cm, respectively. Fishes were fed @ 5% of body weight for three times a day: morning at 8.00 am, afternoon at 12.00 pm and evening at 5.00 pm. Fish growth parameters were recorded monthly through sampling 30 fish of each species from each treatment pond. Although, there was no significant difference among pond parameters, the final fish body weight was significantly greater for the stocking rate of four fish m^{-2}. The findings suggest that stocking rate of four fish m^{-2} is most appropriate in achieving optimum growth of Rohu and Cauvery white carp in subtropical region of Bhutan.

Keywords: Cauvery white carp; Feed Conversion Ratio; Growth; Rohu, Stocking rate; Specific Growth Rate.

1. INTRODUCTION

Fish is an important meat commodity in diet of Bhutanese people. Fish is a good source of protein, fatty acids, vitamins, minerals and essential micronutrients. Realizing the nutritional importance of fish, aquaculture was initiated in early 1980s in Bhutan. Over the last three decades, fish farming has expanded and aquaculture is becoming a profitable enterprise. However, the average Bhutanese fish farm's productivity is low due to poor culture management practices. Under optimum condition, generally, one acre of fish farm is capable of producing 4.0 metric ton (MT) of fish in six months with an average individual harvest weight of 0.70 kg. But the current average productivity of Bhutanese fish farm is about 1.4 MT and the average individual harvest weight is 0.23 kg. Fish farmers in Bhutan often face low yield that culminates in low profit margins. Fish growth is affected by several factors. Of these factors, stocking rate is important. The poor growth of fish, to some extent arises from lack of sufficient knowledge on the best practice of fish stocking densities in ponds. For this reason, a study was proposed to address the concern in a local setting that could be representative of various fish farm

sites in Bhutan. In particular, a study on the effects of different stocking rate on growth performance of Rohu (*Labeo rohita* Hamilton) and Cauvery white carp (*Cirrhinus mrigala* Hamilton) has not been conducted. Therefore, there is a need for a fish production technology capable of producing an average individual harvest weight of minimum 0.650 kg in six months, which is close to optimum productivity.

The research was envisaged to generate knowledge on appropriate fish stocking density that would maximize production and profitability of aquaculture enterprises in subtropical region of Bhutan. We conducted an on-farm study with the objective to establish the most appropriate stocking densities for Rohu and Cauvery white carp in earthen ponds. This was achieved by evaluating the effects of four different stocking rates on growth performance of Rohu and Cauvery white carp under Bhutanese management conditions.

2. MATERIALS AND METHODS

2.1 Pond preparation

Four small earthen ponds at NRDCA were used for on-farm trial as treatment ponds. Each pond size was 270 m^2. Considering the limited ponds at NRDCA, there was no replication of ponds and treatments. The ponds were thoroughly prepared and limed @ 250 kg ha^{-1} $application^{-1}$ (Das et al. 2011). Bamboos along with its twigs were provided to all the treatment ponds so that it can serve as hideouts from predators and also serve as substrate for periphyton production. All ponds were provided with four numbers of bamboo twigs of approximately same surface area. Organic manure in the form of cattle dung was applied as basal dose @ 4 tones ha^{-1} yr^{-1}. Manure and fertilizer were applied three times to all treatment ponds during the entire culture period, based on the planktonic productivity of individual ponds, which was evaluated on weekly basis. The thumb rule of manuring is to ensure optimum plankton bloom at any given point of time. Manuring was done one week after liming in all treatment ponds.

2.2 Experimental design and treatments

The experimental design was Randomized Complete Block with one treatment factor, namely four stocking densities. The fish species were Rohu and Cauvery white carp. The stocking densities were two fingerlings per square meter for treatment 1 (T_1), four fingerlings per square meter for treatment 2 (T_2), six fingerlings per square meter for treatment 3 (T_3) and eight fingerlings per square meter for treatment 4 (T_4). In total, the initial stocking densities of T_1, T_2, T_3 and T_4 ponds were 534, 1068, 1620 and 2160, respectively. Delayed mortality was assessed by transferring at least 30 individuals in hapa for three days in all treatments.

2.3 Stocking

The research ethics guidelines of Department of Livestock were followed and all fish were subjected to minimal stress and pain during the entire study period. Each treatment pond was stocked with stunted fingerlings on 30th March, 2017 two weeks after manuring or after the ponds were productive. The initial average weight and length of Rohu were 8.10 g and 8.74 cm, respectively. The initial average weight and length of Cauvery white carp were 7.49 g and 9.20 cm, respectively. Single Stocking Single Harvesting (SSSH) culture system with combination of two species (consisting of two Indian major carp species) was followed. Stocking species ratio was 6:4, where 60% were Rohu and 40% were Cauvery white carp. The fingerlings were conditioned at least for 24 hours to adapt them to practical condition associated with live fish transportation. Stocking rate was the treatment factor.

2.4 Feeding

Considering the availability of local feed ingredients, crude feed formulated from rice bran and mustard oil cake in 2:3 ratios (40%:60%) was used in all treatments. The fish was provided with feed @ 5% of body mass per day and feeding rate was adjusted to 2% during the course of research based on feed utilization (Jena et al. 2001). The biomass of fish was estimated every month based on sampling data. Feeding was done three times a day as feeding frequency of more than three times has shown significant growth as compared to two times in case of Rohu (Abid and Ahmed 2009). Feeding was done at 8 am in the morning, 12 pm in the afternoon and 5 pm in the evening. Same feeding methods were followed for all treatments. Feed was dispensed along the four corners of pond in the form of ball.

2.5 Other Management Aspects

The water flow inside the ponds was adjusted to maintain the optimum water level in fish pond by compensating the water loss through seepage and evaporation. In order to maintain desired water pH and pond hygiene, lime was applied @ 100 kg ha^{-1} $application^{-1}$ once in three months. Apart from this, the lime was applied as and when required during the course of culture period.

Manuring was done with cow dung on the basis of water transparency to ensure optimum plankton population at any given point of time. The transparency of all ponds was judged visually, supplemented by elbow method on weekly basis or

as and when required to decide on manuring. Key water quality parameters such pH, DO_2, temperature, transparency and color were recorded during the entire culture period.

2.6 Duration of experiment

The trial was conducted for a period of six months. In order to assess the growth and health of the fish, sampling was done at monthly interval. Minimum of 30 individuals of each species was considered as an effective sample size.

2.7 Data collection and analysis

Fish was sampled and the length and weight were recorded at monthly interval, using measurement scale and electronic balance. The following equations were used to evaluate the growth performance of fish under different treatments.

i. Mean gain in length (cm) = Mean final length (cm) – Mean initial length (cm)
ii. Mean gain in weight (g) = Mean final weight (g) – Mean initial weight (g)

Specific growth rate (SGR) and Feed Conversion Ratio (FCR) were calculated at the end of the experiment for each treatment using formulae developed by Hopkins (year).

$$\text{SGR (\% per day)} = \frac{\text{LogW2} - \text{LogW1}}{\text{T}} \times 100$$

Where, W2 = mean final weight (g), W1 = mean initial weight (g), T is culture period (days).

iii. Feed Conversion Ratio (FCR):

$$\text{FCR} = \frac{\text{Total feed consumed (kg)}}{\text{Total weight gained (kg)}}$$

2.6 Data analysis

The dataset was analyzed using multivariate ANOVA. Since the ponds were not replicated, analysis was carried out separately for each fish species. Stocking density was an independent variable and fish body length and weight were dependent variables. The difference in the means of dependent variables among stocking densities was considered significant when p value was less than 0.05. Statistical software SPSS version 23.0 was used to analyze data.

3. RESULTS AND DISCUSSION

3.1 Water quality parameters

There were no significant differences in water quality parameters among the treatments (Table 1). However, when compared between treatments, highest pH was recorded in T2, followed by T1, T4, and then T3 being the lowest. T1 exhibited highest DO_2 value, followed by T2, T3 and T4, respectively. The highest and lowest temperatures was recorded in T2 and T1, respectively. However, all the parameters recorded were within the optimal range that is ambient for normal growth performance of Rohu and Cauvery white carp as reported by Hossain (2000). Similar result is also reported by Haque et al. (2015) on experiment conducted on different stocking densities in Bangladesh.

3.2 Effects of stocking rate on SGR

The Specific Growth Rate (SGR) of Rohu and Cauvery white carp across treatments is presented in Figure 1. The highest SGR of 0.59 was found in Rohu cultured in T2, followed by 0.58 in T3, 0.50 in T4 and 0.44 in T1. Similarly, in Cauvery white carp, the highest SGR of 0.59 was found in T1, followed by 0.52 each in T2 and T3 and lowest SGR of 0.48 in T4. SGRs recorded in his study were comparable with the findings of a study of Hossain et al. (2008) who reported similar SGR. In this study, the high SGRs of Rohu and Cauvery white carp were in T2 and T1, respectively, which could be due to low stocking rate as compared to T3 and T4.

3.3 Effects of stocking rate on FCR of *Rohu* and *Cirrhinus mrigala*

Rohu exhibited best FCR value in T2 (0.97) and lowest FCR value in T4 (1.08) (Figure 2). On the other hand, Cauvery white carp had highest FCR in T1 (0.98) and T2 (0.98) and lowest in T4 (1.04). Similar results are reported by Manomaitis et al. (2004) and Islam et al. (2014). However, this result contradicts with the findings of Kausar and Salim (2006) and Saeed et al. (2005) who reported high

Table 1: Water quality parameters in different treatment ponds during experiment. (ns-nonsignificant).

Treatment	pH	DO_2 (mg L^{-1})	Temperature (°C)	Transparency (cm)
2 fingerlings m^{-2}	7.69 ± 0.43	5.41 ± 0.98	29.18 ± 2.04	27.57 ± 1.63
4 fingerlings m^{-2}	7.74 ± 0.45	5.31 ± 1.16	29.34 ± 2.10	27.64 ± 1.72
6 fingerlings m^{-2}	7.64 ± 0.39	5.27 ± 0.99	29.16 ± 2.12	27.64 ± 1.72
8 fingerlings m^{-2}	7.65 ± 0.36	4.79 ± 1.09	29.32 ± 2.16	27.64 ± 1.72
p value	ns	ns	ns	ns

FCR values in Rohu.

In this study, the best FCR of Rohu and Cauvery white carp in T2 and T1, respectively, could be due to low stocking rate and consequent low stocking densities.

3.4 Effects of stocking rate on growth performance of Rohu and Cauvery white carp

The fingerlings of Rohu in T2 had a significantly higher final growth performance, followed by T3, T_1 and T4 (Table 2). Similarly, the growth performance was higher in T1 than T4. Similar growth performance result is reported by Mamun and Mahmud (2014) and Basak et al. (2017) on Rohu in Bangladesh.

Cauvery white carp in Bangladesh. In this study, the highest performance of fishes cultured in T2 could be due to low stocking rate and its consequent stocking densities that provides ideal pond ecosystem.

4. CONCLUSION

The stocking rate of four fish m^{-2} exhibited the highest growth performance by both fish species. Therefore, the stocking rate of four fish m^{-2} is recommended for successful polyculture in areas that lie within the similar agro-ecological zones of this study.

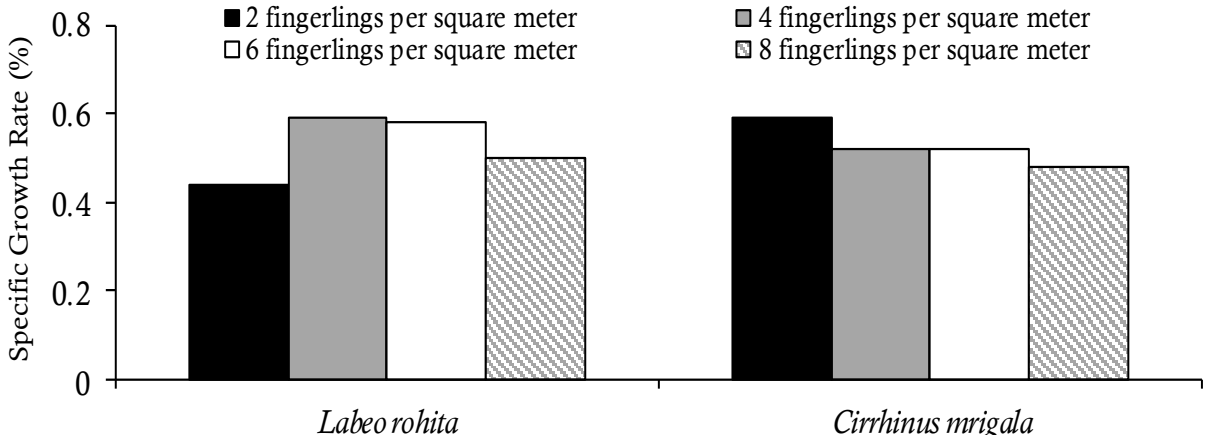

Figure 1: Specific Growth Rate (SGR) of Rohu and Cauvery white carp across treatments.

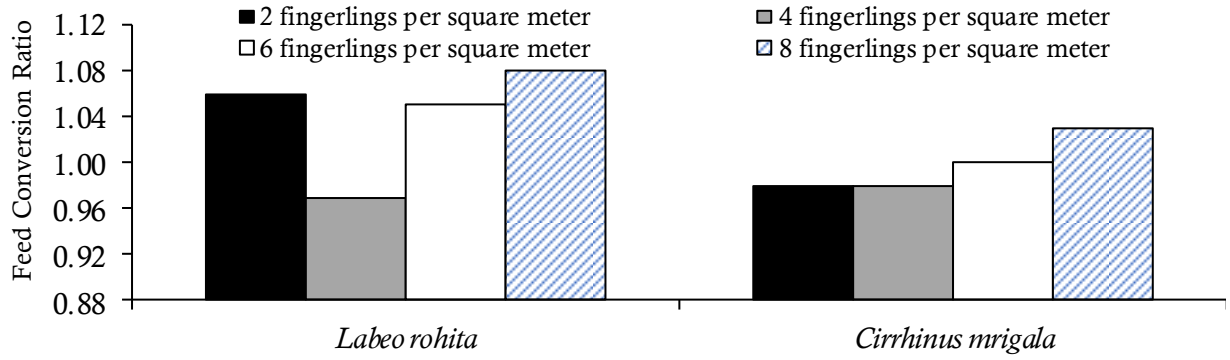

Figure 2: Feed Conversion Ratio (FCR) of Rohu and Cauvery white carp across treatments.

Similarly, the highest growth performance by Cauvery white carp was recorded in T2. Unlike Rohu, Cauvery white carp cultured in T1 had the second highest growth, followed by T3 and T4.

Growth performance was significantly higher in T2 than T1. T2 had a greater initial growth performance than T3. Although, statistically not significant, the growth performance of T3 was greater than T4 (Table 2). Similar growth performance result is reported by Mamun and Mahmud (2014) and Basak et al. (2017) on

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Table 2: Initial and Final Body Weight (BW) & Body Length (BL) of fish species (Mean ± SD). Means with different letters within the column differs significantly at p≤0.05. Superscript with different letters within the column differs significantly at p≤0.05.

	Rohu			Cauvery white carp		
	(BW in g/BL in cm)			(BW in g/BL in cm)		
Treatment	Initial Body Weight and body length	Final Body Weight and body length	Growth (g) (final-initial weight)	Initial Body Weight and body length	Final Body Weight and body length	Growth (g) (final-initial weight)
2 fingerlings m^{-2}	8.02/8.79	138.5/22.5ac	130.48	7.50/9.30	153.1/24.2ac	145.5
4 fingerlings m^{-2}	8.09/8.61	274.9/26.8b	266.79	7.47/9.11	171.6/24.8b	164.17
6 fingerlings m^{-2}	8.14/8.79	141.7/21.7ad	133.52	7.53/9.19	133.8/22.7ad	126.22
8 fingerlings m^{-2}	8.12/8.79	135.7/21.9cd	127.59	7.48/9.20	110.7/21.8cd	103.24

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