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Effect of stocking density on the growth rate of common carp *Cyprinus carpio* Linnaeus, 1758

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Abstract
To test the effect of different stocking density on their growth and survival rate of common carp, *Cyprinus carpio* Linnaeus 1758 was cultured in three tanks for ten weeks from September 2016 to January 2017. These carps were fed with commercial small pellets (Tokyu) every day. A total of 90 healthy looking fingerlings were selected and used. Mortality and survival rates in each tank were checked every day. During the studied period, the survival rate was the highest in GI (100%) followed by GII (93.33%) and GIII (91.11%) respectively. The result in this project shows that GI is the best population density for the growth and survival rates of common carp. GI (5 density) could be expressed as optimal density. Therefore, stocking rate of 0.13 fish/L would be suggested as optimal rate.

Keywords: *Cyprinus carpio*, population density, growth and survival rates

Introduction
Fish is a good source of protein and it also has essential amino acids with minerals like zinc, magnesium and sodium etc. In this regard fishes are of utmost national importance in increasing the country's food resources (Rath, 1993) [1].
Stocking density is an important factor that affect on growth, efficiency and reproductive performance in fish. Specific stocking density can have positive and negative effect on fish growth (Merino, 2007) [2].
To supply the growing market, fish farmers need to keep the fish at the highest sustainable stocking densities to produce a large number of fish (Olivier and Kaiser, 1997) [3]. Knowing the optimal stock density is one of the basic factors of intensive fish culture. The density should be the resultant value of the environmental requirements of a given fish species and broadly understood economic efficiency (Holm *et al*., 1990; Kuipers and Summerfelt, 1994; Szkudlarek and Zakes, 2002) [4-6]. Fish stocking density is the most sensitive factor determining the productivity of a culture system as it affects growth rate, size variation and mortality (Kaiser *et al*., 1997) [7].
To understand the effect of each factor, for example density in the present work, variation in the population of growth the animal concerned is made while other factors kept almost constant. This can be achieved by keeping all groups of different population sizes in the same room under similar environmental conditions.
A thorough understanding of the fish growth is a prerequisite for conducting experiment on the effects of such environmental factors.
The growth of the body as a whole is the result of simultaneous growth of all its parts for which individual rates are highly variable. The increase in dimension of the body as a whole may be expressed absolutely as centimeters or gram per day. It may also be expressed as the relative growth as the percentage of the mass at the start. In experimental works, absolute growth and absolute growth rates are most commonly employed as indicated by Ricker (1979) [8].
Today, common carp, *Cyprinus carpio* is one of the most popular fish in Myanmar. Success in the culture of common carp is attributed to its ability to resist poor water quality and disease, to tolerate wide ranges of temperature, salinity and low oxygen levels. Common carp are growing faster than other fish and desirable for consumers. It is omnivores and one of the commercial fish (Takeuchi, 2002) [9]. In Myanmar, it is a common freshwater fish being successfully cultured in ponds and lakes. For these reasons, common carp, *Cyprinus carpio* is selected as candidate species for this research.

The aim of this study was to determine the optimum population size for an optimum volume of culture medium (water here) and to examine various stocking densities on growth and survival rate of common carp within glass aquaria.

Materials and Methods

Collection of specimens

One hundred and fifty fingerlings of *Cyprinus carpio* were obtained from the Nickel Pet Shop. The fingerlings were brought to the laboratory and kept in a small glass aquarium 60 cm x 120 cm x 60 cm with ample supply of water until they become acclimatized to their new surroundings. During this period, they were fed with commercial small pellets.

Selection for specimens to study

When the fingerlings were approximately from 0.5 g to 1.6 g in weight and 2.2 cm to 4.9 cm in standard length, a total of 90 healthy looking fingerlings were selected and used throughout the course of the experiment.

Procedure of the experiment

The fingerlings were divided into three groups of 5 fish individuals (Group I), 10 fish individuals (Group II) and 15 fish individuals (Group III) per group and each group was kept in a glass aquarium (Plate 1). Each aquarium was filled with 40 Liter of water.

Nine glass aquaria with the dimension of 45 cm x 45 cm x 45 cm in each were used in this experiment. Each aquarium of 40 L capacity was covered with the size of 140 cm x 50 cm mosquito net to prevent the fish jumping out of water. All aquaria were kept in the same room so as to alleviate the effects of environmental variable. About half of water with faeces and uneaten food were siphoned off and refilled with tap water three times per week. Three replicate tanks were made for each stocking density.

Feeding

The fingerlings were fed with commercial small pellets (Tokyu) every day. Feeding was made twice a day, one in the morning 7:00 am and another in the evening 5:00 pm. The food was provided up to the 5% of the total body weight.

Collection of Data

Body weight (g) was taken with a digital balance (Rai, BB0811). Standard length (cm) and total length (cm) were measured with a plastic ruler every two weeks (Plate 1).

Environmental Condition

Water quality parameters such as pH and temperature were recorded during the experimental period. The water quality parameters monitored during the study period were temperature 21 – 28 ˚C and pH 7 – 7.6.

Calculation of Growth

Survival rate (%) = 100 x (Final number of fish/ Initial number of fish) (Ricker, 1975)[10]

Weight Gain (WG) = (FW - IW) (Cited by Debrnth *et al*., 2006) [11]

$$\text{Specific Growth Rate (SGR) \%} = \frac{100\ [\text{In final weight} - \text{In initial weight}]}{\text{times (days)}}$$

IW = Initial mean weight

FW = Final mean weight

In = Natural logarithm reading

Statistical Analysis

The parameters used were specific growth rate (SGR) and survival rate (SR). In order to find significant differences among groups, different density data analysis was performed by using ANOVA (Critical value of $p<0.05$ was set as the limit of significance). Data were analyzed by one way SPSS (version 21). Mean weight gain was determined by subtracting the mean initial weight from mean final weight. Fish from each tank were weighed at every two weeks interval.

Results

Duration of the studied period lasted for five months. Allocations of fish to three different groups are given in Table 1. During this period, the specific growth rate (SGR), the mean standard length (MSL) and mean body weight (MBW) were observed and they were shown in (Figure 1). No significant difference was observed in the initial weight of all densities groups.

From September 2016 to January 2017, the studied fish attained final specific growth rate (SGR), weight gain and mean body weight and mean standard length by different density groups (Table 2, Figure1, 2).

Food was provided at the rate of total body weight of 5%. Rearing medium was 40 liter of water; faeces and uneaten food were siphoned off. The mean body weight increase was 3.32 g, 2.72 g and 2.21 g for GI (density 5), GII (density 10) and GIII (density 15). Specific growth rate showed the highest in GI individuals followed descending order by GII (density 10) to GIII (Table 2, Figure 2)

Mean body weight comparison between GI and GIII showed significance ($p<0.05$) (Appendix). There was no statistical difference in the mean body weight of the GI and GII and then GII and GIII. The maximum growth rate was observed in GI when compared with GII and GIII. GI (5 density) revealed the highest mean weight gain of 4.04 g, and GII (10 density) and GIII (15 density) were 3.41 g and 2.01 g respectively (Table 3). At the end of the experiment, survival rate of fish in all experiment glass aquaria were (91.11-100%). The survival rate was the highest in GI (100%) followed by GII (93.33%) and GIII (91.11%) (Table 3).

Table 1: Allocation of fish in different groups

Group number	Stocking density		Total volume of water (Liter)	Effective volume of water (Liter)
	Fish/L	Fish/Tank		
I	0.13	5	40	8
II	0.25	10	40	4
III	0.38	15	40	2.67

Table 2: Bi weekly means body weight, Weight gain and Specific growth rate of *Cyprinus carpio* under three different density groups during studied period

Bi-weekly	GI			GII			GIII		
	MBW	WG	SGR%	MBW	WG	SGR%	MBW	WG	SGR%
1st	1.46	-	-	1.38	-	-	1.28	-	-
2nd	2.01	0.55	3.67	1.79	0.41	2.70	1.51	0.13	1.52
3rd	2.30	0.29	1.93	1.95	0.16	1.07	1.69	0.19	1.28
4th	2.66	0.36	2.38	2.30	0.35	2.33	1.85	0.15	1.01
5th	3.06	0.40	2.66	2.66	0.36	2.42	2.07	0.22	1.46
6th	3.39	0.33	2.20	2.85	0.19	1.26	2.20	0.13	0.92
7th	3.76	0.37	2.52	3.01	0.16	1.05	2.46	0.26	1.72
8th	4.29	0.53	3.50	3.44	0.43	2.88	2.77	0.31	2.06
9th	4.74	0.45	2.99	3.64	0.20	1.30	2.97	0.20	1.29
10th	5.50	0.76	5.12	4.18	0.54	3.60	3.28	0.31	2.13
Mean	3.32	0.45	2.69	2.72	0.31	1.86	2.21	0.21	1.33

MSL= ean standard length, MBW= mean body weight

Table 3: Growth performance of common carp, *Cyprinus carpio* at different stocking densities in glass aquaria during 5 months.

Growth parameters	Population Density		
	5	10	15
Initial mean weight	1.46 ± 0.94	1.38 ± 0.59	1.28 ± 0.64
Final mean weight	5.50 ± 2.25	4.18 ± 1.72	3.28 ± 1.17
Weight gain	4.04 ± 0.14	2.80 ± 0.13	2.01 ± 0.07
SGR%	2.69	1.86	1.33
Survival%	100	93.33	91.11

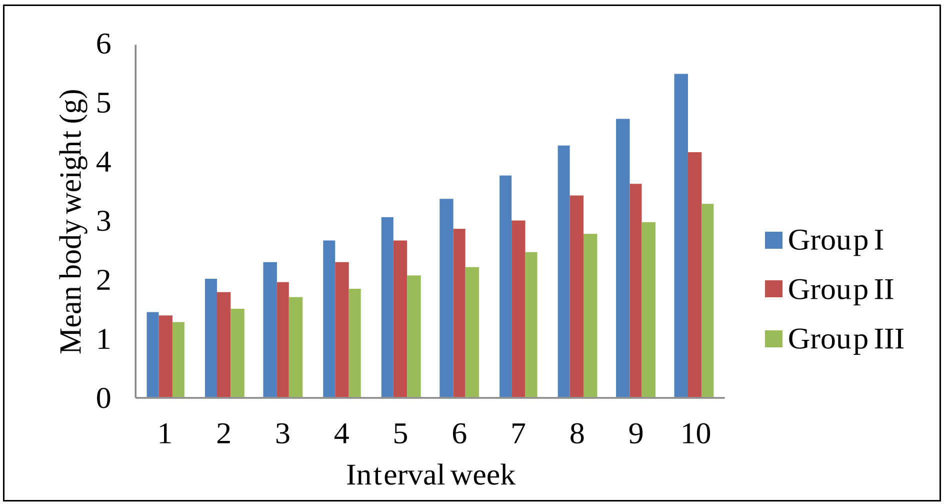


Fig 1: Comparsion of mean body weight of different density groups from September (2016) to January (2017)

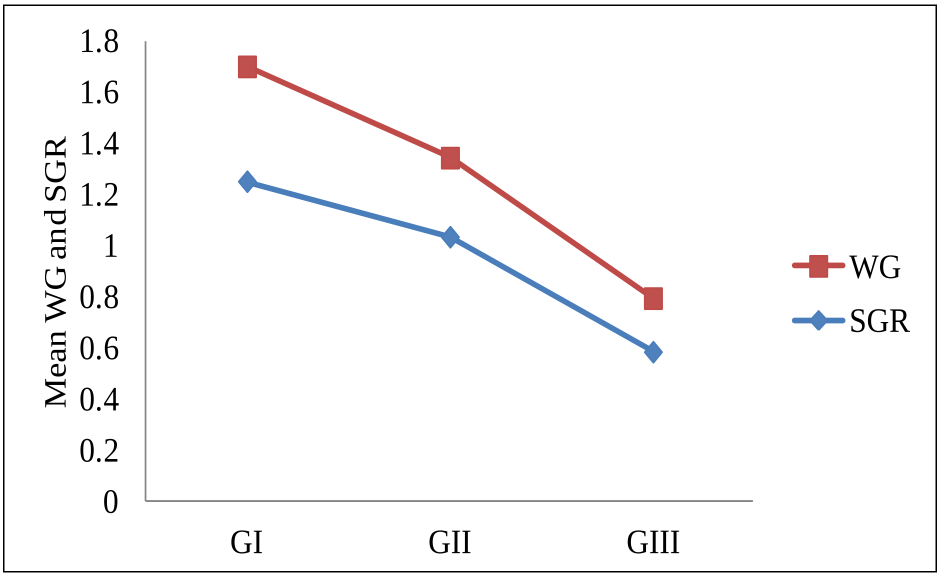
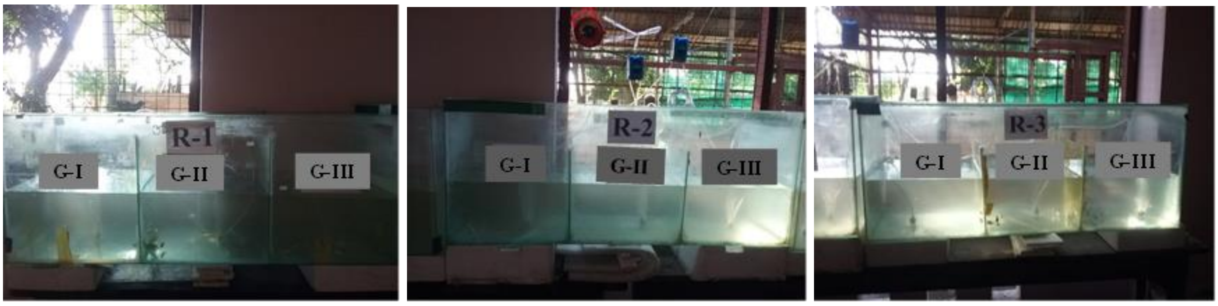
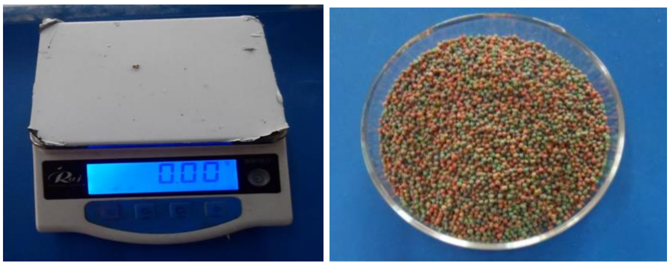


Fig 2: Specific growth rate and weight gain of different density growth of common carp in 10th interval weeks



Replication I Replication II Replication III



The Digital balance Tokyu pellets

Plate 1: Glass aquaria for G-I, G-II and G-III, the Digital electric balance and Tokyu commercial pellets

Discussion

The result is made on the basis of increase in body weight taken for five months by different density on *Cyprinus carpio*. The present work took five months from September 2016 to January 2017. In the experiment, survival rate of common carp fingerlings had been observed between (91-100%). Group I had no mortality among the different density groups. However, Group II and Group III had a few mortality, but were not significant. Probably, the fishes, handing for weighing and measuring length interval weekly could have exerted stress on them. Similary, Kay Thi Myint (2002) [12] reported a few mortality. Forty liters of diffusible volume of water which works to be 2.66 (40/15) liters for each in Group III of 15 fingerlings did not seem to affect on the health of the fish and may have on the growth rate. According to Kyaw Sann Win (2004) [13], forty litres of diffusible volume of water which works to be 2(40/20) litres for each tank of 20 fingerlings did not seem to affect on the health of fish, but did have on the growth rate.

During the studied period, the final mean length and weight were 5.29 cm and 5.50 g in G I, in G II, 5.13 cm and 4.18 g and 3.65 cm and 3.28 g in G III respectively. Statistically significant difference between the growth rate of different densities was observed as density increasing (density of 15, G III), growth rate was significantly lower ($p<0.05$). In mean body weight comparison, G I and G III were highly significant ($p<0.05$) but G I and G II, G II and G III were not statistically significant.

The mean specific growth rate for three density groups of 5, 10 and 15 were 2.69%, 1.86% and 01.33% respectively. Comparison of the interval weekly mean weight gain between the density of Group I and II showed a difference of 0.14 g and Group I and III of 0.24 g in favour of the former.

The mean specific growth rate and weight gain for three density groups were revealed in a line graph.

Mean SGR and WG declined imperceptibly from Group I to II and II to III, but from G I to III it declined drastically. This was the result of decrease in weight gain. The same trend has been expressed by Kay Thi Myint (2002) [12], where density groups of 3, 6, 9 and 12 were apprently decreased spectacular. Imanpoor *et al.* (2009) [14] obtained similar result in common carp. Stocking density is one of the most important factors affecting growth yield and survival of cultured fish (Smith *et al.*, 1778) [15]. As fish density increased, competition for food and living space was intensifier. Culture can be either density-dependent or density-independent. When stocking density negatively affects fish growth, the culture is density-dependent (Huang and Chiu, 1997) [16]. Gholipour *et al.* (2007) [17] reported that increasing density has a negative effect on growth and specific growth rate in rainbow trout. In this study, the results appear to be density-dependent.

Ellis *et al.*, 2002 [18] expressed that stocking density is an important factor for fish welfare, but cannot be seen in separation from other environmental factors To achieve desirable size at harvesting, stocking density must be systematically regulated. These factors can be easily measurable and can be useable as an indicator of population stress. Therefore, a stocking rate of 0.13 fish/L would be suggested as optimal in this research.

Conclusion

From the data obtained, it can be concluded that the best growth and survival rate for common carp, *Cyprinus carpio* under laboratory condition is recommended to stock density of 0.13 fish/L. At the end of experiment, mean body weight comparison G I and G III is highly significant ($p<0.05$) but G I and G II, G II and G III are not statistically significant.

In the present work, it could be concluded that increasing density (density of 15) has a negative effect on growth, weight gain and specific growth rates on *Cyprinus carpio*, common carp. G I (5 density) could be expressed as optimal density. The result of this study can be useful in evaluating the effects of density on some biological parameters.

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